

Krabel, Stefan; Siegel, Donald S.; Slavtchev, Viktor

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by

**Stefan Krabel
Donald S. Siegel
Viktor Slavtchev**

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Max Planck Institute of Economics
Kahlaische Str. 10
D-07745 Jena
www.econ.mpg.de

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The Internationalization of Science and its Influence on Academic Entrepreneurship

January 2009

Stefan Krabel

Max Planck Institute of Economics

Donald S. Siegel

University at Albany, SUNY

Viktor Slavtchev

Max Planck Institute of Economics

Abstract

We conjecture that the mobility of academic scientists increases the propensity of such agents to engage in academic entrepreneurship. Our empirical analysis is based on a survey of researchers at the Max Planck Society in Germany. We find that mobile scientists are more likely to become nascent entrepreneurs. Thus, it appears that citizenship and foreign-education are important determinants of the early stages of academic entrepreneurship.

JEL-classification: L26, O31

Keywords: Academic Entrepreneurship, Human Capital, Scientific Mobility, Knowledge Transfer, Immigrant Entrepreneurship

Contact: Stefan Krabel, Max Planck Institute of Economics,
Kahlaische Strasse 10, 07745 Jena,
Tel: +49-3641 686 731, Fax: +49-3641 686 710,
e-mail: krabel@econ.mpg.de

1 INTRODUCTION

Technological entrepreneurship is regarded to be an important driver of economic development (Schumpeter, 1934). Scientific research results in innovation, which leads to new and improved products and production processes. In recent years, scholars have analyzed scientists who have an entrepreneurial orientation. Their actions can be considered a direct way of transferring scientific knowledge to markets. Moreover, firms founded by scientists have become economic institutions, by opening new markets or niches that contribute to economic growth (Zucker, 2007; Zucker et al. 1998). Consequently, there is a growing interest among scholars and policy makers to understand the process by which scientists found firms (Shane and Venkataraman 2003; Toole and Czarnitzki, 2007).

Studies of scientific entrepreneurship highlight the nexus of an entrepreneurial opportunity and entrepreneurial capabilities at the core of the entrepreneurial act (Ventakaraman 1997; Ardichcili, Cardozo and Ray 2003). Recognizing the scientific and commercial potential of a scientific invention often represents the starting point of a researcher's entrepreneurial intention. Entrepreneurial capabilities and commitment to ideas may induce scientists to pursue these ideas by starting a new venture.

In this paper, we develop a link between scientific entrepreneurship and scientific mobility. Scientists who accept research positions in non-native countries have to adapt to a new, uncertain environment. We conjecture that this process of adapting to a new culture and society stimulates opportunity recognition and increases entrepreneurial commitment. Our theoretical perspective predicts that mobile scientists are more entrepreneurial than non-mobile scientists, as their behavior

exhibits attributes conducive to entrepreneurial activity. Specifically, we hypothesize that foreign scientists and foreign-educated, native scientists are more likely to be entrepreneurial than domestic-educated, native researchers.

Our empirical analysis is based on researchers from the Max Planck Society in Germany, which is regarded as one of Europe's "science powerhouses." Moreover, we distinguish between two differing stages of the entrepreneurial process, namely the involvement in starting a new venture (nascent entrepreneurship) and the business actually entering the market. Our findings suggest that experience abroad (from education and citizenship) is positively related to both the likelihood of nascent entrepreneurship. Later stages of entrepreneurship appear to be unrelated to experience abroad.

The contribution of this study is at least twofold. In addition to previously known factors, we find evidence that individual experience is important for identifying the entrepreneurial inclination of scientists. The results suggest that adaption processes enhance entrepreneurial capabilities and commitment as well as the ability of recognizing entrepreneurial opportunities. Thus, the results of this study also open a discussion if organizations and countries can benefit from circulating and hosting international scientists. As foreign experience appears unrelated to start-up, the results suggest that it is important to distinguish between different stages of the entrepreneurial process.

The remainder of the paper is organized as follows. The following section elaborates on the nexus of an entrepreneurial opportunity and entrepreneurial capabilities. Section three develops the link between scientific mobility and scientific

entrepreneurship and derives the hypotheses. Section four describes the data and variables. The empirical analysis and results are presented in section five. Section six discusses the results and concludes.

II. ACADEMIC ENTREPRENEURSHIP

Schumpeter (1934) considered market entry of new firms as a major driver of economic renewal and development. New businesses can directly effect economic growth through to the creation of new markets and new jobs (Schumpeter 1911; Baumol 2004; Geroski 1995). New firms can also improve market efficiency through competition as they either crowd out inefficient incumbent firms or spur them to improve innovativeness and productivity (Schumpeter 1947; Aghion et al. 2004; Baumol et al. 1988; Baldwin and Gorecki 1991).

The more that a new firm is based on new knowledge and technology, the greater the impact it has on economic development (Audretsch and Keilbach 2004; Wong et al. 2005). Technology-based, innovative firms typically have better economic performance, grow faster and consequently have greater survival chances (Hall and Oriani 2006; Van Reenen 1997; Cefis and Marsili 2005; Almus and Nerlinger 1999; Doms et al. 1995; Colombo and Grilli 2005). This argument particularly applies to firms founded by scientists as such firms are typically innovative, with only few organizational routines established. Moreover, firms operating at the technological frontier often rely on tacit knowledge. Thus, founders' scientific expertise and skills represent the key resources available to the firm. As to the degree to which tacit knowledge is embedded in people, firms' business fields, strategies and performance depend greatly on the founders' competences. (Cooper

and Bruno 1977; Cooper 1986; Feeser 1987; Feeser and Willard 1990; Shane and Stuart 2002; Shane 2004, Ch. 2).

The relevance of scientists' knowledge and expertise for firms is highlighted e.g. by Darby and Zucker (2001), who provide evidence indicating that the survival chances of U.S. biotech firms is related to knowledge flows from academic institutions. The authors report that 80 percent of the firms which have developed working arrangements with star scientists by 1990, survived through 1999. On the contrary, only 17 percent of the firms without star-collaboration in survived on the same period. Moreover, Zucker et al. (1998) and Zucker et al. (2002) find that the more intensive the interaction between firms and scientists as indicated by the number of firms' publications coauthored by star scientists, the higher the performance of the firm is in terms of both product development and employment growth.

Consequently, there is a growing interest among scholars and policy makers in the process of knowledge creation and technology-based scientific entrepreneurship (O'Shea et al. 2005; Wright et al. 2007). In fact, a better understanding of the entrepreneurial process in public research institutions might be particularly important for European countries to overcome the so-called 'European paradox'. European economies are thought leading in global scientific research, but lag behind the US in terms of economic performance (see for discussion Dosi et al. 2006). This paradox describes the fact that European countries have large investments in scientific research, while the economic return of these investments is relatively small in comparison to the U.S. (see for discussion Dosi et al. 2006). Zucker et al. (2007) and Wright et al. (2007) regard the insufficient level of academic entrepreneurship as one

main reason for the disconnection between the generation of cutting edge scientific knowledge and economic performance.

Opportunity recognition and entrepreneurial commitment

The entrepreneurship literature emphasizes that the entrepreneurial act requires a conjunction of entrepreneurial opportunity and entrepreneurial capabilities of individuals (Ventakamaran 1997; Shane and Ventakamaran 2000; Alvarez and Busenitz, 2001; Ardichvili, Cardozo and Ray 2003). Kirzner (1973, 1979) argues that the entrepreneur differs from the non-entrepreneur with respect to the degree of alertness regarding new opportunities. Following the Schumpeterian notion of an entrepreneur, entrepreneurial opportunities can be classified in three distinct categories (Schumpeter, 1934; Schumpeter, 1947. First, due to asymmetric information some individuals are - or believe themselves - better informed than others. These more informed individuals are more likely to become entrepreneurs. The second type of entrepreneurial opportunities stems from relative price changes due to social, political, demographic and other economic reasons. Externalities such as changes in the relative prices of resources, goods, information and knowledge create new opportunities and make options feasible which have not yet been considered. Third, the invention of new products and technologies lead to changes in the relative prices of resources, goods, information and knowledge. Consequently, entrepreneurial opportunities and new markets emerge. All three types of entrepreneurial opportunities allow individuals who seize them to earn economic rents in the market place (Amit, Glosten and Muller 1993; Kirzner 1997).

This argument particularly applies for highly innovative ventures. The reason is that such ventures are typically organized around scientific expertise that has been accumulated for many trials of experiments. Expert knowledge is therefore considered tacit, complex and highly sophisticated. Moreover, there are no prior experience and routines established (Agarwal et al., 2004). In such cases, scientists' expertise and human capital play a key role for both, the absorption and evaluation of external information as well as for the extension of the knowledge frontier. Moreover, scientific experience and expert skills put start-ups in a better position to develop new capabilities (Shane, 2000). The expertise helps to tackle technical problems and to overcome junctures (Vohora, Wright and Lockett 2004). In this line of reasoning, founders' competences are considered critical resources of in the early stages of the new ventures (Wright et al. 2007). In other words, scientific spin-offs commercialize the scientific research and the human capital of their founders.

The translation of research findings into a commercial product or service requires, however, also capabilities and skills different from scientific excellence. Beyond the ability to do research leading to breakthroughs, scientists need to be able to recognize the market potential of such breakthroughs. Similarly, they have to possess the ability to plan, to organize and to manage the commercial exploitation of scientific research. Social contacts and participation in business networks stimulates the access to external information and resources, and the better utilization of internal capabilities. In their notion of an entrepreneurial commitment, Wright et al. (2007) add further aspects. They suggest that scientists need to possess the ability to act against convention, the ability to cope with risk and uncertainty. The commitment of scientists to entrepreneurship represents the critical juncture leading them from

opportunity recognition to a pre-organization phase and subsequently to concrete steps of the venture formation.

Entrepreneurial commitment does not necessarily require scientists to progressively pursue the intention to start a venture, but needs at least a passive search for discovery (Ardichvili et al., 2003). In this line of reasoning, entrepreneurial activity is released by receptiveness to external signals and the awareness of opportunities. Scientific entrepreneurship often follows this scheme as scientists do not actively try to become entrepreneurs, but are open to evaluate the commercial value of discoveries. Thus, individual values and norms may influence entrepreneurial commitment. Values and norms change the value of information, resources and knowledge and therefore the value of opportunities (Licht, 2007). Similarly, Schwartz (2003) points out the importance of personal attributes such as self-direction and stimulation for entrepreneurial activity.

Alvarez and Busenitz (2001) suggest that the entrepreneurial capabilities develop over time. In the course of life individuals learn continuously and the way they make decision changes. As time goes by and situations and environments change, the ways individuals evaluate information change. Also routines and strategies that have been successful in the past become updated and adjusted according to new situations and environments. Similarly, individual perception, values, norms and attitudes are influenced by changing situations and environment. Consequently the alertness of opportunities and the commitment to entrepreneurship change.

III. SCIENTIFIC MOBILITY AND ACADEMIC ENTREPRENEURSHIP

In this section, we consider how the mobility of scientists may influence the recognition, development and exploitation of entrepreneurial opportunities. Our analysis leads to the claim that mobile scientists are more likely than their non-mobile to start entrepreneurial activity. Individual attributes that enhance mobile scientists propensity to entrepreneurship are: the tolerance of risk and uncertainty, high degree of human and social capital, as well as high entrepreneurial commitment.

Accepting research positions in foreign countries requires mobile scientists to adapt to new circumstances. Mobile scientists can be considered relatively risk-seeking, given that working in a foreign country is associated with unpredictable and sometimes dramatic changes in the work environment. Such changes include the new working conditions and the adaption to socio-cultural aspects. The adaption to a new environment may develop the skill of adjusting quickly to unanticipated situations and scenarios. This skill may indirectly expand entrepreneurial capabilities, since entrepreneurs are often obliged to make decisions while facing new situations. Such capabilities are considered of particular importance for the establishment of new highly innovative firms, which cannot rely on past experience and historical data relating to the business idea. Moreover, Keh, Foo and Lim (2002) suggest that risk perception influences opportunity exploitation. It appears, therefore, justified to consider mobile scientists less 'inhibited' to entrepreneurship than their stay-at-home counterparts.

The decision to move a long distance and to change a cultural, social and work environment also indicates openness towards new surroundings. Mobile scientists may even have the desire to mature and change themselves or even to partly affect

their new environment. This corresponds well with Schumpeter's theoretical remarks (1934), denoting entrepreneurs as pro-active and driven by the desire to create new things (Marcati, Guido and Peluso, 2008; Zhao and Seibert, 2006). Further, studies on scientist mobility suggest that an important incentive for academics and scientists to move is their pursuit of self-realization and individual career progression (Mahroum, 1999, 2000; Avveduto, 2001; Williams et al., 2004). Following this line of reasoning, the decision to move implies that scientists consider new jobs as a challenge and an opportunity, while anticipating the necessity of thrift and hard work in order to succeed (Martin-Rovet, 1995; Martin-Rovet and Carlson, 1995). Thus, mobile scientists can be described as open, opportunity-seeking and willing to accept challenges. These personal characteristics are likely to be conducive to entrepreneurial capabilities and entrepreneurial commitment.

Scientists' ability to recognize opportunities may also increase with mobility, since mobility enhances the scope and breadth of social and human capital. By working in foreign countries scientists expand their social networks and their scientific expertise through working with new peers. Increasing endowment and access to broad and diverse knowledge constitute fertile ground for the entrepreneurial act (Jacobs, 1969; Alvarez and Busenitz, 2001). According to the latter study, entrepreneurial processes rely on access to various sources of information and the ability to (re-)combine dispersed, but complementary information. In this line of reasoning, scientists with experience in different socio-cultural environments may recognize and exploit opportunities others do not see or underestimate. In fact, as Granovetter (1985, 1978) shows, sufficiently close contacts to a large pool of people are important channel to get access to various sources of information and resources.

Similarly, Shane and Venkataraman (2000) and Singh et al. (1999) confirm the importance of social contacts and networks for both the recognition and the successful exploitation of opportunities. Greve and Salaff (2003) suggest that these social interactions are particularly important in the planning period.

Consequently, we hypothesize:

<p><i>H1: Native scientists with intense experience of performing research in different countries are more likely to engage in entrepreneurial activity than native scientists who performed the majority of their research in their home country</i></p>
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Modern science is global and international. Many science institutions and research teams are multicultural combining leading researchers regardless of origin. In his seminal paper on the sociology of science, Merton (1957) offers a foundation of scientific mobility as he identifies ‘universalism’ and ‘communism’ of intellectual property as basic norms of science. The ideology of universalism requires scientists to seek for truth and appreciate progress, no matter of origin. Moreover, scientists are required to exchange their knowledge with other experts as the role of science includes the progressive pursuit of truth. In the last decades, the need for exchange has lead to an increasing movement of scientists across countries. Research teams have become international and heterogeneous. Further, scientists compete globally and publish in international journals.

In the context of internationalization of science, studies on researchers movement report a vision of scientists moving to science powerhouses (Meyer, 2003; Laudel, 2005). Thus, it is possible to identify Germany, the U.S. and the U.K. as ‘hosting countries’ with a large extent of scientific inward movement (Zucker, 2007). Analyzing this pattern of scientific circulation – often referred to as brain drain –

studies reveal that the driving force of mobility is the incentive to work in renowned institutions having the possibility to do good science (Morano-Foadi, 2005; Laudel, 2005). Economic benefits as higher income, higher living standards and higher contractual security cannot be completely opposed as a further plausible explanation, but represent a less important factor than the scientific perspective (Ackers, 2005). By accepting research positions abroad, most foreign scientists seek the opportunity to improve the value of their work (Gaillard and Gaillard, 1997). Therefore, this choice can be seen as a strategic one, increasing the expertise and human capital of foreign scientists. Entrepreneurial activity may represent a logical career trajectory following experience abroad, exploiting the gained knowledge and expertise. This might be especially true when foreign scientists work for science powerhouses.

Moreover, the aforementioned argumentation leading to hypothesis 1 can be adopted for foreign scientists, since mobility also includes the possibility of foreign citizens moving into a country to work for domestic research institutions. Moving to a foreign country reveals a certain tolerance of a new, uncertain work environment which is conducive to entrepreneurial commitment. Especially the movement to a science powerhouse increases the human capital, which is often a driving force of scientific entrepreneurship. We consequently predict the following:

H2: Foreign scientists are more likely to engage in entrepreneurial activity than native scientists

IV. Data Description and Construction of Variables

The data are based on a survey of researchers at the Max Planck Society (MPS). MPS was founded in 1911 as the Kaiser Wilhelm Gesellschaft and renamed in 1948, obtaining its current name. Similar to the German universities, the Max Planck Society is supposed to conduct basic research and therefore almost entirely funded by public money. However, there are noteworthy differences between the Max Planck Society and the German universities, which make these two institutions complements rather than substitutes. While the universities have to do both, teaching and research, the Max Planck Society explicitly focuses only on basic research and strives for scientific excellence in cutting-edge research fields. Accordingly, the research conducted at the Max Planck Institutes is new and innovative, partly multidisciplinary and often requires costly equipment and long-term funding. In order to achieve this goal, the Max Planck researchers are endowed with great freedom in choosing their particular research topic and are free from teaching obligations in universities.

Moreover, the Max Planck Society seeks to ensure both, the systematic circulation and availability of diversified knowledge within the society. Common practice of the Max Planck Society is to stimulate collaborative relationships to various research institutions all over the world and the exchange of researchers, and to organize international research schools. This, in turn, allows to screen and to recruit scientific elite. Such a policy is not restricted to only designated researchers but covers also talented young ones which increases the likelihood that those scientists will later become members of the scientific elite themselves.

The outcome of research conducted Max Planck Society Institutes is respectable. Research excellence of the MPS is documented by 32 Nobel Prizes

awarded to the MPS. According to Times Higher Education, the MPS is ranked first among the non-university institutions in science and third in technology after AT&T and Argonne National Laboratory in 2006¹. Consequently, the Max Planck Society is seen as one of Europe's science powerhouses.

Although oriented towards fundamental and basic research, there is a number of spin-off companies founded by researchers from the max Planck Society. The success of at least some of these companies reveals that basic research can have commercial applications. In order to support the transfer and commercialization of technology the Max Planck Society, has a distinct institution, Max Planck Innovation, the central technology transfer office (TTO) of the society. Accordingly, Max Planck Innovation is inter alia supposed to provides professional services and assistance for technology based spin-off companies from the Max Planck Society. Such services include assessing the commercial potential of the technology, assistance in writing a business plan as well as financial planning and search for potential financiers (venture capital companies, banks and business angels). However, Max Planck Innovation is not supposed to invests capital in the spin-offs. According to the records, since 1990 Max Planck Innovation has assisted 85 spin-offs in high-tech industries such as biotechnology, biochemistry and physical engineering. In 2008, these 85 companies employ circa 2,220 people. Unfortunately, there is not information available about spin-off companies without any technological base which not assisted by Max Planck Innovation.

¹ For the years 2007 and 2008 non-universities rankings were excluded from the statistics provided by Times Higher Education.

Analyzing data from the Max Planck Society has some advantages. The most important advantage is that our analysis does not suffer from unobserved heterogeneity and omitted variable bias, due to institutional differences, which have been found to significantly influence the entrepreneurial activity of scientists (Phan and Siegel 2006; Moray and Clarysse 2005; Powers and McDougall 2005).

Identifying and tracking entrepreneurial scientists: Data generation

Our sample of entrepreneurial and non-entrepreneurial scientists is based on a survey we conducted within the Max Planck Society in Germany between mid-October and mid-December, 2007. In the 2007-2008 period, the MPS consists of 80 independent research institutes comprising more than 9,000 scientists who perform basic research natural sciences, life sciences, and humanities. Before performing the survey, we contacted the executive directors of each institute to ask for permission to interview the scientists. Most of the directors (67 out of 80) permitted us to conduct the interviews and provided us with the necessary contact information to scientists, whenever this was not publicly available online. The directors of 11 institutes refused interviews while the 2 Max Planck Institutes located in foreign countries were excluded due to compatibility reasons. Our population for the survey consisted of 7,808 scientists of 67 Max Planck Institutes.

The survey was conducted by TNS Emnid GmbH, a professional opinion research institute. Trained interviewers from TNS Emnid GmbH contacted every scientist in the population by phone. Participation in the survey was voluntary, so that the available scientists could refuse to participate at all and skip any specific question. Thus, scientists that could not be contacted with three calls and scientists that refuse

an interview are not included in the data. The survey questions were particularly designed to analyze the commercialization activities of scientists. The feasibility and reliability of the survey questions were test and improved during a pilot study (interviews with randomly contacted scientists from various public research institutions in Germany) conducted in August and September, 2007. The final questions on the survey cover past, potential and nascent entrepreneurship, different commercialization channels, individual attitudes toward commercialization activities, as well as questions on research experience, industrial experience, education, demographics, and risk-taking behavior. Hence, we ended up with 2,604 interviews.

In order to track the progress of the entrepreneurial process, a second survey wave was performed in August 2008. During the second wave, we collected information regarding whether the scientists are still in the nascent phase, have abandoned their commercial ideas, or successfully started a new company. The file also contains information about the nature of the newly established business. This enables us to analyze the determinants of entrepreneurship in two distinct stages: nascent phase and actual firm formation. Hence, only those scientists were selected for interviews, who were identified as nascent entrepreneurs in 2007 (83 out of 2,604). Similar to the first wave, the TNS Emnid GmbH tried to contact the selected scientists up to three times, whereat the participation in this follow up survey was also voluntary with the possibility to skip any particular question. From the selected nascent scientists only 61 agreed to be surveyed for a second time, from which only 50 could be contacted. As one nascent entrepreneur refused to answer questions about the current state of his business start up, we are endowed with the second-wave information of 49 scientific entrepreneurs.

Dependent Variables

Nascent entrepreneurship

While measuring the entrepreneurial activities of scientists, the classification of the Global Entrepreneurship Monitor and US-American Panel Study of Entrepreneurial Dynamics was adopted (Reynolds et al., 2004a, b). Accordingly, scientists were classified as nascent entrepreneurs if they were engaged in any activity associated with starting a business. These activities may include applying for public or private financing, seeking for venture capital, writing a business plan, looking for office space or forming the founding team. According to its definition, the dependent variable indicating *nascent entrepreneurship* is binary, indicating whether the scientist is involved in start-up activities (coded as 1) or not (coded as 0).

Start-up

In the second wave, information about the progress of the start-up process was collected. There were three possibilities: “The business is still in the planning steps”, “The planned business has been founded” and “Stopped start-up activities”. This allows analyzing the determinants of both, the transition process from nascent entrepreneurship to actual start-up and well as of stopping any entrepreneurial activities. The state of the entrepreneurial process is captured by the variable *Start-up* taking values of 0, 1 and 2 according to the three options mentioned above.

Variables of main interest

Foreign education is measured by binary variable coded as 1 in case of German scientists that have obtained their Ph.D. degree from universities outside Germany.

Foreign citizenship is measure by binary variable coded as 1 in case of non German scientists. Scientists with multiple citizenship, including the German one, were counted as Germans. The reason for this conservative decision is that we want to assess the pure effect of scientific mobility.

Control variables

Lifetime share of current employment at the MPS:

We further created a variable measuring the ratio of the number of years a scientist has worked since being employed by her or his current Max Planck Institute divided by scientist's age. The higher the value of this variable is, the longer is (relatively) the time spent in one particular environment. Thus, this variable indicates less mobility in the last years, so that we expect a negative relationship with entrepreneurial activities.

Human Capital:

High level of human capital typically indicates distinguished professional skills, scientific excellence and large professional networks that may be conducive for entrepreneurship (Wright et al, 2007). Typically applied measure for human capital is the time, mostly years spent in education. However, in the context of the Max Planck Society, where having university degree is a recruitment requirement, using the time spent in education appears less appropriate. Therefore, we measure human capital as the research position of a scientist. Basically, there are four position types one of which scientists holds: *Ph.D. student*, *postdoctoral researcher*, *group leader* and

director. Accordingly, four binary variables were utilized to indicate the particular research position of a scientist.

Inventive activities:

Inventive activities, in particular patents, are supposed conducive to entrepreneurship (Stuart and Ding, 2006). The reason is that they indicate not only scientific excellence, but also the generation of novel knowledge with some commercial value (Feldman, Link and Siegel, 2002). In order to control for such effects, the binary variable *patent* is included, with 1 if scientist has ever granted a patent or is currently applying for a patent.

Private sector work experience:

Work experience in the private sector prior to their occupation at Max Planck is typically found conducive for subsequent entrepreneurship because it may indicate ties and contacts to the private sector actors such as other business owners, suppliers and customers, and external finance sources (Shane and Stuart, 2002). Furthermore, having worked in the private sector for a while is likely to stimulate both, the alertness to entrepreneurial opportunities as well as the assessment of their commercial potential. To control for such effects, a binary variable is included that indicates whether scientists have prior work experience in the private sector (coded as 1) or not (coded as 0).

Serial entrepreneurship:

Shane and Khurana (2003) report that scientists who have already founded a business are more entrepreneurial in subsequent periods. They conjecture that such scientists already possess an entrepreneurship-related experience that is conducive for

subsequent activities. Moreover, such activity also captures further unobserved factors that might be conducive for starting a business. To control for such effects, a binary variable is included that indicates whether scientists have prior entrepreneurial experience (coded as 1) or not (coded as 0).

Incentives:

There is some evidence that scientists are utility maximizing economic agents, who capitalize on the commercial value of the knowledge that they have accumulated while conducting research. For example, Etzkowitz (2003) suggests that entrepreneurship is a feasible option for scientists to generate personal income out of their research while Owen-Smith and Powell (2003) refer to the possibility to increase reputation. Accordingly, the scientists in our sample were asked to which extent entrepreneurship contributes to income generation and reputation. The importance of these motive were assessed on a 5-point Likert-type scale, from 1 “Strongly disagree” to 5 “Strongly agree”. Additionally, the scientists were asked to estimate the degree to which entrepreneurship is common in their research field on the same 5 point Likert-type scale.

The employment contracts of scientists at the Max Planck Society are typically restricted to 12 years. However, this does not apply for relatively small group of designated researchers - mainly directors and group leaders - which enjoy life time contracts. Hence, we control for the higher entrepreneurial propensity of scientists with *temporary contracts* by including binary variable with 1 temporary contract and 0 lifetime contract.

Risk aversion

Risk aversion is thought to positively influence entrepreneurial commitment and thus, the likelihood for opportunity exploitation (Keh, Foo and Lim 2002). The measure of risk aversion utilized in our study is adopted from the German Social Economic Panel (GSOEP) and relates to the financial risk attitude of the scientists. Respondents hypothetically won in a lottery and were confronted with a financially risky, but yet lucrative investment. They could either invest nothing, 20 percent, 40 percent, 60 percent, 80 percent or the entire lottery winnings of 100 000 Euro. According to the answers given, our risk variable takes six integer values from 0 to 5, while a value of 0 denotes that the scientist would not invest any money and a value of 5 denotes that the scientists would invest the entire winnings.

Gender, age and research discipline:

In order to control for further unobserved individual and institutional characteristics gender, age and research discipline are included. *Gender* is measured by means of a binary variable indicating female researcher, while *age* is measured in terms of years. Possible effects from the particular research field of the scientists are captured by three binary variables according to the three research sections in which the Max Planck Society is divided: the biology and medicine section, the humanities, as well as the chemistry, physics and technology section.

Sample characteristics and empirical approach

From the 7,808 Max Planck researchers potentially available for survey, only 2,604 could be reached with three phone calls and agreed to participate. Guest researchers (59 out of 2,604) were excluded. Hence, the analysis of the likelihood for nascent

entrepreneurship is basically based on 2,545 observations. However, as the scientists were allowed to skip any particular question, deviations from this figure are possible.

The results of the first survey, suggest that in 2007 only 3.3 per cent of the Max Planck scientists (83 out of 2,545) scientists were engaged in activities associated with starting an own business. This result is comparable with results from other countries. Scientists who were identified as nascent entrepreneurs in December 2007 were selected for follow-up interviews in August 2008. From the selected nascent scientists only 60 agreed to be surveyed for a second time, from which only 49 could be contacted. Table 1 presents descriptive statistics of data and variables.

As discussed above among the Max Planck Society, scientific mobility appears common practice. The German scientists that have obtained their Ph.D. degree from universities in other countries account for about 8 % of all Max Planck scientists. However, German scientists with foreign Ph.D. are more typical for the group of nascent entrepreneurs (about 10 %). Interestingly, the distribution of German scientist with foreign Ph.D. seems to be shaped in few countries. Germans with a PhD degree from universities in the UK and in Switzerland each account for about 1.7 per cent. Only about 4.1 per cent obtained their PhD from universities outside Europe, whereat those with PhD degree from universities in the US account for 3.2 percent.

According to the recruitment policy of the Max Planck Society described above, scientists with various origin and educational background are employed at institutes of the Max Planck Society. From all scientists employed at Max Planck institutes about 61 per cent are Germans. Further 23 per cent of the Max Planck scientists come from different European countries. Among these, scientists from other

West European countries and those from East European countries constitute the two largest groups with about 12.2 and 6.7 percent respectively. About 8 per cent of all currently employed scientists come from Asia, with Chinese 3.5 per cent and Indians 2.8 per cent. Scientists from North America account for about 3 per cent, with US American 2.3 per cent. The scientists from Latin America account for 2.5 per cent, while scientists from Africa, Australia and other countries for about 3 per cent.

Insert Table 1 about here

Among the respondents, approximately 18 % have worked in the private sector, on average 0.7 years. Focusing on the group of nascent entrepreneurs, 36 % have private sector work experience of 1.3 years. While 5.5 % of all scientists were business owners or founders in the past, 25 % of the nascent entrepreneurs have entrepreneurial experience in the past. 16 % of all surveyed scientists have ever filed for a patent. Interestingly, 48 % scientists of the identified nascent entrepreneurs have patenting experience.

While Ph.D. students and post doctoral researchers are nearly equally represented in the both groups, the proportion of senior researchers in the group of nascent entrepreneurs is relatively high. Group leaders and directors account for about 13.4 % and 2.5 % in the group of all researchers while for 16 % and 10 % in the group of nascent entrepreneurs.

There are more scientists in the group of nascent entrepreneurs than among all scientists that acknowledge that entrepreneurship may increase reputation. The group

of nascent entrepreneurs is on average less risk averse than the entire population.

Nascent entrepreneurship seems more common in research fields in which the commercialization of research output is common practice and in fields like biology and medicine, and physics, chemistry and engineering.

V. EMPIRICAL RESULTS

Nascent entrepreneurship

Logistic regression models are applied in order to test the two hypotheses that scientists' mobility influences their likelihood to be nascent entrepreneur. Results can be found in table 2, which contains three different regression models. Model I contains the variables regarding mobility, the lifetime share of current employment as well as control variables regarding human capital, inventive activities, private sector and serial entrepreneurship experience, risk, gender and research discipline. Except the variable indicating temporary work contract, incentive variables are further included in model I. The variable indicating a temporary work contract substitutes the variable of lifetime share of the current employment in model II, as these two variables are highly correlated (correlation of .6388). Model III expands model I by including the age variable. This model is used to test whether the variables relating to human capital remain robust, independent of the inclusion of age. All models are computed with robust standard errors, adjusted for institute affiliation. This adjustment accounts for the possibility that start-up activity may be influenced by the institute a scientists works for as e.g. spin-off number varies across institutes.

Insert Table 2 about here

Our results confirm that scientific mobility is conducive to entrepreneurial activity. Foreign scientists are more likely to be nascent entrepreneurs than their domestic-educated, native peers. The difference is highly significant. German scientists having been educated abroad are also significantly more likely to be nascent entrepreneurs than the domestic-educated Germans. Thus, we find support for both our hypotheses. Furthermore, the variable measuring the lifetime share of current employment is negative significant at the one percent-level in model I, while being insignificant in model III. We interpret this finding as an indicator that immobility is less critical but tends to hinder entrepreneurial activity rather than stimulating it. Combined with the mobility indicators, the picture of mobility being conducive to scientific entrepreneurship is confirmed.

We further find a positive effect of human capital on entrepreneurial activity. Scientists holding a group leader or director position are significantly more likely to be nascent entrepreneurs. This finding complements the research stream indicating that star scientists are more likely to be entrepreneurial. Interestingly, Ph.D. students are also significantly more likely to engage in entrepreneurial activity as the control group of post-doctoral researchers. This finding might be influenced by the choice of a German sample, as it is common in Germany to switch career tracks after receiving the doctorate. Moreover, both findings jointly suggest that there are two peaks of entrepreneurial activity, being either at very early or at very late stages of the academic career.

In line with prior research, inventive activity is found to be a significant positive driver of entrepreneurship. The estimated coefficient for work experience in the private sector is insignificant, while prior entrepreneurial activity is highly positive significant. We interpret the latter finding as a confirmation of prior findings that entrepreneurship-relevant experience is conducive for subsequent activities.

Regarding the incentives of scientists, we find the perceptions, that science is respectively common and reputation-increasing within a scientists' research field, as significant positive effects on the likelihood of being a nascent entrepreneur. These findings imply that researchers' sense of the role of science partly determines their commercialization and entrepreneurial orientation. Interestingly, our variable indicating monetary benefits is insignificant denoting that monetary incentives are not important, whereas non-monetary benefits as reputation do have an impact. Temporary work contracts are another positive incentive driving scientific entrepreneurship. This finding highlights that scientists with permanent contracts are less likely to switch careers than their counterparts who are forced to search for a new job when the contract expires.

The estimated gender coefficient is not significant suggesting that across scientist there are no significant gender differences regarding the probability to be nascent entrepreneur. Moreover, neither the risk attitude nor the research discipline has any impact on the probability to be nascent entrepreneur. Our age variable is negative significant only at the ten percent-level, while not influencing other measures greatly. The negative sign of the age distribution and the positive stimuli of being in late career stage reveal the U-shape distribution of scientific entrepreneurship.

Altogether, two main results spring from our empirical analysis. First, mobility is conducive to scientific entrepreneurship. Evidence suggests our hypotheses to be confirmed as foreign citizenship and foreign education both predict the likelihood of being a nascent entrepreneur. Second, our results picture that a certain subpopulation of scientists is commercially active and that entrepreneurship is most likely to occur within this subpopulation. Human capital, commercial experience - as inventions or firm founding - as well as the perceptions that commercializing science is common or reputational are important factors shaping scientific entrepreneurship.

Progress of the start-up

In order to test our theoretical model, we further examine whether mobility influences the progress of the start-up. In our theory we derive why scientific mobility may be conducive to entrepreneurial commitment and opportunity recognition. Given that these factors are important in early stages of entrepreneurship, we extend our study by conducting a second stage analysis. This analysis refers to the progress of the start-up activity, verified approximately nine months after the scientists were identified as nascent entrepreneurs. The main purpose of this analysis is an examination whether mobility of scientists and human capital is also conducive for later stages of the scientific entrepreneurship process.

We again employ logistic regression to estimate the influence of mobility and control variables on the progress of entrepreneurial active. We identify scientists as still entrepreneurially active, when they have either started the business or still actively prepare the venture creation. As we do not have any observations of

entrepreneurial scientists from the humanities section, we dropped this variable from the analysis. Further, regarding human capital, we only include the group of directors and group leaders. Thereby we test whether scientists in very high positions are different from scientists in lower positions. All other independent variables are the same in the model I of the first-stage analysis. Results can be found in Table 3.

Insert Table 3 about here

The econometric results reveal that few variables are significant. There is only a slight positive effect of age and a slight negative effect from perceived reputation of commercializing science. Two explanations seem plausible for explaining our results. First, the time frame of approximately nine months between two stages of entrepreneurship might be too small to reveal significant relationships between variables. Moreover, our analysis is restricted to 41 observations, which represents only a limited population of the entrepreneurial scientists. Second, the theoretical approach predicts that human capital, opportunity recognition and entrepreneurial commitment are of great importance only in early stages of scientific entrepreneurship. In later stages, the development of the business rather depends on the capability to attract investors and to build a start-up team. Our results weakly suggest, that these capabilities are not significantly influenced by any type of human capital.

VI. SUMMARY AND CONCLUSIONS

Our findings imply that citizenship, foreign-education, and mobility are important determinants of academic entrepreneurship. Previous studies have found that

opportunity recognition and entrepreneurial commitment are key determinants explaining why and when scientists engage in the gestation of a new venture. This requires scientists to be able to cope with uncertainty, to think commercially and to actively progress their innovative ideas to market novelties. Based on these theories and referring to prior findings showing that mobile scientists are ‘opportunity seekers’, we match attributes of mobile scientists to attributes of entrepreneurial scientists. Our empirical results support our hypothesis that mobile scientists are more likely to become nascent entrepreneurs. Given that scientists are nascent entrepreneurs, we do not detect any differences between foreign-born, domestic-educated natives and foreign-educated natives. This finding suggests that citizenship and foreign-educated effects on entrepreneurship are only important for early stages of academic entrepreneurship.

We conclude by offering some implications to policy makers and practitioners that emerge from our findings. Our results allow the interpretation that internationalization of science is beneficial to host countries which may benefit from increasing entrepreneurial activity resulting from multinational composition of research teams. Thus, institutional leaders hiring classy researchers from other countries - native or foreign – do not only contribute to knowledge exchange, but also indirectly to scientific entrepreneurial activity. This finding opens a broad research window examining the impact of internationalization of science on academic entrepreneurship.

Our analysis is a first cut at exploring the relationship between mobility and opportunity recognition, as well as entrepreneurial commitment among academic

scientists. We need additional evidence on the antecedents and consequences of these academically-based new ventures. For instance, it would be useful to examine whether startups launched by “foreign” scientists tend to be more successful than comparable entrepreneurial ventures.

Several limitations of our study must be noted. The most obvious one is that our results are based on academic science in a single country and thus, may not generalize to other countries. Another limitation is our inability to disentangle the effect of mobility on opportunity recognition and the effect of mobility on entrepreneurial commitment.

Table 1: Descriptive Statistics

Variable	All scientists					Nascent only				
	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max
Citizenship										
<i>German with foreign Ph.D.</i>	2545	0.079	0.270	0	1	83	0.096	0.297	0	1
<i>German citizenship</i>	2545	0.615	0.487	0	1	83	0.398	0.492	0	1
Research Position										
<i>Ph.D. student</i>	2545	0.447	0.497	0	1	83	0.446	0.500	0	1
<i>Postdoc</i>	2545	0.277	0.447	0	1	83	0.217	0.415	0	1
<i>Group leader</i>	2545	0.134	0.341	0	1	83	0.157	0.366	0	1
<i>Professor</i>	2545	0.010	0.099	0	0	83	0.000	0.000	0	1
<i>Director</i>	2545	0.025	0.155	0	1	83	0.097	0.297	0	1
<i>Other positions</i>	2545	0.123	0.328	0	1	83	0.084	0.280	0	1
Human capital										
<i>Inventive activities</i>	2536	0.157	0.363	0	1	83	0.482	0.503	0	1
<i>Priv_Sec_Exp (years)</i>	2535	0.670	2.077	0	28	83	1.301	2.174	0	8
<i>Serial</i>	2542	0.054	0.227	0	1	83	0.253	0.437	0	1
Work context										
<i>Lifetime share of MPG employment</i>	2527	0.116	0.126	0	0.723	83	0.094	0.129	0	0.717
<i>Temporary contract</i>	2424	0.182	0.386	0	1	82	0.159	0.367	0	1
Commercialization										
Incentives										
<i>Commercialization is monetarily beneficial</i>	2273	3.037	0.966	1	5	81	2.864	1.046	1	5
<i>Commercialization is reputation increasing</i>	2494	2.973	1.062	1	5	82	3.366	1.094	1	5
<i>Risk aversion</i>	2497	1.831	1.457	0	5	79	2.114	1.641	0	5
<i>comm_common</i>	2495	2.535	1.045	1	5	80	3.188	0.969	1	5
Gender, research discipline										
<i>Female</i>	2545	0.323	0.468	0	1	83	0.289	0.456	0	1
<i>Age</i>	2531	35.424	9.551	21	74	83	35.277	10.377	22	67
<i>Biology&Medicine</i>	2025	0.464	0.499	0	1	70	0.486	0.503	0	1
<i>Physics, chemistry and engineering</i>	2025	0.462	0.499	0	1	70	0.486	0.503	0	1
<i>Humanities</i>	2025	0.074	0.262	0	1	70	0.029	0.167	0	1

Table 2: Influence of Mobility on the Likelihood of Being a Nascent Entrepreneur

<i>Independent Variables</i>	<i>Dependent Variable: Nascent Scientific Entrepreneur</i>		
	I	II	III
Circulation in Science			
<i>german citizenship * foreign education</i>	1.218** (0.582)	1.149** (0.582)	1.1200** (0.559)
<i>foreign citizenship</i>	1.011*** (0.293)	1.063*** (0.289)	0.907*** (0.295)
<i>lifetime share of current employment</i>	-3.383* (1.892)	-	-1.62 (2.15)
Incentives and Risk attitude			
<i>risk attitude (5 point rating scale)</i>	0.056 (0.097)	0.074 (0.098)	0.051 (0.098)
<i>commercialization of science is monetarily beneficial (5-point rating scale)</i>	-0.198 (0.134)	-0.173 (0.141)	-0.206 (0.136)
<i>commercialization of science is reputational in research field (5-point rating scale)</i>	0.324** (0.134)	0.284** (0.134)	0.299** (0.134)
<i>commercialization of science is common in research field (5-point rating scale)</i>	0.258** (0.120)	0.258** (0.123)	0.259** (0.120)
Human capital: work experience and age			
<i>prior entrepreneurial experience</i>	1.143*** (0.374)	1.154*** (0.386)	1.161*** (0.382)
<i>work experience in industry (years)</i>	0.018 (0.050)	0.024 (0.053)	0.049 (0.055)
<i>age</i>	-	-	-0.051* (0.286)
Human capital: Research position			
<i>phd student</i>	0.918*** (0.330)	0.984*** (0.330)	0.679** (0.349)
<i>Groupleader</i>	1.012** (0.489)	0.998** (0.472)	1.127** (0.507)
<i>director</i>	1.705*** (0.615)	2.019*** (0.615)	2.185*** (0.697)
Gender, research discipline and inventions			
<i>female</i>	0.022 (0.328)	0.049 (0.330)	-0.008 (0.333)
<i>Biology and Medicine Section</i>	0.189 (0.286)	0.147 (0.286)	0.217 (0.288)
<i>Humanities Section</i>	-0.167 (0.656)	-0.700 (1.019)	-0.636 (1.003)
<i>patenting experience</i>	1.744*** (0.314)	1.681*** (0.320)	1.827*** (0.319)
<i>Temporary work contract</i>	-	-1.041**	-

		(0.511)	
Wald Chi2	130.96	123.72	140.63
Pseudo R2	0.1951	0.1953	0.2014
Number of observations	1976	1900	1976
Regressions for logistic regression, standard errors - adjusted for institutes - are given in parentheses			
*** Significant at 1%-level, ** significant at 5%-level, * significant at 10%-level			

Table 3: Influence of Mobility on Start-up Progress

<i>Independent Variables</i>	<i>Dependent Variable: Start-up Progress</i>	
	<i>Coef.</i>	<i>Robust Std. Err.</i>
<i>german_citizenship * foreign education</i>	-0.5035899	1.329493
<i>foreign citizenship</i>	1.186562	1.128603
<i>lifetime share of current employment</i>	-4.808428	5.83703
<i>commercialization of science is common in research field</i>	-0.3289972	0.4403085
<i>commercialization of science is reputational in research field</i>	-0.792253*	0.4774781
<i>commercialization of science is monetarily beneficial</i>	-0.2275629	0.5366899
<i>risk attitude</i>	-0.2693885	0.2555332
<i>entrepreneurial experience</i>	-1.07618	0.9337575
<i>work experience in industry (years)</i>	0.1649436	0.1755093
<i>gender</i>	0.0897026	0.9634249
<i>age</i>	0.1853475*	0.1095037
<i>research position: director or group leader</i>	-1.43864	1.013403
<i>patenting experience</i>	0.5489296	0.9385674
<i>Biology and Medicine Section</i>	0.745844	1.172731
<i>Wald Chi2</i>	10.59	
<i>Pseudo R2</i>	0.2357	
<i>Number of observations</i>	41	
Regressions for logistic regression, standard errors - adjusted for institutes - given in parentheses		
*** Significant at 1%-level, ** significant at 5%-level, * significant at 10%-level		

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