Peer Effects in Science

Evidence from the Dismissal of Scientists in Nazi Germany

Fabian Waldinger (LSE & CEP)*

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Abstract

This paper analyzes peer effects among university scientists. Specifically it investigates whether the number of peers and their average quality affects the productivity of researchers in physics, chemistry, and mathematics. The usual endogeneity problems related to estimating peer effects are addressed by using the dismissal of researchers by the Nazi government as a source of exogenous variation in the peer group of scientists staying in Germany. Using a newly constructed panel dataset of all physicists, chemists, and mathematicians at all German universities from 1925 until 1938 I investigate (1) *department level* peer effects, (2) peer effects among scientists of the same *specialization* within a department, and (3) peer effects among *co-authors.* There is no evidence for peer effects at the department level or the specialization level. Among co-authors, however, there is strong and significant evidence that peer quality affects a researcher's productivity. Loosing a coauthor of average quality reduces the productivity of a scientist of average quality by 12.5 percent in physics and 16.5 percent in chemistry.

1 Introduction

This paper analyzes peer effects among university scientists. It is widely believed that peer effects are an important element of academic research. Individual researchers, however, may not consider these effects when deciding about their place of employment. This could potentially lead to a misallocation of talent and to underinvestment in academic research. Having a good understanding of peer effects is therefore crucial for researchers and policy makers alike. Despite

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the widespread belief in the presence of peer effects among scientists there is only limited empirical evidence for these effects.

The main reason for this lack of evidence lies in the fact that obtaining causal estimates of peer effects is very challenging. An important problem for any estimation of peer effects is caused by sorting of scientists. Highly productive scientists often work alongside other productive researchers while less productive researchers often work in universities with less productive colleagues. The key question is whether productive scientists are more productive because they are collaborating with successful peers or because their productivity is higher per se. Estimation techniques which do not address the sorting of researchers will thus overestimate the importance of peer effects. Another problem corroborating the estimation of peer effects is the presence of unobservable factors which affect a researcher's productivity but also the productivity of his peers. For scientists these factors could be the construction of a new laboratory which the econometrician may not observe. These unobserved factors would usually lead to an upward bias of peer effects. Estimates of spill-over effects may also be distorted by measurement problems. The main problem is the correct measurement of a researcher's peer group. It is not only difficult to identify the peers of any given scientist but also to ascertain the quality of these peers. These problems will complicate any attempt to obtain unbiased estimates of peer effects. A promising strategy to estimate peer effects is therefore to analyze a scientist's productivity if his peer group changes due to reasons which are unrelated to his own productivity.

This paper proposes the dismissal of scientists by the Nazi government as an exogenous and dramatic change in the peer group of researchers in Germany. Almost immediately after Hitler's National Socialist party secured power in 1933 the Nazi government dismissed all Jewish and so called "politically unreliable" scholars from German universities. Around 13 to 18 percent of all scientists were dismissed between 1933 and 1934 (13.6 percent of physicists, 13.1 of chemists, and 18.3 percent of mathematicians). Many of the dismissed scholars were outstanding members of their profession, among them the famous physicist and Nobel Laureate Albert Einstein, the chemist Georg von Hevesy who would receive the Nobel Prize in 1943, and the Hungarian mathematician Johann von Neumann. Scientists at the affected departments were thus exposed to a dramatic change in their peer group. Researchers in unaffected departments, however, did not loose a single colleague. I use this dramatic change in the peer group of scientists who remain in Germany to identify peer effects among physicists, chemists, and mathematicians.

I focus on these subjects because advancements in these fields are widely believed to be an important source of technological progress. Other reasons for focusing on science are the following. The productivity of scientists can be well approximated by analyzing publications in academic journals. It was part of the scientific culture to publish results in scientific journals already in the 1920s and 1930s, which is the time period studied in this paper. I also concentrate on the sciences because of the attempt of the Nazi regime to ideologize all parts of society after 1933. These policies also affected university research. The impact on different subjects, however, was very different. Subjects such as economics, psychology, history, or sociology were affected much more than the sciences.[1] The last reason for focusing on physics, chemistry, and mathematics is the fact that researchers at the German universities were in many cases the leading figures in those fields in the early 20th century. Examples for this leading role of German science at the time are the Nobel Prize awards to researchers from German universities. Between 1910 and 1940, 27 percent of Nobel laureates in physics and 42 percent of Nobel prize winners in chemistry were affiliated with a German university; this is a much larger fraction than that of any other country at that time. If peer effects are an important determinant of a researcher's productivity they are likely to be especially important in a flourishing research environment such as Germany in the early 20th century.

In order to investigate peer effects, I construct a new dataset of all physicists, chemists, and mathematicians teaching at all 33 universities and technical universities *(Technische Hochschulen)* in Germany at the time. Using data from historical university calendars I obtain a panel dataset of all scientists at these universities covering the years 1925 until 1938. I do not consider the years after 1938 because of the start of World War II in 1939. In order to assess the extent of the dismissal I compile a list of all dismissed physicists, chemists and mathematicians from a number of different data sources. Finally, I obtain data on publications and citations of these researchers in the leading academic journals of the time. More details on the data sources are given in the data section below.

This dataset allows me to investigate spill-over effects among scientists. The collaboration of researchers can take different levels of intensity. A very direct way of peer interaction is the collaboration on joint research projects involving joint publication of results. There are, however, more subtle interactions of colleagues in universities. Peer effects would also be present if researchers discuss ideas and comment on each other's work but do not copublish. Yet another way in which peers may affect a researcher's productivity is through peer pressure. A scientist's work effort may depend on the effort of his peers because he may want to match or surpass their research output. Having more (less) productive peers would thus increase (reduce) a researcher's productivity. The definition of peer effects in this paper encompasses any of these different types. In addition to these different levels in the intensity of peer interactions there are two main dimensions of peer groups which may matter for academic research. The first dimension is the *number* of peers a researcher can interact with. Another important dimension of a scientist's peer group is the *quality* of his colleagues. This paper is the first to separately identify the importance of these two aspects of peer interactions.

This paper is also the first to analyze three different geographic dimensions of spill-over effects, namely at the department level, at the specialization level, and at the level of coauthors. Many researchers believe that peer interactions occur at the level of academic departments. The first part of the analysis therefore investigates spill-over effects at the department level. The dismissal is a very strong and precise predictor of changes in the number and the average

[1] The sciences were not completely unaffected by the Nazi regime. The most famous example is the "German Physics" movement by a small group of physicists which tried to ideologize physical research. The consensus among historians of science, however, is that the movement never mangaged to have a strong impact on the physics community as a whole. See Beyerchen (1977) for details.

quality of peers. I find, however, that neither the number of dismissed colleagues nor the dismissal induced change in average department quality significantly affects the productivity of physicists, chemists or mathematicians. I also estimate a more structural model of peer effects instrumenting the peer group variables with the dismissal. I do not find any significant effects of the number of peers or their average quality at the *department* level.

Using the same methodology I can also analyze peer effects at the level of a researcher's specialization within his department. It is therefore possible to investigate the presence of peer effects among all theoretical physicists in a department for example. The dismissal is a very strong predictor for the number and the quality of peers at the specialization level. Neither the number of dismissed peers in a researcher's specialization nor their average quality have a significant impact on a researcher's productivity over time. When instrumenting a researcher's peer group with the dismissal I do not find evidence for peer effects at the *specialization* level.

In addition to that I investigate an even narrower definition of a researcher's peer group by estimating peer effects among *coauthors* for physics and chemistry. Due to the very low level of coauthorships in mathematics I cannot analyzes spill-over effects for coauthors in mathematics. I find that losing a coauthor of average quality reduces the average researcher's productivity by about 12.5 percent in physics and 16.5 percent in chemistry. Losing coauthors of higher than average quality leads to an even larger productivity loss. Furthermore, I show that the effect is solely driven by recent collaborations. The productivity of scientists who loose a colleague with whom they did not coauthor in the last four years before the dismissal does not fall due to the dismissal. It is not entirely clear whether one would like to call the joint publication of papers a real spill-over effect. I therefore investigate whether authors who loose a coauthor also publish less if one focuses on the publications which were not co-authored with the dismissed coauthor. Finding a drop in these publications after the dismissal would suggest classic spill-over effects between coauthors. I find a negative and significant effect from loosing a high quality coauthor even on the publications which were published without the dismissed coauthor. This is evidence for peer effects among coauthors.

Understanding the effects of the dismissal of a large number of scientists during the Nazi period is interesting in its own right. The findings of this paper may also lead to a better understanding of similar events which occurred in other countries. One example is the purge of thousands of scientists who did not adhere to the communist ideology in the Soviet Union under Stalin. The scope of this paper, however, goes beyond the understanding of historical events, because it allows the identification of peer effects using an exogenous variation in a researcher's peer group. The question remains whether evidence on peer effects in Germany in the 1920s and 1930s can be used to understand peer interactions today. A number of reasons suggest that the findings of this study may be relevant for understanding spill-overs among present-day researchers. The three subjects studied in this paper were already well established at that time; especially in Germany. Scientific research followed practices and conventions which were very similar to current research methods. Researchers were publishing their results in refereed academic journals, conferences were common, and researchers were surprisingly mobile. Unlike today, they could not communicate via E-mail. They did, however, vividly discuss research questions in letters. Given the dramatic fall in communication and transportation costs it is quite likely that localized peer interactions are even less important today than in the 1920s and 1930s. The increased specialization in scientific research makes it harder to find researchers working on similar topics in the same department. This will further contribute to the fact that today's department level and within department specialization level peer effects are less important than in the past.

As described before I do find that peer effects among *coauthors* are important. The reduction in transportation and communication costs would suggest that potential benefits from collaborating with researchers who are located in a different university may be even more important today. The increased importance of teams in the production of scientific research and increased cooperation between researchers from different universities and even countries may be a result of peer effects among coauthors.[2] Thus my results are likely to provide a lower bound for peer effects among coauthors.

This study contributes to a growing literature on peer effects among university researchers. It is, however, one of the first to analyze peer effects among scientists using credibly exogenous variation in peer quality. To my knowledge it is the first study which is able to separate the effects from the number of colleagues and the average quality of those peers. Furthermore, it is the first paper to directly analyze peer effects a three levels of peer interactions: at the level of academic departments, at the level of specializations within those departments, and among coauthors.

Azoulay, Wang and Zivin (2007) investigate peer effects among coauthors in the life sciences. Using the death of a prolific researcher as an exogenous source of variation in a scientist's peer group they find that deaths of coauthors lead to a decline in a researcher's productivity. They find stronger effects for more prolific coauthors. Furthermore, they find that co-location of scientists does not increase the effect of a dead coauthor. Surprisingly, they do not find a stronger decline for recent coauthors compared to coauthors who coauthored with the dead scientist long before he died. As they only observe coauthors but not the universe of peers at the university of a dying researcher they cannot directly investigate department level or specialization level peer effects. A recent study by Weinberg (2007) analyzes peer effects among Nobel Prize winners in physics. He finds evidence for mild peer effects among physics Nobel laureates. Using the timing of starting Nobel Prize winning work he tries to establish causality. It is quite likely, however, that this does not fully address the endogeneity problem which may affect his results on spill-overs. Kim, Morse, and Zingales (2006) estimate peer effects in economics and finance faculties and find positive peer effects for the 1970s, and 1980s, but negative peer effects for the 1990s. They show some evidence that their results are not contaminated by endogeneity problems. The regression specifically analyzing peer effects, however, does not control for

[2] Wuchty, Jones, and Uzzi (2007) show that the number of co-authors in science research increased dramatically since 1955. Furthermore, Adams et al. (2005) show an increase in the geographic dispersion of research teams in the US.

endogenous selection of peers.[3]

The remainder of the paper is organized as follows: the next section gives a brief description of historical details. A particular focus is given to the description of the quantitative and qualitative loss to German science. Section 3 gives a more detailed description of the data sources used in the analysis. Section 4 describes the identification strategy in further detail. The effect of the dismissal on the productivity of department level and specialization level peers remaining in Germany is analyzed in section 5. Using the dismissal as an exogenous source of variation in peer quality I then present instrumental variable results of department level and specialization level peer effects in section 6. Regressions presented in Section 7 probe the robustness of these findings. In section 8 I then present evidence on peer effects between coauthors. Section 9 concludes.

2 The Expulsion of Jewish and 'Politically Unreliable' Scholars from German Universities

Shortly after the National Socialist Party seized power in 1933 the Nazi government implemented the "Law for the Restoration of the Professional Civil Service" on the 7th of April of 1933. Despite this misleading title the law was used to expel all Jewish and "politically unreliable" persons from civil service in Germany. At that time most German university professors were civil servants. Therefore the law was directly applicable to them. Via additional ordinances the law was also applied to university employees who were not civil servants. Thus the law affected all university researchers at the German universities. The main parts of the law read:

> *Paragraph 3:* Civil servants who are not of Aryan descent are to be placed in retirement... (this) does not apply to officials who had already been in the service since the 1st of August, 1914, or who had fought in the World War at the front for the German Reich or for its allies, or whose fathers or sons had been casualties in the World War.
>
> *Paragraph 4:* Civil servants who, based on their previous political activities, cannot guarantee that they have always unreservedly supported the national state, can be dismissed from service.
>
> ["Law for the Restoration of the Professional Civil Service", quoted after Hentschel (1996)]

[3] Another related strand of the literature focuses on regional spill-over effects of patent citations. Jaffe, Trajtenberg, and Henderson (1993) use an ingenious method to control for pre-existing regional concentration of patent citations. They find that citations of patents are more geographically clustered than one would expect if there were no regional spill-over effects. Thompson and Fox-Keane (2005) challenge those findings in a later paper.

In an implementation decree it was further specified that all members of the Communist Party were to be expelled. The decree also specified "Aryan decent" in further detail as: "Anyone descended from Non-Aryan, and in particular Jewish, parents or grandparents, is considered non-Aryan. It is sufficient that one parent or one grandparent be non-Aryan." The law was immediately implemented and resulted in a wave of dismissals and early retirement from the German universities. A careful early study by Harthorne published in 1937 counts 1111 researchers from German universities and technical universities[4] who were dismissed between 1933 and 1934. This amounts to about 15 percent of the 7266 university researchers present at the beginning of 1933. Most dismissals occurred in 1933 immediately after the law was implemented. Not everybody was dismissed as soon as 1933 because the law allowed Jewish scholars to remain in office if they had been in office since 1914 or if they had fought in the First World War or had lost a father or son in the War. Nonetheless, many of the scholars who could stay according to this exception decided to leave voluntarily; for example the Nobel laureates James Franck and Fritz Haber. They were just anticipating a later dismissal as the Reich citizenship laws (*Reichsbürgergesetz*) of 1935 revoked the exception clause.

Table 1 reports the number of dismissals in the three subjects studied in this paper: physics, chemistry, and mathematics. Similarly to Harthorne, I focus my analysis on researchers who had the Right to Teach (*venia legendi*) at a German university. According to my calculation about 13.6 percent of the physicists who were present at the beginning of 1933 were dismissed between 1933 and 1934.[5] In chemistry the loss between 1933 and 1934 was about 13.1 percent and thus slightly lower than in physics.[6] Mathematics experienced the biggest loss of the three subjects with about 18.3 percent dismissals between 1933 and 1934.[7] It is interesting to note, that the percentage of dismissals in these three subjects and at the German universities overall was much higher than the fraction of Jews living in Germany. It is estimated that about 0.7 percent of the total population in Germany was Jewish at the beginning of 1933.

My data does not allow me to identify whether the researchers were dismissed because they were Jewish or because of their political orientation. Other researchers, however, have investigated this issue. Deichmann (2001) studies chemists in German and Austrian universities (after the German annexation of Austria in 1938 the Nazi government extended the aforementioned laws to researchers at Austrian universities). She finds that about 87 percent of the dismissed chemists were Jewish or of Jewish decent. The remaining 13 percent were dismissed for political reasons. Siegmund-Schultze (1998) estimates that about 79 percent of the dismissed scholars in mathematics were Jewish. This suggests that the vast majority of the dismissed were either Jewish or of Jewish decent.

[4] The German university system had a number of different university types. The main ones were the traditional universities and the technical universities. The traditional universities usually covered the full spectrum of subjects. The technical universities focused on technical subjects.

[5] This number is consistent with the number obtained by Fischer (1991) who reports that 15.5 percent of physicists were dismissed between 1933 and 1940.

[6] Deichmann (2001) calculates a loss of about 24 percent from 1933 to 1939. The difference between the two figures can be explained by the fact that she includes all dismissals from 1933 to 1939. Furthermore my sample includes 5 more universities which all have below average dismissals.

[7] Unfortunately there are no comparable numbers for mathematics by other researchers.

Before giving further details on the distribution of dismissals across the different universities I am going to provide a brief overview over the fate of the dismissed researchers. Immediately after the first wave of dismissals in 1933 foreign émigré aid organizations were founded to assist the dismissed scholars with obtaining positions in foreign universities. The first organization to be founded was the English "Academic Assistance Council" (later renamed into "Society for the Protection of Science and Learning"). It was established as early as April 1933 by the director of the London School of Economics, Sir William Beveridge. In the US the "Emergency Committee in Aid of Displaced Scholars" was founded in 1933. Another important aid organization, founded in 1935 by some of the dismissed scholars themselves, was the Emergency Alliance of German Scholars Abroad ("Notgemeinschaft Deutscher Wissenschaftler im Ausland"). The main purpose of these and other, albeit smaller, organizations were to assist the dismissed scholars in finding positions abroad. In addition to that prominent individuals like Eugen Wigner, Albert Einstein or Hermann Weyl tried to use their extensive network of personal contacts to find employment for less well-known scientists. Due to the very high international reputation of German physicists, chemists, and mathematicians many of them could find positions without the help of the aid organizations. Less renowned and older scientists had more problems in finding adequate positions abroad. Initially many dismissed scholars fled to European countries. Many of these countries were only temporary refuges because the dismissed researchers often obtained temporary positions, only. The expanding territory of Nazi Germany in the early stages of World War II led to a second wave of emigration from the countries which were invaded by the German army. The main destinations of dismissed physicists, chemists, and mathematicians were the United States, England, Turkey, and Palestine. The biggest proportion of dismissed scholars in all three subject eventually moved to the United States. For the purposes of this paper it is important to note that the vast majority of the emigrations took place immediately after the researchers were dismissed from their university positions. Further collaborations with researchers staying in Germany were thus extremely difficult and did hardly occur. A minority of the dismissed, however, did not leave Germany and most of them died in concentration camps or committed suicide. Very few, managed to stay in Germany and survive the Nazi regime. Even these scientists who stayed in Germany were no longer allowed to use university laboratories and other resources. The possibility of ongoing collaboration of the dismissed scientists with researchers staying at the German universities was thus extremely limited.

The aggregate numbers of dismissals hides the fact that the German universities were affected very differently by the dismissals. Even within a university there was a lot of variation across different departments. Whereas some departments did not experience any dismissals others lost more than 50 percent of their personnel. The vast majority of dismissals occurred in 1933 and 1934. Only a limited number of scientists was dismissed after these years. All dismissals occurring after 1933 affected researchers who had been exempted under the clause for war veterans or for having obtained their position before 1914. In order to have a sharp dismissal measure I thus focus on the dismissals in 1933 and 1934. Table 2 reports the number of dismissals in the different universities and departments. An example for the huge variation in dismissals is the university of Göttingen, one of the leading universities at the time. It lost 40 percent of its researchers in physics and more than 60 percent in mathematics. The reduction of peer quality in physics and mathematics was even higher than the fraction of dismissed scholars. In chemistry, however, no a single scholar was dismissed in Göttingen. Table 2 also demonstrates that the dismissal did not always have a negative impact on average peer quality. Negative signs in the "Fall in Peer Quality" variable indicate an improvement in the average quality of the stayers' peers. An improvement in average peer quality could occur if below department average researchers were dismissed.

Table 3 gives a more detailed picture of the quantitative and qualitative loss in the three subjects. In physics about 13 percent of all researchers were dismissed between 1933 and 1934. The proportion of chaired professors among the dismissals was, however, slightly lower at about 11 percent. The dismissed were on average about 5 years younger than the stayers. It is remarkable that the proportion of Nobel laureates (who either already had received the Nobel Prize or were to receive it in later years) among the dismissed was far higher than one would expect given the total number of dismissals. The fact that the dismissed made above average scientific contributions is also exemplified by the fact that the proportion of publications in the leading journals was about 20 percent which is higher than the 13 percent which would correspond to their head count.[8] When considering a publication's quality by weighting the publications with subsequent citations of a paper, the high productivity of the dismissed becomes even more apparent. The dismissed physicists published about 39 percent of citation weighted publications. The fact that the dismissed physicists were of above average quality has already been noticed by Fischer (1991).

About 33 percent of the publications in the top journals were co-written papers. About 11 percent (for the dismissed 14 percent) of all papers were written with a coauthor who was teaching at a university in Germany. There are two main reasons for the fact that only one third of the coauthors were teaching at a German university. Presumably, a large fraction of coauthors of the physicists in my dataset are their assistants or Ph.D. students. Furthermore, coauthors could teach at a foreign university or be employed by a research institute. The last line of Table 3 shows the low level of cooperation within a department; only about 4 percent (9 percent of the dismissed) of all publications were coauthored with a member of staff from the same university.

The dismissed chemists are more similar to the average in their field as can be seen from the second panel of Table 3. The proportion of full professors among the dismissed almost corresponded to their proportion among all chemists. Also their average age was very close to the population average in chemistry. The proportions of Nobel Prize winners, publications and citation weighted publications was higher than one would expect from their proportion in the overall population. These differences, however, were smaller than in physics. The percentage of co-written papers was much higher in chemistry compared to physics. About 76 percent of

[8]For a more detailed description of the publications data see the Data Section.

published papers were published by more than one author. Interestingly only about 12 percent of the top publications in chemistry were published with coauthors who had the Right to Teach at a German university. Only about 5 percent of all published papers were copublished with a coauthor who was a member of staff in the same department. This is low given the overall high level of coauthorship in chemistry.

In mathematics the differences between the dismissed scholars and the stayers are even more pronounced than in physics. The dismissed scholars were less likely to be full professors but they were also on average about 7 years younger than the stayers. The dismissed not only published more than their counterparts who remained at the German universities but their publications seem to be of much higher scientific importance. This is exemplified by the fact that their publications were cited far more often than their proportion in the general population would suggest. Only about 11 percent (15 percent for the dismissed) of the publications in mathematics were coauthored. An even smaller fraction of the papers were coauthored with researchers who had the right to teach at the German universities. Coauthorships with mathematicians from the same department only accounted for 3 percent of all published papers (4 percents for the dismissed). This suggests an even lower level of inter-departmental cooperation in mathematics compared to the other two subjects.

Despite a relatively similar quantitative loss in all three subjects the qualitative loss in chemistry was lower than in physics. The qualitative loss in mathematics was even higher than in physics. Before investigating the effect of the dismissal on the productivity of researchers who stayed in Germany I first describe my data sources in the next section.

3 Data

3.1 Data on Dismissed Scholars

The data on the dismissed scholars is obtained from a number of different sources. The main source is the "List of Displaced German Scholars". This list was compiled by the relief organization "Emergency Alliance of German Scholars Abroad". With the aid of the Rockefeller Foundation it was published in 1936. The purpose of publishing this list was to secure positions for the dismissed researchers in countries outside Nazi Germany. Overall, the list contained about 1650 names of researchers from all university subjects. The list gives a very complete picture of the dismissal of scholars by the Nazi government. I extracted all dismissed physicists, chemists, and mathematicians from the list. In the appendix I show a sample page from the physics section of that list. Interestingly, there are four physicists on that page who had already received the Nobel Prize or were to receive it in later years. Out of various reasons a small number of dismissed scholars did not appear in that list. To get a more comprehensive picture of all dismissals I complement the information in the "List of Displaced German Scholars" with information from other sources.

The main additional source is the "Biographisches Handbuch der deutschsprachigen Emigration nach 1933 - Vol. II : The arts, sciences, and literature". The compilation of the handbook was initiated by the "Institut für Zeitgeschichte München" and the "Research Foundation for Jewish Immigration New York". Published in 1983 it contained short biographies of artists and university researchers who emigrated from Nazi Germany. Kröner (1983) extracted a list of all dismissed university researchers from the handbook. I use Kröner's list to append my list of all dismissed scholars.

In addition to these two main data sources I rely on data compiled by historians who studied individual academic subjects during the Nazi era. Beyerchen (1977) included a list of dismissed physicists in his book about the physics community in Nazi Germany. I use the information included in that list to amend my list of dismissed scholars. Furthermore, I use data which is contained in an extensive list of dismissed chemists which was compiled by Deichmann (2001). In a similar fashion I complement my list with the information listed in Siegmund-Schultze's (1998) book on dismissed mathematicians.

It is important to note that my list of dismissals also contains the few researchers who were initially exempted from being dismissed but resigned voluntarily. The vast majority of them would have been dismissed due to the racial laws of 1935 anyway and were thus only anticipating their dismissal. All of these voluntary resignations were directly caused by the discriminatory policies of the Nazi regime.

3.2 Data on all Scientists at German Universities between 1925 and 1938

To investigate the impact of the dismissals on the researchers who stayed at the German universities I construct a full list of all scientists at the German universities from 1925 to 1938. Using the semi-official University Calendar[9] I compile an annual roster of *all* physicists, chemists, and mathematicians at the German universities from the winter semester 1924/1925 (lasting from November 1924 until April 1925) until the winter semester 1937/1938. The data for the technical universities starts in 1927/1928, because the University Calendar included the technical universities only after that date. The University Calendar is a compilation of all individual university calenders listing the lectures held by each scholar in a given department. If a researcher was not lecturing in a given semester he was still listed under the heading "not lecturing". From this list of lectures I infer the subject of each researcher to construct the yearly faculty lists of all physics, chemistry, and mathematics departments. This allows me to

[9]The University Calender was published by J.A. Barth. He collected the official university calenders from all German universities and compiled them into one volume. Originally named "Deutscher Universitätkalender". It was renamed into "Kalender der deutschen Universitäten und technischen Hochschulen" in 1927/1928. From 1929/1930 it was renamed into "Kalender der Deutschen Universitäten und Hochschulen". In 1933 it was again renamed into "Kalender der reichsdeutschen Universitäten und Hochschulen".

track yearly changes of all researchers of individual departments between 1925 and 1938.[10,11]

To assess a researcher's specialization I consult seven volumes of "Kürschners deutscher Gelehrten-Kalender". These books are listings of German researchers compiled in irregular intervals since 1925.[12] The editors of the book obtained their data by sending out questionnaires to the researchers asking them to provide information on their scientific career. I use the information in all volumes published until 1950 to ascertain a scientist's specialization. Because of the blurred boundaries of the specializations in mathematics many mathematicians did not provide their specialization. In those cases I infer their specialization from the main publications they list in the "Gelehrtenkalender". As the participation of the researchers in the complication was voluntary not all of them provided their personal information to the editor. If I cannot find a scientist's specialization in any of the volumes of the "Gelehrtenkalender", which occurs for about 10 percent of the scientists, I conduct an internet-search for the scientist to obtain his specialization. Overall I obtain the scientist's specialization for about 98 percent of all researchers.[13] Table A1 in the appendix gives an overview of all specializations and the fraction of scientists in each of them.

3.3 Publication Data

To measure a researcher's productivity I construct a dataset containing the publications of each researcher in the top academic journals of the time. At that time most German researchers published in German journals. The quality of these German journals was usually very high because many of the German physicists, chemists, and mathematicians were among the leaders in their field. This is especially true for the time before the dismissal as is exemplified by the following quote; "Before the advent of the Nazis the German physics journals (*Zeitschrift für Physik, Annalen der Physik, Physikalische Zeitschrift*) had always served as the central organs of world science in this domain... In 1930 approximately 700 scientific papers were printed

[10] At that time a researcher could hold a number of different university positions. Ordinary Professors held a chair for a certain subfield and were all civil servants. Furthermore there were different types of Extraordinary Professors. First, they could be either civil servants (*beamteter Extraordinarus*) or not have the status of a civil servant *(nichtbeamteter Extraordinarius)*. Universities also distinguished between extraordinary extraordinary professors *(ausserplanmäßiger Extraordinarus)* and planned extraordinary professors *(planmäßiger Extraordinarius)*. Then as the lowest level of university teachers there were the *Privatdozenten* who were never civil servants. Privatdozent is the first university position a researcher could obtain after the 'venia legendi'.

[11] The dismissed researchers who were not civil servants (Privatdozenten and some Extraordinary Professors) all disappear from the University Calendar between the winter semester 1932/1933 to the winter semester 1933/1934. Some of the dismissed researchers who were civil servants (Ordinary Professors and some Extraordinary Professors), however, were still listed even after they were dismissed. The original law forced Jewish civil servants into early retirement. As they were still on the states' payroll some universities still listed them in the University Calendar even though they were not allowed to teach or do research anymore. My list of dismissals includes the exact year after which somebody was barred from teaching and researching at a German university. I thus use the dismissal data to determine the actual dismissal date and not the date a dismissed scholar disappears from the University Calendars.

[12] The first volume was compiled in 1925. The other volumes I have used were published for the years 1926, 1928/29, 1931, 1935, 1940/41, and 1950.

[13] Some researchers cite more than one specialization. Therefore, physicists and chemists have up to two specializations and mathematicians up to four.

in its (the Zeitschrift für Physik´s) seven volumes of which 280 were by foreign scientists." (American Association for the Advancement of Science (1941)). Simonsohn (2007) shows that neither the volume nor the content of the "Zeitschrift für Physik" changed dramatically in the post dismissal years until 1938. Not surprisingly, however, he finds that the dismissed physicists published less and less in the German journals after the dismissal. It is important to note that the identification strategy outlined below relies on changes in publications of researchers in different German departments which were differently affected by the dismissal. A decline in the quality of the considered journals would therefore not affect my results as all regressions are estimated including year fixed effects.

The list of top publications is based on all German general science, physics, chemistry, and mathematics journals which are included in the "ISI Web of Science" for the time period 1915 to 1940. Furthermore I add the leading general journals which were not published in Germany, namely Nature, Science, and the Proceedings of the Royal Society of London to the dataset. I also add four non-German top specialized journals which were suggested by historians of science as journals of some importance for the German scientific community.[14] The "Web of Science" is an electronic database provided by Thomson Scientific containing all contributions in a very large number of science journals. In 2004 the database was extended to include publications between 1900 and 1945. The journals included in that extension were all journals which had published the most relevant articles in the years 1900 to 1945.[15] This process insures that all publications which can be obtained for the early time period 1900 to 1945 were published in the most important journals.

Table 4 lists all journals used in my analysis. For each of these journals I obtain all articles published between 1925 and 1940 from the "ISI Web of Science". A very small number of the contributions in the top journals were letters to the editor or comments. I restrict my analysis to contributions classified as "articles" as they provide a cleaner measure for a researcher's productivity. The database includes the names of the authors of each article and statistics on the number of subsequent citations of each of these articles. For each researcher I then calculate two yearly productivity measures. The first measure is equal to the sum of publications in top journals in a given year. In order to quantify an article's quality I construct a second measure which accounts for the number of times the article was cited in *any* journal included in the Web of Science in the first 50 years after its publication. This includes citations in journals which are not in my list of journals but which appear in the Web of Science. This therefore includes citations from the international scientific community and is not as heavily based on Germany as the publications measure. This measure, which I call citation weighted publications, is defined

[14]The relevant journals for chemists were suggested by Ute Deichmann and John Andraos who both work on chemistry in the early 20th century. Additional journals for mathematics were suggested by Reinhard Siegmund-Schultze and David Wilkins; both are specialists in the history of mathematics.

[15]For that extension Thomson Scientific judged the importance of a journal by the later citatons (cited between 1945 and 2004) in the Web of Science of articles published between 1900 and 1945. This measure insures that the most relevant journals for the time period 1900 to 1945 were included in the extention. For more details on the process see www.thomsonscientific.com/media/presentrep/facts/centuryofscience.pdf.

as the sum of citations (in the first 50 years after publication) of all articles published in a certain year. The following simple example illustrates the construction of the citation weighted publications measure. Suppose a researcher published two top journal articles in 1932. One is cited 5 times in any journal covered by the Web of Science in the 50 years after its publication. The other article is cited 7 times in 50 years. Therefore the researcher's citation weighed publications measure for 1932 is 5+7=12.

Table A2 lists the top researchers for each subject according to the citation weighted publications measure. The researchers in this table are the 20 researchers with the highest yearly averages of citation weighted publications for publications between 1925 and 1932. It is reassuring to realize that the vast majority of these top 20 researchers are well known in the scientific community. Economists will find it interesting that Johann von Neumann is the most cited mathematician. The large number of Nobel laureates among the top 20 researchers indicates that citation weighted publications are a good measure of a scholar's productivity. Nevertheless, the measure is not perfect. As the "Web of Science" only reports lastnames and the initial of the first name for each author there are some cases where I cannot unambiguously match researchers and publications. In these cases I assign the publication to the researcher whose field is most closely related to the field of the journal in which the article was published. In cases where this assignment rule is still ambiguous between two researchers I assign each researcher half of the publications (and half of the citations). Another problem is the relatively large number of misspellings of authors' names. All articles published between 1925 and 1940 were of course published on paper. In order to include these articles into the electronic database Thomson Scientific employees scanned all articles published in the historically most relevant journals. The scanning was error prone and thus lead to misspellings of some names. As far as I discovered these misspellings I manually corrected them. It is possible, however, that there are still misspellings which I could not detect. Therefore, there may still be articles which are not or wrongly assigned to the relevant author.

I merged the publications data to the roster of all German physicists, chemists, and mathematicians. From the list of dismissed scholars I can identify the researchers who were dismissed and those who stayed at the German universities. The end result is a panel dataset of all physicists, chemists, and mathematicians at all German universities from 1925 until 1938 with detailed information on their publications in the top academic journals and their dismissal status.

4 Identification

The main purpose of this paper is to estimate peer effects among scientists. The standard approach when estimating peer effects consists of regressing an individual's productivity on the average productivity of his peers. The productivity of academic researchers, however, is not only affected by the average quality of their peers but also by the number of peers they can interact with. Having smart colleagues may be useful in many ways: coauthored work may be of higher quality and comments from prolific peers may be useful for their own work. Furthermore, peers may attract more research funding to the department, or have better contacts to researchers outside the department. Having more colleagues in your department may be important because all these interactions are more likely to occur if there are more peers to interact with, especially because it may be easier to find colleagues who are working on similar research questions. Researchers in larger departments may also benefit from a lower teaching load and from teaching more specialized courses which are more related to their current research.

As university departments differ substantially in the average quality of its researchers and also in size it is important to distinguish these two dimensions of peer effects for academic research. In order to estimate peer effects among scientists I therefore propose the following regression:

$$
\begin{aligned}
(1) \qquad \# \text{ Publications}_{iut} = \beta_1 + \beta_2(\# \text{ of Peers})_{ut} + \beta_3(\text{Avg. Peer Quality})_{ut} \\
+ \beta_4\text{Age Dummies}_{iut} + \beta_5\text{YearFE}_t + \beta_6\text{UniversityFE}_u + \beta_7\text{IndividualFE}_i + \varepsilon_{iut}
\end{aligned}
$$

I regress the number of publications of researcher i in university u and year t on measures of the peer group and other controls. In order to control for the quality of a published article I also use a second measure for a researcher's productivity, namely citation weighted publications. As the subjects in consideration are quite different I estimate these regressions separately for physics, chemistry, and mathematics. The measures for peer quality are a researcher's peers and the average quality of these peers. Average peer quality is calculated as the mean of the average productivity (between 1925 and 1932)[16] of a researcher's peers.[17] Over time changes in the average peer quality measure will therefore occur only if the composition of the department changes. The yearly fluctuations in publications of the same set of peers will not affect the peer group measure. The underlying assumption of this measure is therefore that Albert Einstein always has the same effect on his peers independent of how much he publishes in a given year.

It is quite likely that the effect of peers is only measurable after a certain time lag. Peers influence the creation of new ideas and papers before the actual date of publication. Another delay is caused by the publication lag (the time it takes for a paper to appear in a journal after the paper was submitted by the author). Science research, however, is published faster than research in other subjects like economics. Anecdotal evidence suggests that the effect of peers should thus be measured with a lag of about one year. An illustrative example of the timing of peer interactions in science research at the relevant time is the postulation of the "uncertainty principle" by Heisenberg in 1927. In 1926 Heisenberg was working with Niels Bohr in Copenhagen. It is reported that during that time Heisenberg and Bohr spent days

[16] I use the pre-dismissal period to measure the average quality of peers as this measure will not be affected by the dismissal. Using a measure which considers the average productivity of each researchers from 1925 to 1938 does not have a substantial impact on my findings.

[17] Say a department has 3 researchers in 1930. One published on average 10 (citation weighted) publications between 1925 and 1932. The other two have 20 and 15 citation weighted publications respectively. Then the average peer quality variable for researcher 1 in 1930 will be (20+15)/2 = 17.5. Average peer quality for researcher 2 will be (10+15)/2 = 12.5 and so on.

and nights discussing the concepts of quantum mechanics in order to refine them. In early 1927 Niels Bohr went on a holiday and it was during that time that Heisenberg discovered and formulated his famous "uncertainty principle". He published this discovery in the "Zeitschrift für Physik" in 1927.[18] Therefore I use a lag of one year for the peer group variables when estimating equation (1).

As further controls I include a full set of 5-year age group dummies to control for life-cycle changes in productivity when estimating equation (1).[19] Furthermore, I control for yearly fluctuations in publications which affect all researchers by including year fixed effects. To control for individual differences in a researcher's talent I also add individual fixed effects to all specifications. Furthermore, I add university fixed effects to control for university specific factors affecting a researcher's productivity. These can be separately identified because some scientists change universities. I show below that the results are hardly affected by including university fixed effects in addition to individual fixed effects.

A number of issues occur when using OLS to estimate equation (1). One problem is caused by the fact that a researcher's productivity is affected by his peers but at the same time the researcher affects the productivity of his peers. Manski (1993) refers to this problem as the reflection problem. It is therefore important to keep in mind that the estimated effects will be total effects after all productivity adjustments have taken place.

Other problems, however, are potentially more severe in this context. An important problem is caused by selection effects. These occur not only because of self selection of researchers into departments with peers of similar quality but also because departments appoint professors of similar quality. Furthermore, larger departments tend to hire researchers with above average qualities. The inclusion of university fixed effects would in principle address this problem. Differential time trends of different departments, however, would make selection issues an important problem even in models which include university fixed effects. These selection effects introduce a correlation of the peer group measures with the error term and will thus bias the estimates of β_2 and β_3.

Another problem may be caused by omitted variables. Omitted factors may not only affect a researcher's productivity but also the size of the department or the average productivity of his peers. This would again bias OLS estimates of β_2 and β_3.

Furthermore, measurement error could bias the estimates of regression (1). An important measurement problem is the correct peer group of a researcher. In addition to that are average number of publications (citation weighted) of peers are by no means a perfect measure for the quality of a researcher's peer group. Even if the number of publications were a perfect measure of peer quality the variable would still suffer from measurement error due to misspelling of names in the publications data. Omitted variables and measurement error will thus introduce further biases of β_2 and β_3.

An instrumental variables strategy can deal with the selection issues, the omitted variables

[18] For a detailed historic description of the discovery of the uncertainty principle see Lindley (2007).

[19] Levin and Stephan (1991) show that age is an important determinant of scientists' productivity.

bias, and the measurement error problem. I therefore propose the dismissal of scholars by the Nazi government as an instrument for the scientists' peer group. Figure 1 shows the effect of the dismissal on the peer group of physicists.

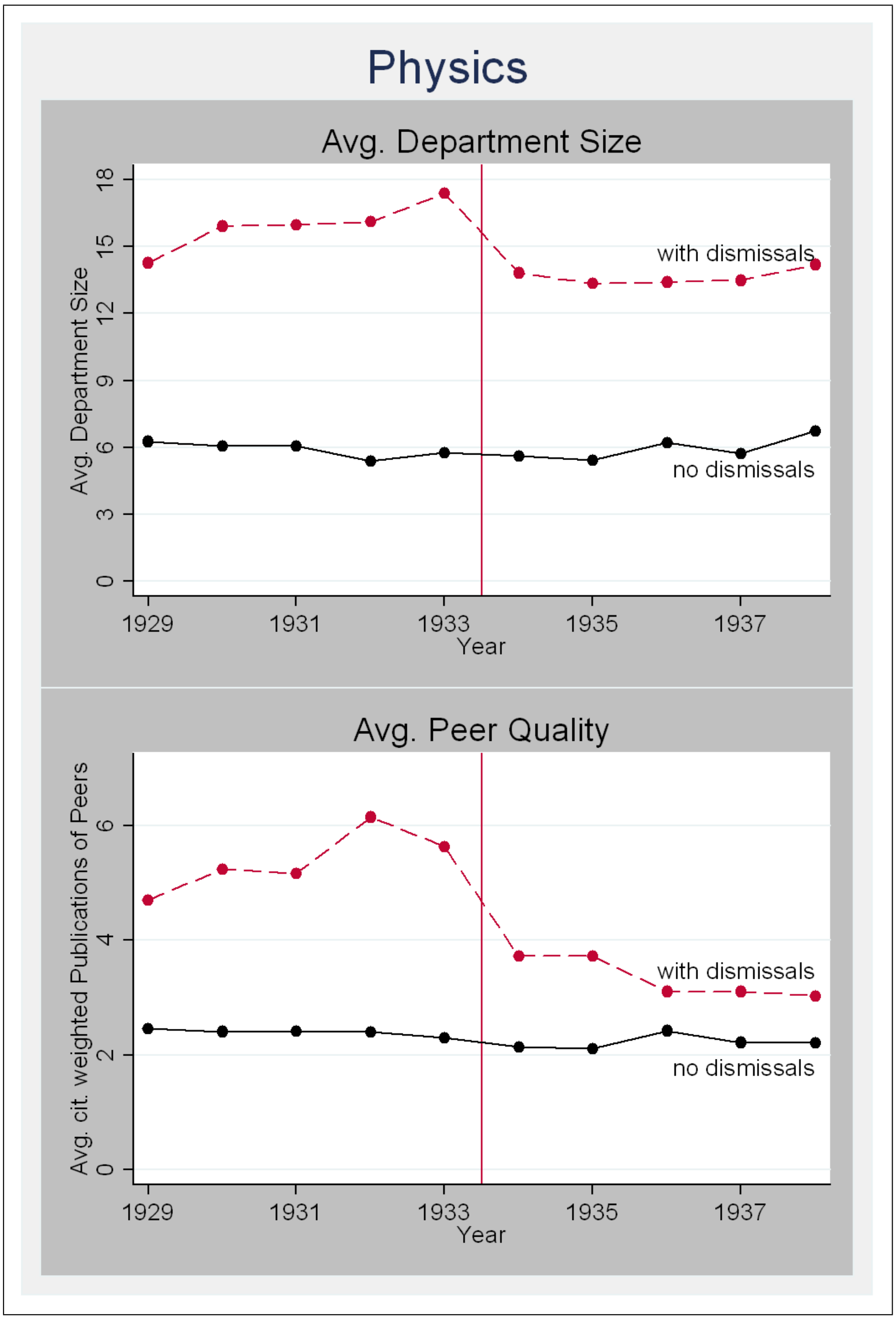

Figure 1: First Stages Physics

The top panel shows the average department size for two groups of physicists: physicists in departments with dismissals in 1933 or 1934 and physicists in departments without dismissals. It becomes clear from Figure 1 that the affected departments were of above average size. The size of departments without dismissals did hardly change over this time period. In the affected departments, however, the dismissal led to a strong reduction in the number of physicists. The top panel of Figure 1 also shows that the dismissals affected the German university system for years after the actual dismissal. This is because the affected departments could not immediately fill their vacancies due to the lack of suitable researchers without a position and the slow appointment procedures. Successors for dismissed chaired professors, for example, could only be appointed if the dismissed scholars gave up all their pension rights because the dismissed professors were originally placed into early retirement. The states did not want to pay the salary for the replacement and the pension for the dismissed professor at the same time. As some of the dismissed hoped to recuperate their chair after what they hoped would be a short Nazi interlude many of them did not immediately cede they pension rights. It thus took years to fill open positions in most cases. Highlighting this problem Max Wien, a physicist in Jena, wrote a letter to Bernhard Rust, the Minister of Education in late November 1934. Describing the situation for chaired professorships at the German universities he stated in this letter that "out of the 100 existing [chaired professor] teaching positions, 17 are not filled at present, while under natural retirements maybe two or three would be vacant. This state of affairs gives cause for the gravest concern..." (cited after Hentschel 1996).

The second panel of Figure 1 shows the evolution of average peer quality in the two types of departments. Obviously one would expect a change in the average quality of peers only if the quality of the dismissed was either above or below the pre-dismissal department average. The bottom panel of Figure 1 demonstrates two interesting points: the dismissals occurred at departments of above average quality and within those departments the dismissed were on average more productive than the physicists who were not dismissed. As a result the average quality of peers in affected departments fell after 1933 while it remained very stable for researchers in unaffected departments. This graphs only shows averages of the two groups of departments. As can be seen from Table 3 some departments with dismissals also lost below average peers. For those departments the average quality increased due to the dismissal. Overall, however, the dismissal reduced average department quality in physics.

Figure 2 explores the effect of the dismissal on the peer group of chemists. The top panel of Figure 2 plots the department size for chemists in affected and unaffected universities. Like in physics most of the dismissals occurred in larger departments and had a strong effect on the department size of these departments. The bottom panel of Figure 2 explores the effect of the dismissal on the average quality of peers. The affected departments were also of above average quality but the difference was less pronounced than in physics. As suggested by the summary statistics presented before the dismissal had a smaller overall effect on the average quality of the affected chemistry departments. Despite the fact that the dismissal did not have a large effect on peer quality for the *average* across all departments it did indeed have strong effects on peer quality as can be seen from Table 3. The effects in departments with reductions in peer quality and in departments with improvements in peer quality, however, almost cancel out in the aggregate.

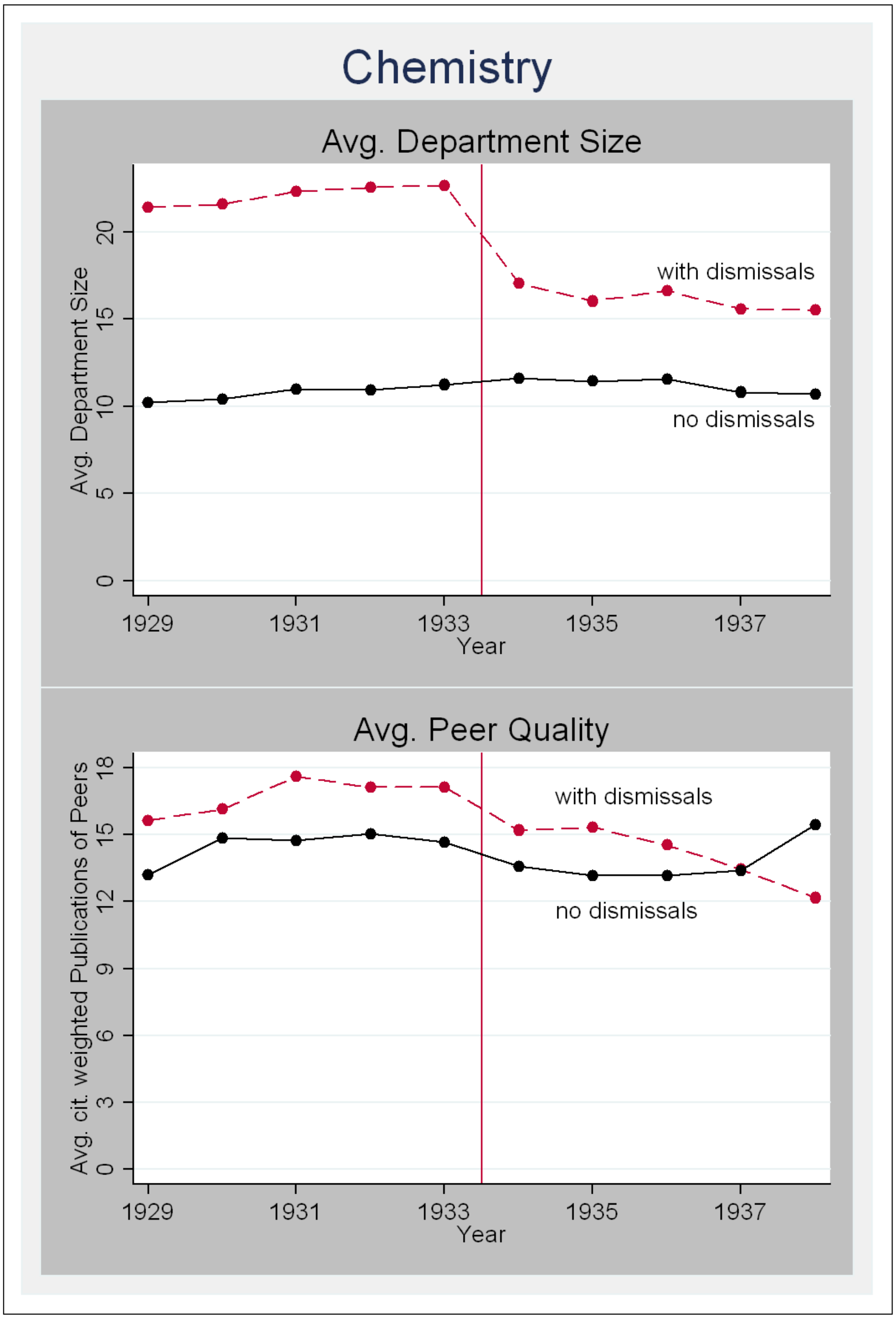

Figure 2: First Stage Chemistry

Figure 3 investigates the effect of the dismissals on the peer group of mathematicians. The top panel of Figure 3 shows the evolution of department sizes for mathematicians in departments with and without dismissals. Similarly to physics and chemistry the affected departments were larger before the dismissal. After 1933 the department size fell sharply in the affected universities. The bottom panel of Figure 3 investigates the effect of the dismissal on the average quality of the researchers' peer group. The mathematicians in the affected departments were above average quality before the dismissal. Due to the dismissal average peer quality fell drastically in the affected departments because average productivity of the dismissed was above average productivity of their respective department.

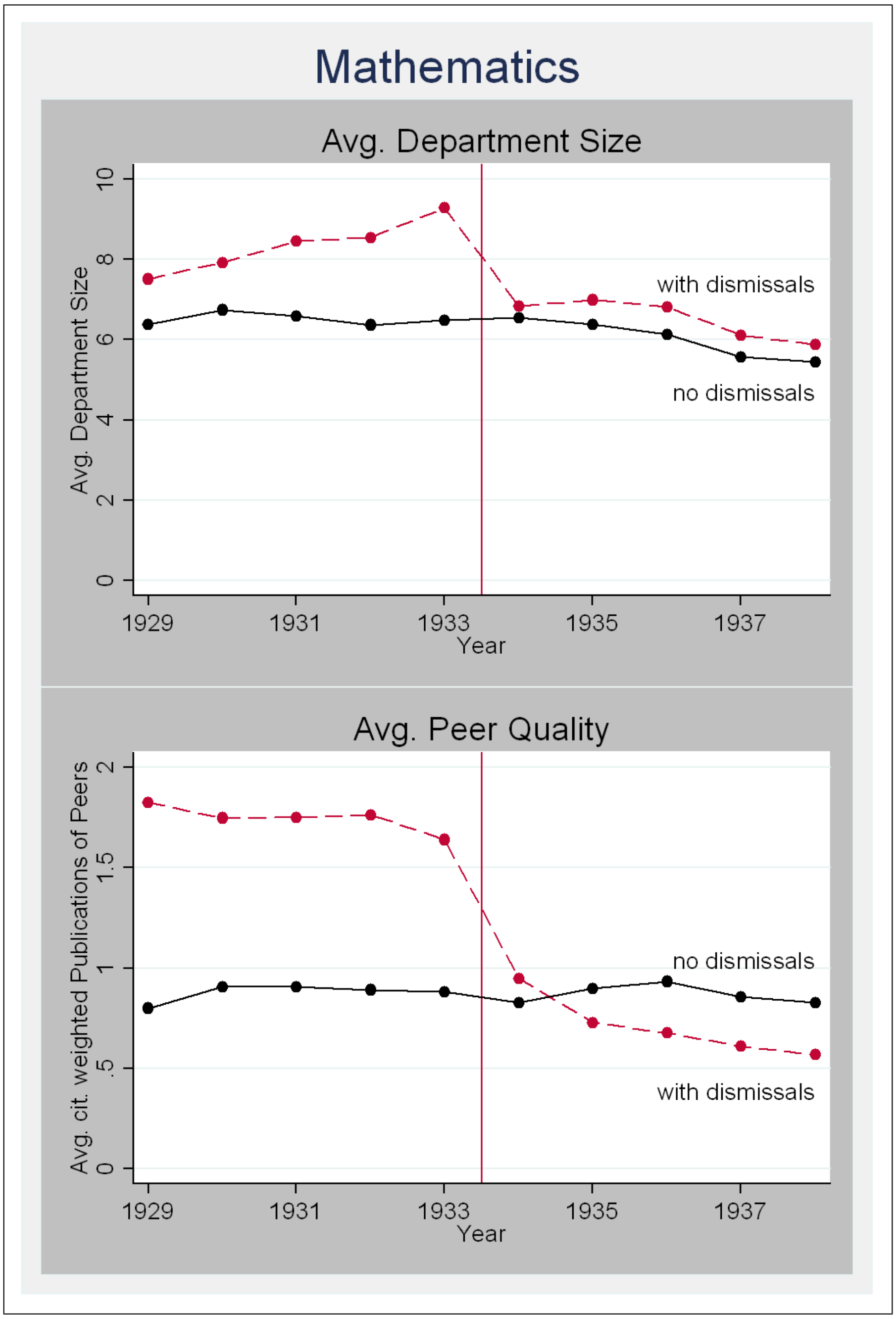

Figure 3: First Stages Mathematics

Figures 1 to 3 suggest that the dismissal had indeed an effect on the number of peers and their average quality. It is therefore possible to use the dismissal as an instrumental variable for the endogenous peer group variables. In this setting there are two endogenous variables: the number of peers and the average quality of peers. This gives rise to two first stage equations:

$$\text{(2)} \qquad \#\text{ of Peers}_{ut} = \gamma_1 + \gamma_2(\#\text{ Dismissed})_{ut} + \gamma_3(\text{Dismissal induced Reduction in Peer Quality})_{ut} + \gamma_4\text{Age Dummies}_{iut} + \gamma_5\text{YearFE}_t + \gamma_6\text{UniversityFE}_u + \gamma_7\text{IndividualFE}_i + \varepsilon_{iut}$$

$$\text{(3)} \qquad \text{Avg. Peer Quality}_{ut} = \delta_1 + \delta_2(\#\text{ Dismissed})_{ut} + \delta_3(\text{Dismissal induced Reduction in Peer Quality})_{ut} + \gamma_4\text{Age Dummies}_{iut} + \gamma_5\text{YearFE}_t + \gamma_6\text{UniversityFE}_u + \gamma_7\text{IndividualFE}_i + \varepsilon_{iut}$$

It is important to note that all regressions estimated in this paper are estimated for scientists who were present at the beginning of 1933 and were not dismissed (the so called stayers). The dismissal is then used as a source of exogenous variation in their peer group. Equation (2) is the first stage regression for department size. The main instrument for department size is the number of dismissed peers between 1933 and 1934 in a given department which is 0 until 1933 and equal to the number of dismissals thereafter.[20] I also include another instrument which captures the dismissal induced reduction in average quality of peers. This will be more important for equation (3), the first stage equation for average peer quality. The dismissal induced reduction in average peer quality is measured as the pre-dismissal average quality of all researchers in the department minus the average quality of the researchers who were not dismissed. The dismissal induced reduction in average quality variable is 0 until 1933. Researchers in departments with dismissals of colleagues of *above* average quality (relative to the department average) have a *positive* value of the dismissal induced reduction in peer quality variable after 1933. Scientists in departments with dismissal of *below* average quality have a *negative* value of the reduction in peer quality variable after 1933. The variable will remain 0 for researchers who did not experience any dismissal in their department or for scientists who lost peers who's quality was exactly equal to the department level average. The dismissals between 1933 and 1934 may have caused some researchers to switch university after 1933. This switching behavior, however, will be endogenous and thus have a direct effect on the researchers' productivity. To circumvent this problem I assign each scientist the relevant dismissal variables for the department he attended in the beginning of 1933.

The dismissals did affect all stayers in a department in a similar fashion. I therefore account for any dependence between observations within a department by clustering all results at the department level. This not only allows the error to be arbitrarily correlated for all researchers in one department at a given point in time but it also allows for serial correlation of these error terms.

Using the dismissal as an instrumental variable relies on the assumption that the dismissal had no other effect on a researcher's productivity than through its effect on the researcher's peer group. Dismissal induced disruption effects would therefore be a potential threat to the identification strategy. These could have occurred if the remaining scientists in the department had to take over more administrative or teaching responsibilities due to the dismissal. These effects would most probably lead to an upward bias of the instrumental variable results. The fact that I do not find evidence for peer effects neither at the department level nor at the specialization level, however, reduces the worry that this problem affects the findings of this paper.

Another worry may be that the dismissals changed the incentive structure for stayers in the

[20] This variable is 0 until 1933 for all departments (As I use a one year lag in the dismissal variables it is 0 for 1933 inclusive). In 1934 it is equal to the number of researchers who were dismissed in 1933 in a given department. From 1935 onwards it is equal to the number of dismissals in 1933 and 1934. The following example illustrates this. In Göttingen there were 10 dismissals in mathematics in 1933 and one dismissal in 1934. The # dismissed variable for mathematicians in Göttingen will therefore take the value 0 until 1933. It will be 10 in 1934 and 11 from 1935 onwards.

affected departments. Researchers in departments or specializations with many dismissals may have an incentive to work more to obtain one of the free chairs within the department. Their incentives could also be affected in the opposite direction if they lost an important advocate who was fostering their career. In this case they may decide to work less as the chances of obtaining a chair either in their own department or at another university could be lower. In order to address this concern I estimate a regression which regresses a dummy variable of holding a chair (equivalent to being an ordinary professor) on the department level (and specialization level) variables of number dismissed and dismissal induced reduction in average peer quality and the same controls as the regressions proposed before.[21] The results from this regression are presented in Table A3. The coefficients on the dismissal variables are all very small and none of them is significantly different from 0. This suggests that the results of this paper are probably not contaminated by changes in the incentive structures in the affected departments. Before turning to the estimation of peer effects I now investigate the effect of the dismissals on the stayers' productivity.

5 Effect of Dismissal on Researchers who remained in Germany

5.1 Department Level Dismissal Effect

There is no doubt that the dismissal of the Jewish and "politically unreliable" scholars had a negative impact on the German universities. In this context it is especially interesting to investigate how the dismissal affected the researchers who stayed at the German universities. Did their research productivity suffer because they had less and worse peers? The following figures try to give a graphical answer to this question. Figure 4 plots the publications for stayers in two sets of physics departments: those with dismissals and those without dismissals. The yearly fluctuation in top journal publications is relatively large. Despite this fluctuation the figure suggests that the dismissal does not seem to have a very obvious effect on the publications of the stayers.

[21] The estimated regression is:
$(\text{Holder of Chair})_{iut} = \beta_1 + \beta_2(\#\ \text{Dismissed})_{ut} + \beta_3(\text{Dismissal induced} \downarrow \text{in Peer Quality})_{ut} + \beta_4\text{Age Dummies}_{iut} + \beta_5\text{YearFE}_t + \beta_6\text{UniversityFE}_u + \beta_7\text{IndividualFE}_i + \varepsilon_{iut}$

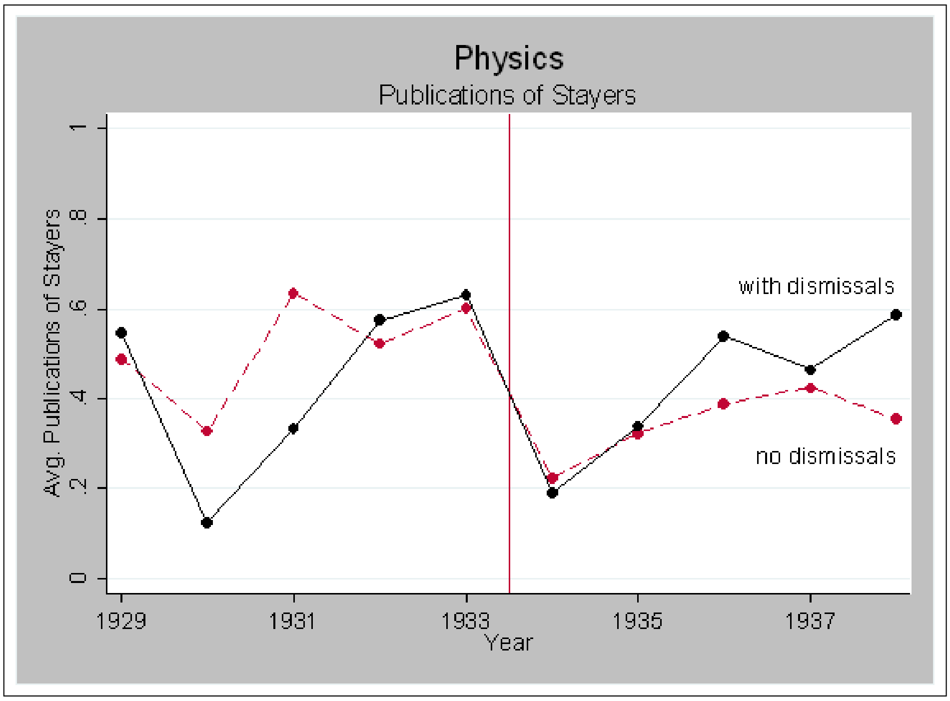

Figure 4: Reduced Form Physics

Figure 5 shows the evolution of the stayers' publications in chemistry departments. The figure suggests no effect of the dismissal on the stayers' productivity in chemistry.

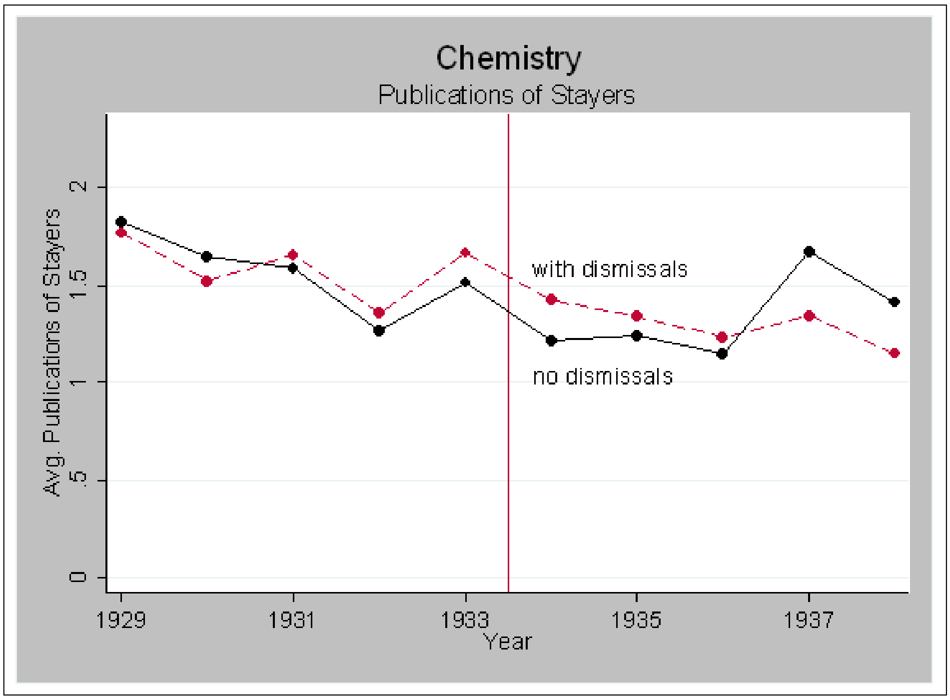

Figure 5: Reduced Form Chemistry

Figure 6 plots the top journal publications of mathematicians. Similarly to the other two subjects the dismissal does not seem to have a pronounced effect on the publications of the stayers.

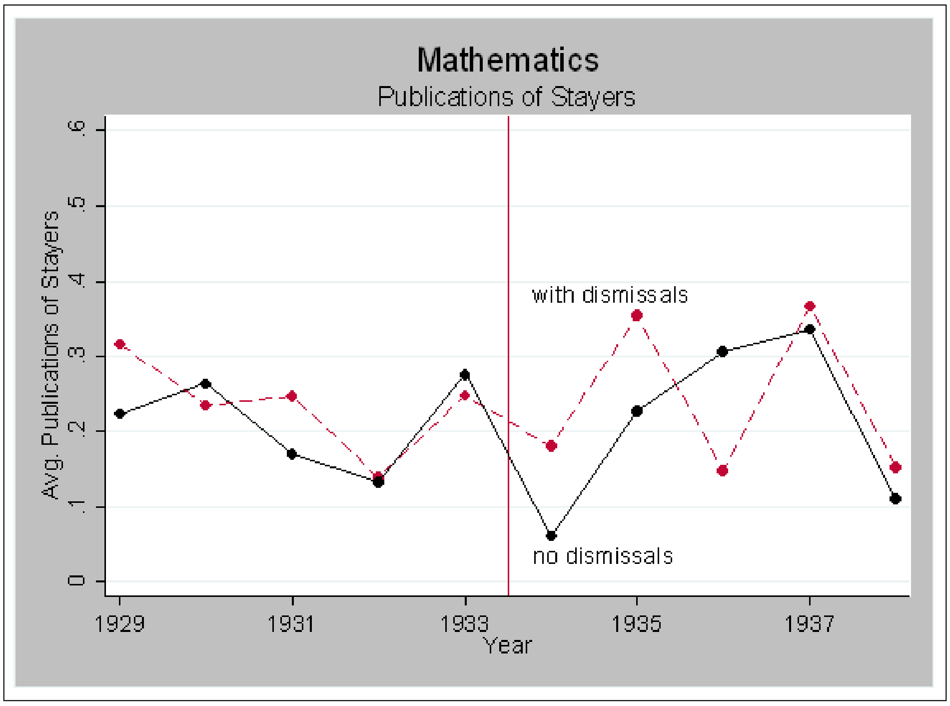

Figure 6: Reduced Form Mathematics

Figures 3 to 6 seem to suggest that the dismissal did not have an effect on the publications of stayers in the affected department. In order to quantify the effect of the dismissal on the stayers I estimate the following reduced form equation.

$$\text{(4)} \quad \#\ \text{Publications}_{iut} = \beta_1 + \beta_2(\#\ \text{Dismissed})_{ut} + \beta_3(\text{Dismissal induced Reduction in Peer Quality})_{ut} + \beta_4 \text{Age Dummies}_{iut} + \beta_5 \text{YearFE}_t + \beta_6 \text{UniversityFE}_u + \beta_7 \text{IndividualFE}_i + \varepsilon_{iut}$$

Using only the stayers I regress the researchers' (citation weighted) publications in each year on the instruments proposed above. Namely the number of dismissed peers and the dismissal induced reduction in peer quality. Researchers in departments which were not affected will have a value of 0 for the dismissal variables. Researchers in departments with dismissals will have 0 until 1933 and then the relevant value for the department to which they were affiliated at the beginning of 1933. I also include the same control variables as the ones proposed for regressions (1) to (3). This regression is essentially a difference-in-differences estimate of the dismissal effect. It compares the change in publications from the pre to the post dismissal period for researchers at the affected departments to the change between the two periods for unaffected researchers.

Table 5 reports the reduced form results for the three subjects under consideration using the peers in a researcher's department as the relevant peer group. Column (1) shows the results from estimating equation (4) without university fixed effects for physicists using the number of publications as the dependent variable. If the dismissal had a negative effect on the number of publications one would expect negative coefficients on the dismissal variables. Both the coefficient on the number of dismissed researchers and the one on the dismissal induced reduction in peer quality are very close to 0 and not significant. The coefficient on the dismissal induced change in peer quality is even positive in sign. This supports the graphical evidence that the publications of the stayers in the affected departments were not strongly affected by the dismissals. In column (2) I add university fixed effects to the specification. The inclusion of university fixed effects hardly affects the results. The dismissal does not have a significant effect on the stayers' productivity. Column (3) shows the results for citation weighted publications as the dependent variable. Also these results are close to 0 and insignificant. Not surprisingly the coefficient is larger than in column (1) because the mean of citation weighted publications variable is 5.1 and thus higher than the mean of publications which is 0.5. The coefficient on the change in peer quality even has the 'wrong' sign if one assumes that loosing high quality peers should negatively affect a researcher's productivity. The results including university fixed effects are reported in column (4). As for publications the inclusion of university fixed effects does hardly change the results and does not affect the finding that the dismissal did not affect the stayers' productivity.

Columns (5) to (8) present the same regressions for chemists. The results using publications as the dependent variable not including university fixed effects are reported in column (5). The dismissal induced reduction in peer quality variable is again insignificant and even shows the wrong sign. There is some evidence that the number of dismissed researchers in a stayer's department has a small negative effect on publications. After controlling for university fixed effects, however, the coefficient on the number of dismissed scholars is no longer significantly different from 0. The coefficient on the dismissal induced reduction in peer quality remains insignificant with the wrong sign. Using citation weighted publications all the coefficients are close to 0 and none of the coefficients is significant even without university fixed effects.

The results for mathematicians are reported in columns (9) to (12). Once again the coefficients are very small and all insignificant. These results are a first indication that peers, measured at the department level, may not affect the productivity of scientists. As departments are comprised of scientists with different specializations I want to investigate whether the dismissal had an effect on the stayer's productivity if one considers a narrower definition of his peer group. These results are reported in the next subsection.

5.2 Specialization Level Dismissal Effect

It may be the case that the researchers in a scientist's department are an inadequate measure for his peer group if he mostly benefits from interactions with peers in his own specialization within the department. The idea is that theoretical physicists mostly interact with the other theoretical physicists in the department and less with experimental physicists. I therefore explore the dismissal effect on the stayers using only peers from a researcher's own specialization as the relevant peer group.[22] The regression is the same as regression (4) but instead of using the number of department level dismissals I use the number of specialization level dismissals.

[22] If a researcher has more than one specialization his relevant peer group is defined as the sum of the peers of his specializations.

Similarly I use the reduction in average peer quality in a researcher's specialization instead of the reduction at the department level.

The results for the specialization level peers are reported in Table 6.[23] Columns (1) and (2) show the results for physicists using the number of publications as the dependent variable. The estimated coefficients are very close to 0 and all insignificant. Using citation weighted publications the results are all insignificant as well as can be seen in columns (3) and (4). Furthermore, all results for physicists have the wrong sign if one expects a negative dismissal effect.

The results for chemistry are reported in columns (5) to (8). None of the coefficients on the dismissal variables is significantly different from 0. The mathematics results are reported in columns (9) to (12). The coefficients on the dismissal variables are small and insignificant when using publications as the productivity measure. When using citation weighted publications as dependent variable I find significant negative effects for the dismissal induced reduction in peer quality. The number of dismissals in a mathematician's specialization however does not affect his productivity.

The department level results suggest that neither the number of peers nor their average quality is very important for a researchers' productivity. Furthermore, the specialization level results indicate that specialization level peer interactions are not important in physics and in chemistry. There is some indication that average peer quality in a researcher's specialization may affect the productivity of mathematicians. The following section explores this in further detail by estimating the peer effects equation (1) instrumenting the peer group variables with the dismissal.

6 Using the Dismissal to Identify Peer Effects in Science

6.1 Department Level Peer Effects

As suggested by Figures 1 to 3 the dismissal had a strong effect on the peer group of the stayers at the German universities. I therefore use this exogenous source of variation in a researcher's peer group to identify peer effects. I start by analyzing department level peer effect before I investigate specialization level peer effects in the following subsection. As explained in the identification section I estimate two first stage equations: one for the number of peers (i.e. department size) and one for the average quality of peers in a researcher's department. The first stage results are presented in Table 7.

Column (1) reports the results from estimating the first stage regression for physicists with department size as the dependent variable. The number of dismissed physicists in a researcher's department has a very strong and significant effect on department size. Reassuringly, the

[23] Due to a small number of missing values for the specialization of a researcher the number of observations is slighly lower than for the department level specifications.

dismissal induced change in the average quality of peers does not seem to have a large effect on department size. The first stage regression for the average peer quality in physics is presented in column (2). The number of dismissals in the department does not have a significant effect on the average quality of peers. The dismissal induced change in peer quality, however, is a very strong and significant predictor of average peer quality for physicists.

Columns (3) and (4) report the first stage regressions for chemists. The results are very similar: the number of dismissals in a department is a very good predictor for department size and the dismissal induced change in peer quality is a very good predictor for the average quality of peers. The regressions for mathematics are presented in columns (5) and (6) and also exhibit a very similar pattern. Overall, the dismissal seems to be a very strong instrument not only for department size but also for the average quality of peers.

Table 8 reports the results from estimating the peer effects model as proposed in equation (1). The first columns of Table 8 show the results for physicists. Column (1) reports the OLS results with publications as the dependent variable. The OLS results are not very informative due to the problems illustrated in the identification section. I therefore turn immediately to discussing the IV results presented in column (2) in which I use the dismissal to instrument the peer group variables.[24] The coefficient on the number of peers is very small and not significantly different from 0. The coefficient on peer quality is also very small and not significant. It even has the wrong sign if one were expecting positive peer effects from interactions with high quality peers. The standard error implies that one can rule out any positive effects of average peer quality with 89 percent confidence. For the number of peers one can rule out any positive effect larger than .087 with 95 percent confidence. Column (3) reports the OLS result using citation weighted publications as the dependent variable. The IV results with citation weighted publications as the dependent variable are reported in column (4). Once again, the coefficients on the peer group variables are not significantly different from 0 and the coefficient on average peer quality is even negative. Not surprisingly the coefficients are larger in magnitude because the mean of citation weighted publications is much larger than the mean of publications.

The chemistry results are reported in the next few columns of Table 8. Column (6) reports IV results when using publications as the dependent variable. The coefficients on department size and on the average number of peers are both very close to 0 and insignificant. The coefficient on the average quality of peers even has a negative coefficient. These results are mirrored in column (8) when using citation weighted publications as the dependent variable. The results for mathematicians are shown in the last few columns of Table 8 and are very similar to the ones in physics and chemistry: the coefficients on the peer group variables are all small and not

[24] In this setup the instruments are strong predictors of the peer group variables. Furthermore, the model is just identified as the number of instruments is equal to the number of endogenous variables. There is thus no worry of bias due to weak instruments. Stock and Jogo (2005) characterize instruments to be weak not only if they lead to biased IV results but also if hypothesis tests of IV parameters suffer from severe size distortions. They propose values of the Cragg-Donald (1993) minimum eigenvalue statistic for which a Wald test at the 5 percent level will have an actual rejection rate of no more than 10 percent. In this case the critical value is 7.03 and thus far below the Cragg-Donald statistics for the first stages for physics, chemistry, and mathematics which is reported at the bottom of Table 8.

significantly different from 0.

The results presented in Table 8 show no evidence for department level peer effects in any of the three subjects. The fact that the results are very similar for all three subjects can be seen as a confirmation that there are indeed no department level peer effects in this setting. Also the fact that I find very similar results for publications and citation weighted publications is reassuring. This indicates that differences in citation behavior of articles from scientists in departments with or without dismissals cannot explain these findings. The following subsection analyzes peer effects using a narrower definition of a researcher's peer group.

6.2 Specialization Level Peer Effects

The relevant peer group considered for the following regressions is defined as all researchers with the same specialization in the scientist's department. For an experimental physicist his peers are now only the other experimentalists in his department but not the theoretical physicists, technical physicists or astrophysicists. The first stage results for specialization level peers are reported in Table 9. The first stage results are again very strong and show that the dismissal is a good predictor for a scientist's number of (specialization level) peers and their respective quality especially in physics in chemistry. For mathematicians the dismissal variables are slightly less significant which is due to the fact that many mathematicians have more than one specialization.

Table 10 reports the results from estimating equation (1) with specialization level peer variables. The IV results for physics using publications as the relevant dependent variable are reported in column (2). Similarly to before the estimated peer group coefficients are very close to 0 and all insignificant. Both peer group variables even have a negative sign. The standard errors implies than one can rule out any positive effects for the number of peers larger than 0.04 with 95 percent confidence. Similarly any positive effects larger than 0.04 can be ruled out for the quality of peers. Keeping in mind that the mean of the publication variable is about 0.5 for physicists these are precisely estimated zeros. Using citation weighted publications as the dependent variable does not affect these conclusions as can be seen from the results reported in column (4).

The results for chemists are all close to 0 and insignificant, too. For publications one can rule out any positive effects of having one more peer greater than 0.098 with 95 percent confidence. For the average quality one can rule out any positive effects greater than 0.009 with 95 percent confidence. These are again very small coeffcients if one considers the mean of the publication variable for chemistry which is about 1.7.

The results for mathematics are less precisely estimated than for physics and chemistry.[25] But also for mathematics there is no evidence for any significant peer effects. The results on peer effects in a researcher's specialization confirm the finding that peer effects do not seem to play an important role within academic departments. The following section probes the

[25] The Cragg-Donald statistics shows that there is no problem of weak instruments as the relevant critical value is 7.03 in this setup.

robustness of these results before I turn to investigating peer effects among coauthors.

7 Sensitivity of Department Level IV Results

Table 11 shows results from a number of robustness checks for department level peer effects for physics. Columns (1) and (2) show the baseline results for publications and citation weighted publications respectively. The fact that I do not find any significant peer effects may be due to including data from 1933 and 1934 in my estimation. A major part of the dismissals occurred in those two years. The concomitant circumstances of the dismissal may have affected the research and publishing process in a way that made me underestimate peer effects. In order to address this issue I therefore re-estimate the IV equation omitting the data from 1933 of 1934. The results from this exercise are presented in columns (3) and (4). These results suggest that the disruption of 1933 and 1934 does not drive my findings for physicists.

Another hypothesis may be that peer effects are more important in the early stages of a researcher's career. Alternatively they may be more important for older researchers. These hypotheses are investigated in regressions reported in columns (5) to (8). I split the sample into researchers younger than 45 and researchers older than 45. The results indicate that neither young physicists nor old physicists benefit from the number of quality of the peers in their department.

Another worry may be that the productivity of stayers in the affected departments was following an upward trend before the dismissal. This would lead to an underestimate of the dismissal effect and thus bias the IV results downwards. This issue is addressed by including university specific time trends when estimating the IV model. The results for physics including university specific time trends are presented in columns (9) and (10) of Table 11. Including university specific time trends does not affect the findings presented before.

Tables 12 and 13 show the same regressions for department level peer effects among chemists and mathematicians. None of the peer group variables is significantly different from 0 in any of the robustness checks. This indicates that peer effects are indeed absent at the department level. The same robustness checks for specialization level peer effects are presented in Tables A4 to A6 in the appendix. The coefficients on the peer group variables for specialization level peers do not change much for any of the three subjects. Almost all coefficients remain very close to zero and are insignificant. For older physicists the number of peers variable is significant at the 5 percent level with an unexpected sign. This result would indicate that having more peers negatively affects the productivity of older physicists.

The robustness checks support the evidence that peer effects are inexistent at the department level and at the specialization level. In the following section I explore peer effects among an even smaller set of peers, namely among coauthors.

8 Effect of Dismissal on Coauthors

This section analyzes peer effects among coauthors. Interactions among coauthors can take very different levels of intensity. The most intense form of interaction is to coauthor papers together. It is not clear whether one would like to call this interaction a peer effect. Most people would probably call the coauthoring of papers joint production. Nonetheless there are other possible interactions among coauthors. They may also discuss work which they will not publish together. This form of interaction constitutes are real peer effect.

I investigate peer interactions among coauthors by analyzing the change in productivity of scientists who loose a coauthor due to the dismissal. As the fraction of papers coauthored with another faculty level researcher is only 6.3 percent in mathematics, only one mathematician who stayed in Germany lost a coauthor due to the dismissal. Therefore I cannot analyze the effect of loosing a coauthor for mathematics. In physics and chemistry, however, there were enough researchers who lost a coauthor due to the dismissal. Figure 7 illustrates the impact of loosing a coauthor for physics. The figure plots average yearly publications for two groups of researchers; researchers who lost a high quality coauthor due to the dismissal and researchers without dismissed coauthors. Figure 7 suggests that physicists who lost a prolific coauthor had a drop in their research productivity but managed to recover after some years.

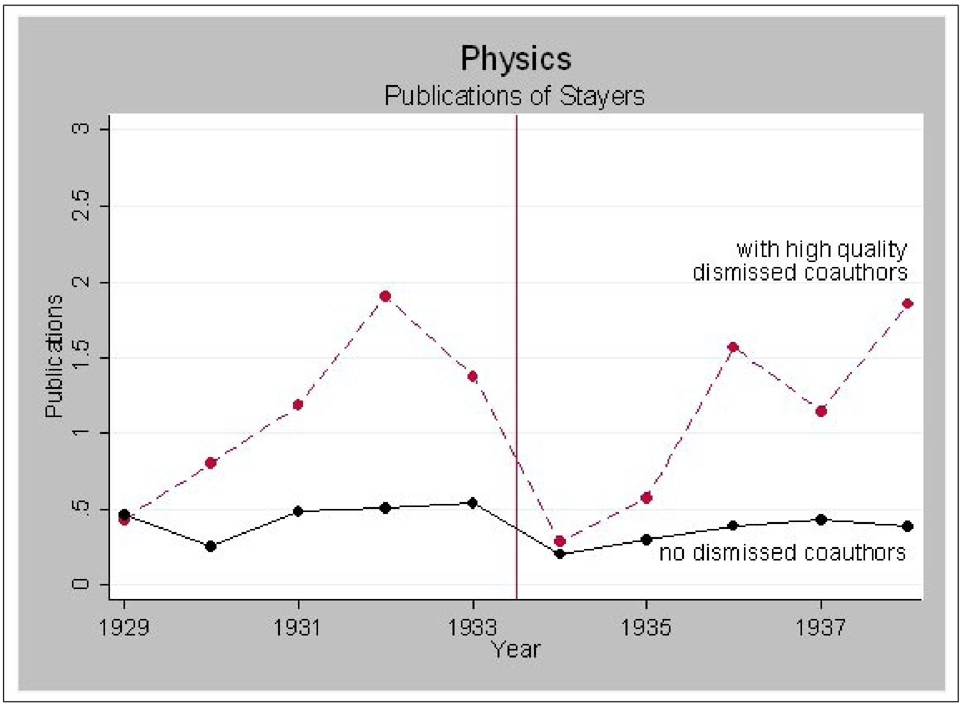

Figure 7: Effect of Dismissal of Coauthors Physics

Figure 8 shows the same graph for chemists. The productivity of chemists who lost a coauthor falls after the dismissal. Similarly to the effect in physics the productivity of chemists with dismissed coauthors recovers some years after the dismissal.

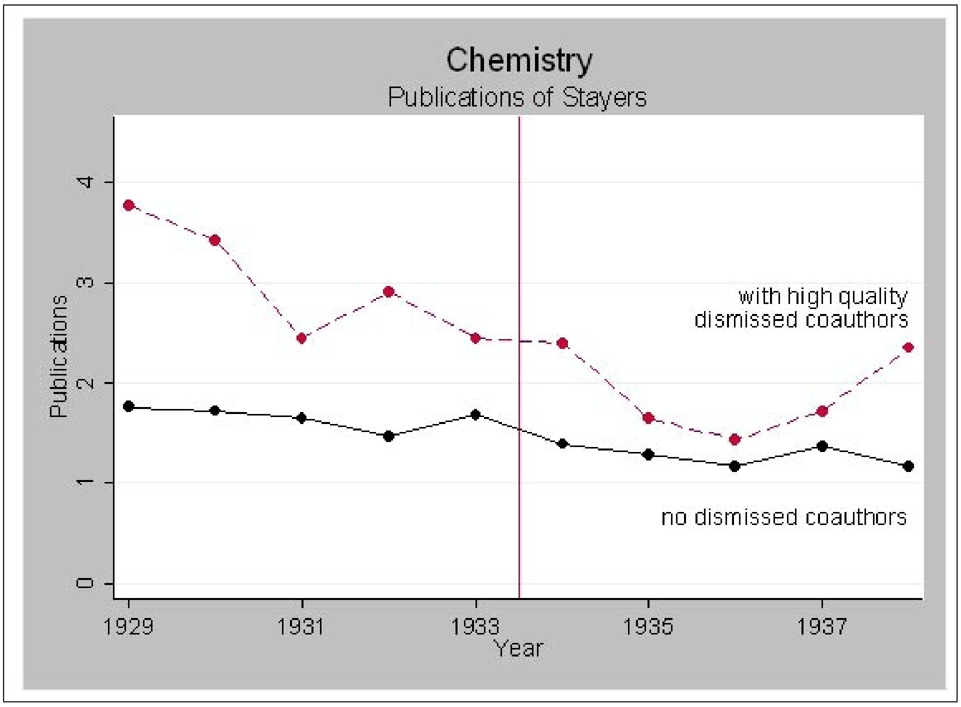

Figure 8: Effect of Dismissal of Coauthors Chemistry

In the following I investigate the effect of the dismissal in further detail. I therefore estimate the following reduced form equation:

$$\text{(5)} \quad \#\ \text{Publications}_{iut} = \beta_1 + \beta_2(\#\ \text{Dismissed Coauthors})_{iut} + \beta_3(\text{Avg. Quality of Dismissed Coauthors})_{iut} + \beta_4\text{Age Dummies}_{iut} + \beta_5\text{YearFE}_t + \beta_6\text{UniversityFE}_u + \beta_7\text{IndividualFE}_i + \varepsilon_{iut}$$

I regress the number of (citation weighted) publications of researcher i in period t and university u on the number of dismissed coauthors, the average quality (measured as before as the yearly average of pre-dismissal citation weighted publications) of the dismissed coauthors, and the same controls as in the regressions reported above. For the basic regression a scientist's coauthors are defined as all colleagues who have coauthored a paper with the scientist in the last five years before the dismissal; i.e. from 1928 to 1932. It is important to note that the dismissed coauthors do not have to be from the same department and indeed are rarely so. As before I estimate this regression for researchers staying in Germany only (the so-called stayers). This regression corresponds to the reduced form regressions reported for the department and specialization level peers. An equivalent instrumental variable approach to before is not feasible for peer effects among coauthors because the timing of the peer interactions cannot be well defined for coauthors. It is neither clear when peer interactions among coauthors start nor when these interactions end because they are likely to interact also before and after they have coauthored papers. I therefore focus on the reduced form results for coauthors.

The regression estimates of equation (5) are reported in Table 14.[26] Columns (1) and

[26] I am estimating these regressions on the same sample as the department level regressions reported before. The number of observations differs slightly from the number of observations in the department level specification because the department level specifications include a researcher twice if he has a joint appointment at two

(2) show the results for physics. The coefficient on the number of dismissed coauthors is not significantly different from 0. The coefficient on the average quality of dismissed coauthors, however, in column (2) shows that loosing a coauthor of average quality reduces the productivity of a physicist of average quality by about 12.5 percent. The results for chemists are reported in columns (3) and (4). The number of dismissed coauthors does not seem to play an important role for the productivity of chemists. The average quality of the dismissed coauthors is, however, highly significant. The estimated coefficient for citation weighted publications indicates that loosing a coauthor of average quality reduces the productivity of the average chemist by about 16.5 percent. The regressions reported in Table 14 use the total number of publications and citations weighted publications as dependent variable. A coauthored publication is counted as a full publication for both coauthors. Another approach is to normalize joint publications by dividing each publication and the citations of each publication by the number of coauthors. Table 15 shows the results obtained when using normalized (citation weighted) publications as the dependent variable. The results are very similar to before.

These results show that scientists who lost high quality coauthors suffered more than scientists who lost less prolific coauthors. The fact that I do not find a significant effect on the number of dismissed coauthors suggests that this effect is not driven by the fact that researchers who lost a coauthor published less because they were lamenting the loss of a coauthor.

The effect of loosing a coauthor may depend on the time span which elapsed since the last collaboration. The regressions reported in Table 16 explore this in further detail. I split the dismissed coauthors into two groups; recent coauthors who had collaborated with a stayer between 1929 and 1932, and former coauthors who had co-written papers with the stayer between 1924 and 1928 and not thereafter. As expected the estimates indicate that only the dismissal of recent coauthors matter for a stayer's productivity. The dismissal of a former coauthor does not affect the productivity of the stayers.

As mentioned above it is not clear whether one would call the joint publication of papers a real peer effect. I therefore investigate how the dismissal affected the number of publications excluding joint publications with the dismissed coauthors. Finding a negative effect of the dismissal on the publications without the dismissed coauthors would suggest the presence of peer effects among coauthors which are more subtle than coauthoring. This is even more true as one would expect that researchers who loose a coauthor substitute towards single-authored publications and publications with other coauthors. This latter effect should reduce any dismissal effect. The results on publications without the dismissed coauthors are reported in Table 17. As before the number of dismissed coauthors does not affect the productivity of scientists. The quality of the dismissed coauthors, however, remains negative and significant. These results suggest the presence of peer effects between coauthors.

universities (This occurs very rarely. Estimating the department and specialization level with weights to account for the few researchers who are appointed at two departments does not alter those results). The number of researchers in the two sets of regressions, however, is exactly the same as can be seen from the number of included researchers.

9 Conclusion

This paper uses the dismissal of scientists by the Nazi government to identify peer effects in science. I use a newly constructed dataset to estimate a peer effects model including the number of peers and their average quality as determinants of a researcher's productivity. I do not find evidence for peer effects among researchers in the same department. Furthermore, I do not find evidence for peer effects among researchers of the same specialization within the same department. These results are very similar for physicists, chemistry, and mathematics and robust to a number of sensitivity checks.

I also investigate peer effects among coauthors. The number of coauthors does not matter for a researcher's productivity. The quality of coauthors, however, is important for the productivity of physicists and chemists. I find that loosing a coauthor of average quality reduces the productivity of an average scientists by 12.5 percent in physics and by 16.5 percent in chemistry. I also show that the loss of coauthors lead to a reduction in the publications excluding the joint publications with the dismissed coauthor. This evidence suggests that there are peer effects between coauthors more subtle than the joint production of research papers.

It is important to note that these results do not mean that being at a good university does not have a positive effect on a researcher's productivity. The regressions reported above include university fixed effects which control for unobserved differences in the quality of laboratories, research seminars, research students, and the like. University quality does matter as the joint significance of the university fixed effects suggest. There is, however, no evidence for peer effects at the university or specialization level.

The evidence in this paper comes from scientists in Germany from 1925 to 1938. It is quite likely that department level and within department specialization level peer interactions are even less important nowadays as communication and transportation costs have fallen dramatically since then. Furthermore, it is quite likely that my estimates of peer effects among coauthors constitute a lower bound as coauthored papers have become more and more important due to increased specialization and the increased importance of 'big science' projects. See Wuchty et al. (2007) for a description of the increased importance of teams in scientific research.

These results suggest some strong policy conclusions. Just co-locating researchers in order to increase their productivity through spill-overs does not seem a useful policy. What seems much more important is to increase the possibility for coauthorships by fostering the mobility of researchers and their exposure to meeting researchers with similar research interests.

References

[1] Adams, James D., Grant C Black, J. Roger Clemmons, and Paula E. Stephan (2005) *"Scientific Teams and institutional collaborations: Evidence from U.S. universities, 1981-1999"*; Research Policy; Vol. 34; No. 3

[2] American Association of the Advancement of Science (1941) *"Physics in Pre-Nazi Germany"*; Science; Vol. 94; No 2247

[3] Azoulay, Pierre, Joshua Graff Zivin, and Jialan Wang (2007) *"Superstar Extinction"*; mimeo

[4] Beyerchen, Alan D. (1977) *"Scientists under Hitler - Politics and the Physics Community in the Third Reich"*; Yale University Press; New Haven

[5] Cragg, John G. and Stephen G. Donald (1993) *"Testing identifiablility and specification in instrumental variables models"*; Econometric Theory; Vol. 9

[6] Deichmann, Ute (2001) *"Flüchten, Mitmachen, Vergessen - Chemiker und Biochemiker in der NS-Zeit"*; Wiley-VCH Verlag; Weinheim

[7] Fischer, Klaus (1991) *"Die Emigration deutschsprachiger Physiker nach 1933: Stukturen und Wirkungen"* in "Die Emigration der Wissenschaften nach 1933"; Eds. : Strauss, Herbert A., Klaus Fischer, Christhard Hoffmann, and Alfons Söllner; K. G. Saur Verlag; München

[8] Gesellschaft für Exilforschung (1998) "*Handbuch der deutschsprachigen Emigration 1933-1945 - Einleitung*", Eds.: Krohn, Claus-Dieter, Patrick von zur Mühlen, Gerhard Paul, Lutz Winkler; Primus Verlag; Darmstadt

[9] Hartshorne, Edward Y. (1937) *"The German Universities and National Socialism"*; Harvard University Press; Cambridge

[10] Henderson, Rebecca; Adam Jaffe; and Manuel Trajtenberg (2005) *"Patent Citations and the Geography of Knowledge Spillovers: A Reassessment: Comment"*: The American Economic Review; Vol. 95; No. 1

[11] Hentschel, Klaus (1996) *"Physics and National Socialism - An Anthology of Primary Sources"*; Birkäuser Verlag; Berlin

[12] Jaffe, Adam B.; Manuel Trajtenberg; and Rebecca Henderson (1993) *"Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations"*; The Quarterly Journal of Economics; Vol. 108; No.3

[13] Jones, Benjamin F. (2005) *"Age and Great Invention"*; NBER Working Paper; No. 11359

[14] Kim, E. Han; Adair Morse; Luigi Zingales (2006) *"Are Elite Universities Losing their Competitive Edge"*; NBER Working Paper; No. 12245

[15] Kröner, Peter (1938) *"Vor fünfzig Jahren - Die Emigration deutschsprachiger Wissenschaftler 1933 - 1939"*; edited by Gesellschaft für Wissenschaftsgeschichte Münster; Heckners Verlag; Wolfenbüttel

[16] Levin, Sharon and Paula Stephan (1991) *"Research Productivity Over the Life Cycle: Evidence for Academic Scientists"*; The American Economic Review; Vol. 81; No. 1

[17] Lindley, David (2007) *"Uncertainty - Einstein, Heisenberg, Bohr, and the Struggle for the Soul of Science"*; Doubleday; New York

[18] Manski, Charles F. (1993) *"Identification of Endogenous Social Effects: The Reflection Problem"*; The Review of Economic Studies; Vol. 60; No. 3

[19] Notgemeinschaft Deutscher Wissenschaftler im Ausland (1936) *"List of Displaced German Scholars"*; London

[20] Röder, Werner, and Herbert Strauss (1992) *"Biographisches Handbuch der deutschsprachigen Emigration nach 1933 - Vol. II : The arts, sciences, and literature"*; edited by Institut für Zeitgeschichte München and Research Foundation for Jewish Immigration, Inc.; New York

[21] Siegmund-Schultze, Reinhard (1998) *"Mathematiker auf der Flucht vor Hitler"*; Deutsche Mathematiker Vereinigung; F. Vieweg

[22] Simonsohn, Gerhard (2007) *"Die Deutsche Physikalische Gesellschaft und die Forschung"*; in "Physiker zwischen Autonomie und Anpassung - Die Deutsche Physikalische Gesellschaft im Dritten Reich; Eds: Hoffmann, Dieter, and Mark Walker; Wiley-VHC Verlag; Weinheim

[23] Stock, James H. and Motoshiro Yogo (2005) *"Testing for Weak Instruments in Linear IV Regression";* in "Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg; Eds: Donald W.K. Andrews, and James H. Stock; Cambridge University Press; New York

[24] Thompson, Peter and Melanie Fox-Kean (2005) *"Patent Citations and the Geography of Knowledge Spillovers: A Reassessment"*: The American Economic Review (2005); Vol. 95; No. 1

[25] Thompson, Peter and Melanie Fox-Kean (2005) *"Patent Citations and the Geography of Knowledge Spillovers: A Reassessment: Reply"*: The American Economic Review (2005); Vol. 95; No. 1

[26] Weinberg, Bruce A. (2007) *"Geography and Innovation: Evidence from Nobel Laureate Physicists"*; mimeo Ohio State University

[27] Wuchty, Stefan, Benjamin F. Jones, and Brian Uzzi (2007) *"The Increasing Dominance of Teams in Production of Knowledge"*, Science, Vol. 316

10 Tables

Table 1: Number of Dismissed Scientists across different Subjects

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	Physics		Chemistry		Mathematics	
Year of Dismissal	Number of Dismissals	% of all Physicists in 1933	Number of Dismissals	% of all Chemists in 1933	Number of Dismissals	% of all Mathematicians in 1933
1933	34	11.8	51	10.9	35	15.6
1934	6	2.1	11	2.4	6	2.7
1935	4	1.4	5	1.1	5	2.2
1936	1	0.3	7	1.5	1	0.4
1937	1	0.3	3	0.6	2	0.9
1938	1	0.3	4	0.9	1	0.4
1939	1	0.3	2	0.4	1	0.4
1940	1	0.3	0	0.0	1	0.4
1933 - 1934	40	13.9	62	13.3	41	18.3

Table 2: Dismissals across different Universities

	Physics						Chemistry						Mathematics					
	Fall in # of Peers			Loss to Peer Quality			Fall in # of Peers			Loss to Peer Quality			Fall in # of Peers			Loss to Peer Quality		
	Scien-tists	Dismissed 1933-34		Quality	Fall in Peer Quality		Scien-tists	Dismissed 1933-34		Quality	Fall in Peer Quality		Scien-tists	Dismissed 1933-34		Quality	Fall in Peer Quality	
University	1933	#	in %	1933	#	in %	1933	#	in %	1933	#	in %	1933	#	in %	1933	#	in %
Aachen TU	3	0	*0*	2.53	0	*0*	12	2	*16.7*	6.24	-0.58	*-9.3*	7	3	42.9	0.10	-0.03	*-33.3*
Berlin	38	8	*21.1*	6.48	4.52	*69.8*	45	15	*33.3*	26.03	6.06	*23.3*	13	5	38.5	5.74	4.17	*72.7*
Berlin TU	21	6	*28.6*	8.16	1.40	*17.2*	41	13	*31.7*	13.38	3.39	*25.4*	14	2	14.3	0.07	-0.01	*-18.2*
Bonn	12	1	*8.3*	1.03	-0.10	*-9.8*	16	1	*6.3*	12.03	2.28	*19.0*	7	1	14.3	0.75	-0.10	*-13.3*
Braunschweig TU	4	0	*0*	0.97	0	*0*	8	0	*0*	6.26	0	*0*	3	0	0	0.00	0	*0*
Breslau	12	2	*16.7*	3.22	-0.11	*-3.6*	10	1	*10.0*	21.33	5.18	*24.3*	6	3	50.0	2.74	2.74	*100.0*
Breslau TU	1	0	*0*	5.63	0	*0*	14	2	*14.3*	30.68	4.06	*13.2*	5	2	40.0	2.76	2.23	*80.7*
Darmstadt TU	9	1	*11.1*	10.49	-0.26	*-2.5*	18	5	*27.8*	2.23	1.26	*56.6*	9	1	11.1	0.33	-0.04	*-12.5*
Dresden TU	6	1	*16.7*	8.16	8.16	*100.0*	17	1	*5.9*	18.56	14.48	*78.0*	10	0	0	0.65	0	*0*
Erlangen	4	0	*0*	0.41	0	*0*	8	0	*0*	9.02	0	*0*	3	0	0	4.29	0	*0*
Frankfurt	12	1	*8.3*	1.43	0.10	*6.8*	18	5	*27.8*	15.51	-4.98	*-32.1*	8	1	12.5	2.35	-0.18	*-7.8*
Freiburg	8	0	*0*	1.09	0	*0*	15	3	*20.0*	15.79	-2.36	*-15.0*	9	1	11.1	1.10	0.35	*31.5*
Giessen	5	1	*20.0*	1.67	1.58	*94.9*	10	0	*0*	4.22	0	*0*	7	1	14.3	0.33	-0.05	*-16.7*
Göttingen	21	9	*42.9*	14.59	10.58	*72.5*	17	0	*0*	37.08	0	*0*	17	10	58.8	3.44	2.34	*67.9*
Greifswald	6	0	*0*	5.30	0	*0*	5	0	*0*	23.09	0	*0*	3	0	0	2.33	0	*0*
Halle	4	0	*0*	2.36	0	*0*	9	1	*11.1*	12.25	-1.64	*-13.4*	7	1	14.3	0.96	-0.04	*-3.7*
Hamburg	11	2	*18.2*	0.40	-0.03	*-8.3*	11	2	*18.2*	6.32	-0.25	*-4.0*	8	0	0	1.65	0	*0*
Hannover TU	3	0	*0*	0.00	0	*0*	14	0	*0*	29.19	0	*0*	6	0	0	0.28	0	0
Heidelberg	8	0	*0*	2.53	0	*0.0*	18	1	*5.6*	59.47	-3.82	*-6.4*	5	1	20.0	2.02	-0.50	*-25.0*
Jena	13	1	*7.7*	4.66	-0.38	*-8.1*	10	0	*0*	31.82	0	*0*	5	0	0	0.00	0	*0*
Karlsruhe TU	8	0	*0*	2.10	0	*0*	14	4	*28.6*	32.66	-6.58	*-20.1*	6	1	16.7	0.00	0	*0*
Kiel	8	1	*12.5*	1.00	0.08	*8.3*	11	0	*0*	9.10	0	*0*	5	2	40.0	0.63	-0.29	*-46.7*
Köln	8	1	*12.5*	10.14	-1.41	*-13.9*	4	1	*25.0*	10.88	6.42	*59.0*	6	2	33.3	0.41	-0.23	*-56.4*
Königsberg	8	0	*0*	5.76	0.00	*0.0*	11	1	*9.1*	6.69	3.62	*54.1*	5	2	40.0	4.90	1.53	*31.1*
Leipzig	11	2	*18.2*	3.67	-0.23	*-6.2*	24	2	*8.3*	18.67	0.29	*1.6*	8	2	25.0	1.48	0.49	*33.1*
Marburg	6	0	*0*	2.10	0	*0*	8	0	*0*	15.74	0	*0*	8	0	0	0.17	0	0
München	12	3	*25.0*	9.18	-3.06	*-33.3*	18	1	*5.6*	10.80	0.79	*7.3*	9	0	0	1.89	0	0
München TU	10	1	*10*	0.95	-0.11	*-11.1*	15	0	*0*	7.41	0	*0*	5	0	0	0.20	0	0
Münster	5	0	*0*	1.15	0	*0*	12	0	*0*	9.95	0	*0*	5	0	0	0.85	0	0
Rostock	3	0	*0*	1.49	0	*0*	8	0	*0*	9.74	0	*0*	2	0	0	0.08	0	0
Stuttgart TU	5	0	*0*	2.36	0	*0*	9	1	*11.1*	9.19	-1.53	*-16.6*	6	0	0	0.04	0	0
Tübingen	2	0	*0*	7.54	0	*0*	10	0	*0*	7.59	0	*0*	6	0	0	1.73	0	0
Würzburg	3	0	*0*	0.00	0	*0*	11	0	*0*	10.34	0	*0*	4	0	0	0.03	0	0

Table 3: Quality of Dismissed Scholars

	Physics				Chemistry				Mathematics			
	All	Stay-ers	Dismissed 33-34		All	Stay-ers	Dismissed 33-34		All	Stay-ers	Dismissed 33-34	
			#	% Loss			#	% Loss			#	% Loss
Researchers (Beginning of 1933)	287	248	39	13.6	466	405	61	13.1	224	183	41	18.3
# of Chaired Profs.	109	97	12	11.0	156	136	20	12.8	117	99	18	15.4
Average Age (1933)	49.5	50.2	45.1	-	50.4	50.5	49.7	-	48.7	50.0	43.0	-
# of Nobel Laureates	15	9	6	40.0	14	11	3	21.4	-	-	-	-
Avg. publications (1925-1932)	0.47	0.43	0.71	20.5	1.69	1.59	2.31	17.9	0.33	0.27	0.56	31.1
Avg. publications (citation weighted)	5.10	3.53	14.79	39.4	17.25	16.07	25.05	19.0	1.45	0.93	3.71	46.8
% Publ. coauthored	33.3	33.6	31.6	-	76.0	75.8	77.1	-	11.3	9.7	14.8	-
% Publ. coauthored (Coaut. at German uni)	10.6	9.9	13.9	-	11.7	12.1	9.7	-	6.3	5.9	6.7	-
% Publ. coauthored (Coaut. same uni)	4.2	3.4	8.7	-	5.1	5.4	3.8	-	2.7	2.0	4.1	-

Table 4: Top Journals

Journal Name	Published in
General Journals	
Naturwissenschaften	Germany
Sitzungsberichte der Preussischen Akademie der Wissenschaften Physikalisch Mathematische Klasse	Germany
Nature	UK
Proceedings of the Royal Society of London A (Mathematics and Physics)	UK
Science	USA
Physics	
Annalen der Physik	Germany
Physikalische Zeitschrift	Germany
Physical Review	USA
Chemistry	
Berichte der Deutschen Chemischen Gesellschaft	Germany
Biochemische Zeitschrift	Germany
Journal für Praktische Chemie	Germany
Justus Liebigs Annalen Chemie	Germany
Kolloid Zeitschrift	Germany
Zeitschrift für Anorganische Chemie und Allgemeine Chemie	Germany
Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie	Germany
Zeitschrift für Physikalische Chemie	Germany
Journal of the Chemical Society	UK
Mathematics	
Jounal für die reine und angewandte Mathematik	Germany
Journal of the London Mathematical Society	Germany
Mathematische Annalen	Germany
Mathematische Zeitschrift	Germany
Zeitschrift für angewandte Mathematik und Mechanik	Germany
Acta Mathematica	Sweden
Proceedings of the London Mathematical Society	UK

Another major journal for physicists at the time was the "Zeitschrift für Physik". Unfortunately, the Web of Science does not include the articles in that journal after 1927. Therefore, I exclude the "Zeitschrift für Physik" from the analysis.

Table 5: Reduced Form (Department Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Physics				Chemistry				Mathematics			
Dependent Variable:	Publi-cations	Publi-cations	Citation Weighted Pub.	Citation Weighted Pub.	Publi-cations	Publi-cations	Citation Weighted Pub.	Citation Weighted Pub.	Publi-cations	Publi-cations	Citation Weighted Pub.	Citation Weighted Pub.
Number Dismissed	-0.018	-0.022	-0.220	-0.369	-0.019	-0.017	-0.176	-0.106	-0.022	-0.022	0.009	0.027
	(0.014)	(0.018)	(0.336)	(0.378)	(0.008)*	(0.009)	(0.213)	(0.205)	(0.017)	(0.017)	(0.182)	(0.161)
Dismissal Induced	0.026	0.028	0.546	0.653	0.020	0.016	0.782	0.718	0.030	0.035	-0.441	-0.266
↓ in Peer Quality	(0.013)	(0.015)	(0.320)	(0.367)	(0.013)	(0.011)	(0.471)	(0.466)	(0.036)	(0.041)	(0.279)	(0.333)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE		✓		✓		✓		✓		✓		✓
Observations	2261	2261	2261	2261	3584	3584	3584	3584	1538	1538	1538	1538
# of researchers	258	258	258	258	413	413	413	413	183	183	183	183
R-squared	0.39	0.39	0.25	0.27	0.67	0.67	0.53	0.54	0.32	0.33	0.2	0.21

**significant at 1% level *significant at 5% level (All standard errors clustered at department level)

Publications are the sum of a scientist's publications in top journals in one year.

Citation Weighted Publications are defined as the sum of subsequent citations (in the first 50 years after publication in any journal included in the "Web of Science", including international journals) of all articles published in a given year.

Number dismissed is equal to the number of dismissed scientists in a researcher's department. The variable is 0 until 1933 for researchers in all departments. In 1934 it is equal to the number of dismissals in 1933 at a researcher's department. From 1935 onwards it is equal to the number of dismissals in 1933 and 1934 in a researcher's department.

Dismissal induced ↓ in Peer Quality is 0 for all researchers until 1933. In 1934 it is equal to (Avg. quality of total department before dismissal) - (Avg. quality of researchers not dismissed in 1933). From 1935 onwards it will be equal to (Avg. quality of total department before dismissal) - (Avg. quality of researchers not dismissed in 1933 and 1934). Researchers in departments with stayers of *below* department level average quality have a positive value of the quality dismissal variable. The quality dismissal variable is negative for scientists in departments with stayers of *above* average quality. Average quality is measured as the department level average of citation weighted publications between 1925 and 1932.

Table 6: Reduced Form (Specialization Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Physics				Chemistry				Mathematics			
Dependent Variable:	Publi-cations	Publi-cations	Citation Weighted Pub.	Citation Weighted Pub.	Publi-cations	Publi-cations	Citation Weighted Pub.	Citation Weighted Pub.	Publi-cations	Publi-cations	Citation Weighted Pub.	Citation Weighted Pub.
Number Dismissed	0.021	0.012	0.641	0.499	-0.011	-0.007	0.837	1.055	-0.034	-0.034	0.272	0.349
	(0.026)	(0.027)	(0.423)	(0.419)	(0.047)	(0.048)	(0.869)	(0.840)	(0.035)	(0.035)	-0.369	(0.375)
Dismissal Induced	0.007	0.006	0.163	0.160	0.006	0.006	-0.004	-0.023	0.020	0.027	-0.556	-0.537
↓ in Peer Quality	(0.018)	(0.021)	(0.319)	(0.335)	(0.008)	(0.008)	(0.098)	(0.096)	(0.032)	(0.032)	(0.262)*	(0.250)*
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE		✓		✓		✓		✓		✓		✓
Observations	2257	2257	2257	2257	3567	3567	3567	3567	1538	1538	1538	1538
# of researchers	256	256	256	256	405	405	413	405	183	183	183	183
R-squared	0.38	0.39	0.25	0.27	0.67	0.67	0.53	0.54	0.32	0.33	0.2	0.21

**significant at 1% level *significant at 5% level (All standard errors are clustered at the department level)

Number dismissed is equal to the number of dismissed scientists within the same *specialization* as the researcher (e.g. it will be equal to the number of dismissed theoretical physicists at a researcher's department for a theoretical physicist). The variable is 0 until 1933 for all researchers. In 1934 it is equal to the number of dismissals in 1933 at a researcher's specialization. From 1935 onwards it is equal to the number of dismissals in 1933 and 1934 in a researcher's specialization.

Dismissal induced ↓ in Peer Quality is 0 for all researchers until 1933. In 1934 it is equal to (Avg. quality of *all* researchers within a specialization in the scientist's department before dismissal) - (Avg. quality of researchers within a specialization in a scientist's not dismissed in 1933). From 1935 onwards it is equal to (Avg. quality of *all* researchers within a specialization in the scientist's department before dismissal) - (Avg. quality of researchers within a specialization in a scientist's not dismissed in 1933 or 1934). Average quality is measured as the specialization level average of citation weighted publications between 1925 and 1932.

Table 7: First Stages (Department Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)
	Physics		Chemistry		Mathematics	
Dependent Variable:	Department Size	Avg. Quality of Peers	Department Size	Avg. Quality of Peers	Department Size	Avg. Quality of Peers
Number Dismissed	-0.566	0.180	-0.964	-0.077	-0.540	0.013
	(0.110)**	(0.090)	(0.101)**	(0.223)	(0.063)**	(0.031)
Dismissal Induced	-0.054	-0.919	0.011	-1.117	0.188	-1.299
↓ in Peer Quality	(0.111)	(0.079)**	(0.082)	(0.138)**	(0.197)	(0.181)**
Age Dummies	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓
Observations	2261	2261	3584	3584	1538	1538
# of researchers	258	258	413	413	183	183
R-squared	0.93	0.77	0.94	0.76	0.86	0.78
F - Test on Instruments	85.9	231.1	46.0	33.3	84.8	61.5

Table 8: Instrumental Variables (Department Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Physics				Chemistry				Mathematics			
Dependent Variable:	Publications		Cit.Weighted Pub.		Publications		Cit.Weighted Pub.		Publications		Cit.Weighted Pub.	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Department Size	-0.003	0.028	-0.196	0.419	-0.011	0.019	0.044	0.161	0.008	0.040	-0.004	-0.044
	(0.005)	(0.029)	(0.116)	(0.514)	(0.008)	(0.011)	(0.266)	(0.288)	(0.013)	(0.032)	(0.080)	(0.300)
Peer Quality	0.011	-0.032	0.018	-0.736	0.007	-0.014	0.107	-0.641	0.009	-0.021	0.507	0.198
	(0.007)	(0.020)	(0.097)	(0.395)	(0.003)*	(0.010)	(0.065)	(0.389)	(0.018)	(0.029)	(0.210)*	(0.257)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	2261	2261	2261	2261	3584	3584	3584	3584	1538	1538	1538	1538
# of researchers	258	258	258	258	413	413	413	413	183	183	183	183
R-Squared	0.40		0.27		0.67		0.54		0.33		0.21	
Cragg-Donald EV Statistic		36.37		36.37		189.49		189.49		56.08		56.08

**significant at 1% level *significant at 5% level (All standard errors clustered at the department level)

Table 9: First Stages (Specialization Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)
	Physics		Chemistry		Mathematics	
Dependent Variable:	Department Size	Avg. Quality of Peers	Department Size	Avg. Quality of Peers	Department Size	Avg. Quality of Peers
Number Dismissed	-0.817	0.330	-0.987	0.143	-0.419	-0.201
	(0.139)**	(0.203)	(0.108)**	(1.370)	(0.159)*	(0.162)
Dismissal Induced	0.059	-0.869	0.011	-1.096	-0.114	-0.866
↓ in Peer Quality	(0.042)	(0.206)**	(0.015)	(0.146)**	(0.110)	(0.193)**
Age Dummies	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓
Observations	2257	2257	3567	3567	1538	1538
# of researchers	256	256	405	405	183	183
R-squared	0.92	0.70	0.92	0.73	0.88	0.77
F - Test on Instruments	18.3	19.4	42.2	40.8	22.3	60.0

Table 10: Instrumental Variables (Specialization Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Physics				Chemistry				Mathematics			
Dependent Variable:	Publications		Cit.Weighted Pub.		Publications		Cit.Weighted Pub.		Publications		Cit.Weighted Pub.	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
# of Peers in Specialization	-0.006	-0.018	-0.353	-0.704	-0.054	0.003	-0.539	-1.067	-0.001	0.101	-0.171	-1.205
	(0.017)	(0.028)	(0.249)	(0.494)	(0.029)	(0.047)	(0.376)	(0.850)	(0.017)	(0.126)	(0.167)	(1.423)
Peer Quality (Specialization)	0.007	-0.008	-0.039	-0.231	-0.002	-0.005	0.031	0.010	0.007	-0.045	0.689	0.778
	(0.004)	(0.024)	(0.063)	(0.414)	(0.002)	(0.007)	(0.039)	(0.091)	(0.015)	(0.059)	(0.331)*	(0.505)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	2257	2257	2257	2257	3567	3586	3567	3567	1538	1538	1538	1538
# of researchers	256	256	256	256	405	405	405	405	183	183	183	183
R-Squared	0.40		0.27		0.67		0.54		0.33		0.22	
Cragg-Donald EV Statistic		116.53		116.53		206.12		206.12		8.56		8.56

**significant at 1% level *significant at 5% level (All standard errors clustered at the department level)

Table 11: Robustness Checks Instrumental Variables Physics (Department Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full Sample	Full Sample	omitting 33 & 34	omitting 33 & 34	younger than 45	45 or older	younger than 45	45 or older	Full Sample	Full Sample
Dependent Variable	Publi-cations	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.	Publi-cations	Publi-cations	Cit. weight. Publ.	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.
Department Size	0.028	0.419	0.003	0.356	0.113	-0.015	1.887	-0.586	0.068	0.545
	(0.029)	(0.514)	(0.029)	(0.812)	(0.068)	(0.039)	(0.980)	(0.529)	(0.042)	(0.612)
Peer Quality	-0.032	-0.736	-0.018	-0.956	-0.067	-0.005	-1.030	-0.243	-0.039	-0.509
	(0.020)	(0.395)	(0.018)	(0.752)	(0.047)	(0.029)	(0.703)	(0.330)	(0.030)	(0.349)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University specific. Time Trends									✓	✓
Observations	2261	2261	1866	1866	840	1421	840	1421	2261	2261
# of researchers	258	258	256	256	138	179	138	179	258	258
Cragg-Donald EV Statistic	36.37	36.37	18.80	18.80	10.11	30.88	10.11	30.88	24.36	24.36

Table 12: Robustness Checks Instrumental Variables Chemistry (Department Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full Sample	Full Sample	omitting 33 & 34	omitting 33 & 34	younger than 45	45 or older	younger than 45	45 or older	Full Sample	Full Sample
Dependent Variable	Publi-cations	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.	Publi-cations	Publi-cations	Cit. weight. Publ.	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.
Department Size	0.068	0.545	0.019	0.161	0.023	0.246	-0.006	0.024	0.325	0.153
	(0.042)	(0.612)	(0.011)	(0.288)	(0.015)	(0.197)	(0.040)	(0.015)	(1.305)	(0.151)
Peer Quality	-0.039	-0.509	-0.014	-0.641	-0.010	-0.187	-0.018	-0.013	-1.650	-0.168
	(0.030)	(0.349)	(0.010)	(0.389)	(0.010)	(0.170)	(0.027)	(0.016)	(1.398)	(0.219)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University specific. Time Trends									✓	✓
Observations	2261	2261	3584	3584	2926	2926	1308	2276	1308	2276
# of researchers	258	258	413	413	411	411	206	295	206	295
Cragg-Donald EV Statistic	24.36	24.36	189.49	189.49	167.87	167.87	46.81	145.75	46.81	145.75

**significant at 1% level   *significant at 5% level   (All standard errors clustered at the department level)

Table 13: Robustness Checks Instrumental Variables Mathematics (Department Level Peers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full Sample	Full Sample	omitting 33 & 34	omitting 33 & 34	younger than 45	45 or older	younger than 45	45 or older	Full Sample	Full Sample
Dependent Variable	Publi-cations	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.	Publi-cations	Publi-cations	Cit. weight. Publ.	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.
Department Size	0.040	-0.044	0.066	0.046	0.066	-0.014	-0.160	0.061	0.005	-0.109
	(0.032)	(0.300)	(0.053)	(0.483)	(0.053)	(0.049)	(0.385)	(0.496)	(0.028)	(0.244)
Peer Quality	-0.021	0.198	-0.038	0.254	-0.092	0.030	-0.442	0.048	0.018	0.108
	(0.029)	(0.257)	(0.035)	(0.355)	(0.081)	(0.028)	(1.147)	(0.274)	(0.034)	(0.425)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University specific. Time Trends									✓	✓
Observations	1538	1538	1256	1256	672	866	672	866	1538	1538
# of researchers	183	183	183	183	106	119	106	119	183	183
Cragg-Donald EV Statistic	56.08	56.08	17.68	17.68	23.99	24.9	23.99	24.9	54.03	54.03

**significant at 1% level *significant at 5% level (All standard errors clustered at the department level)

Table 14: Effect of Dismissal on Coauthors

	(1)	(2)	(3)	(4)
	Physics		Chemistry	
Dependent Variable	Publi-cations	Citation Weighted Pub.	Publi-cations	Citation Weighted Pub.
# of Dismissed Coauthors	0.328	7.668	0.398	-1.020
	(0.525)	(7.888)	(0.366)	(5.766)
Avg. Quality of Dism. Coauthors	-0.007	-0.125	-0.013	-0.165
	(0.003)*	(0.045)**	(0.003)**	(0.036)**
Age Dummies	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓
University FE	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓
Observations	2243	2243	3575	3575
# of researchers	258	258	413	413
R-squared	0.40	0.27	0.67	0.54

**significant at 1% level *significant at 5% level
(All standard errors are clustered at the individual level)

Table 15: Coauthors: Normalized Publications

	(1)	(2)	(3)	(4)
	Physics		Chemistry	
Dependent Variable	Publi-cations	Citation Weighted Pub.	Publi-cations	Citation Weighted Pub.
# of Dismissed Coauthors	0.574	8.441	0.268	-0.652
	(0.553)	(7.209)	(0.188)	(3.688)
Avg. Quality of Dism. Coauthors	-0.006	-0.100	-0.008	-0.086
	(0.003)	(0.042)*	(0.002)**	(0.026)**
Age Dummies	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓
University FE	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓
Observations	2243	2243	3575	3575
# of researchers	258	258	413	413
R-squared	0.39	0.26	0.68	0.49

**significant at 1% level *significant at 5% level
(All standard errors are clustered at the individual level)

Table 16: Coauthors: Timing of Coauthorship

	(1)	(2)	(3)	(4)
	Physics		Chemistry	
Dependent Variable	Publi-cations	Citation Weighted Pub.	Publi-cations	Citation Weighted Pub.
Coauthors 1929 - 1932				
# of Dismissed Coauthors	0.322	7.990	0.048	-8.156
	(0.572)	(7.889)	(0.619)	(11.506)
Avg. Quality of Dism. Coauthors	-0.007	-0.123	-0.012	-0.156
	(0.003)*	(0.039)**	(0.003)**	(0.050)**
Coauthors 1924 - 1928 (not later)				
# of Dismissed Coauthors	-0.011	-2.214	-0.005	-0.087
	(0.959)	(23.495)	(0.405)	(4.609)
Avg. Quality of Dism. Coauthors	0.007	0.108	0.003	0.064
	(0.019)	(0.437)	(0.004)	(0.064)
Age Dummies	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓
University FE	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓
Observations	2243	2243	3575	3575
# of researchers	258	258	413	413
R-squared	0.40	0.27	0.67	0.54

**significant at 1% level *significant at 5% level
(All standard errors are clustered at the individual level)

Table 17: Coauthors: Publications without dismissed Coauthors

	(1)	(2)	(3)	(4)
	Physics		Chemistry	
Dependent Variable	Publi-cations	Citation Weighted Pub.	Publi-cations	Citation Weighted Pub.
# of Dismissed Coauthors	0.458	10.777	0.558	-1.523
	(0.553)	(9.978)	(0.360)	(8.019)
Avg. Quality of Dism. Coauthors	-0.007	-0.144	-0.012	-0.290
	(0.003)*	(0.058)*	(0.003)**	(0.048)**
Age Dummies	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓
University FE	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓
Observations	2243	2243	3575	3575
# of researchers	258	258	413	413
R-squared	0.39	0.28	0.67	0.53

**significant at 1% level *significant at 5% level
(All standard errors are clustered at the individual level)

11 Appendix

Sample Page from List of Displaced German Scholars

BEER, Dr. Arthur P., Researcher; b. 1900., married, 1 child. (English, French, Czech.) 1928/33: Researcher Universitätssternwarte, Breslau, and Deutsche Sternwarte, Hamburg. since 1934: Researcher Solar Physics Observatory, Cambridge University. SPEC.: *Astronomy; Astro- and Geo-Physics.* Temp.

BERG, Dr. Wolfgang, F., Assistant; b. 03., married. (English, French.) 1930/33: Assistant Physikalisches Institut, Berlin University; 1934/36: Researcher Physical Lab., Manchester University; since 1936: Industrial Activity, London. SPEC.: *Experimental Physics. Fluorescence of Atoms and Molecules; Structure and Deformation of Crystals; X-Ray Methods.* Temp.

BERGSTRÄSSER, Dr. Martin, Assistant; b. 02., married. (English, French.) 1927/33: Assistant Technische Hochschule, Dresden; 1933/34: Assistant Deutsche Versuchsanstalt für Luftfahrt, Berlin. SPEC.: *Technical Physics; Testing of Materials; Solidity; Mechanics.* Unpl.

BETHE, Dr. Hans, Privatdozent; b. 06., single. (English.) Till 1933: Privatdozent Göttingen University; 1934/35: Researcher Bristol University; since 1935: Cornell University, Ithaca (N.Y.). SPEC.: *Theoretical Physics. Quantum Mechanics.* Perm.

BIEL, Dr. Erwin, Privatdozent; b. 99., married, 1 child. (English, French, Italian.) Till 1929: Assistant Geographisches Institut, Vienna University; 1929/33: Climatologist Meteorologisches Observatorium, Breslau; 1932/33: Privatdozent Breslau University. SPEC.: *Geo-Physics; Climatology.* Unpl.

BLOCH, Dr. Felix, Privatdozent; b. 05., single. (English.) Till 1933: Privatdozent and Assistant Physikalisches Institut, Leipzig University; since 1933: Prof. Stanford University, California. SPEC.: *Theoretical Physics; Atomic Physics.* Perm.

BOAS, Dr. Walter, Assistant; b. 04., single. (English, French.) 1928/32: Researcher Kaiser Wilhelm Institut für Metallforschung, Berlin; 1933/35: Assistant Fribourg University; since 1936: Researcher Physikalisches Institut, Technische Hochschule, Zürich. SPEC.: *Technical Physics; Metallography; Plasticity and Structure of Metals; X-Rays.* Unpl.

BOEHM, Dr. Gundo, Assistant. Till 1933: Assistant Physikalisches Institut, Freiburg University. SPEC.: *Micellar Structure of Muscles.* Unpl.

BORN, Dr. Max, o. Professor; b. 82., married, 3 children. (English.) 1915/19: a.o. Prof. Berlin University; 1919/21: o. Prof. Frankfurt University; 1921/33: o. Prof. Göttingen University; 1933/35: Lecturer Cambridge University; since 1936: Prof. Edinburgh University. SPEC.: *Theoretical Physics; Quantum Theory; Atomic Structure; Optics; Mathematical Physics.* Perm.

BURSTYN, Dr. Walther, a.o. Professor; b. 77., married. (English, French.) 1920/33: a.o. Prof. Technische Hochschule, Berlin. SPEC.: *Technical Physics.* Unpl.

BYK, Dr. Alfred, a.o. Professor; b. 78., married, 2 children. (English, French, Italian, Dutch.) 1905: Privatdozent Technische Hochschule, Berlin; 1909/33: Privatdozent, later a.o. Prof. Berlin University and Technische Hochschule. SPEC.: *Mathematical Physics; Theoretical Electrotechnics; Quantum Theory; Boundaries of Physics and Chemistry.* Unpl.

COHN-PETERS, Dr. H. Jürgen, Researcher; b. 07. Till 1933: Researcher Berlin University; since 1934: U.S.S.R. SPEC.: *Experimental Physics. High Tension.* Perm.

DEMBER, Dr. Alexis, Assistant; b. 12., single. (English, French.) since 1935: Assistant Physical Institute, Istanbul University. SPEC.: *Electrolytes; Photoelectricity.* Temp.

DEMBER, Dr. Harry, o. Professor; b. 82., married, 2 children. (English, French, Spanish, Turkish.) 1909/33: Privatdozent, later o. Prof. Technische Hochschule, Dresden; and Director Physikalisches Institut; since 1933; o. Prof. Istanbul University and Director Physical Institute. SPEC.: *Cathode and X-Rays; Photo-Electricity; Atmospheric Optics; Atmospheric Electricity.* Perm.

DUSCHINSKY, Dr. F., Assistant; b. 07., single. (French, Italian, Spanish, Dutch.) 1933: Assistant Kaiser Wilhelm Institut für Physik, Berlin; since 1934: Assistant Brussels University. SPEC.: *Experimental Physics; Fluorescence; Molecular Spectra; Optics; High Frequency Technics.* Temp.

EHRENBERG, Dr. Werner, Assistant; b. 01., single. (English, French.) 1924/27: Assistant Kaiser Wilhelm Institut für Faserstoffchemie, Berlin; 1928/30: Researcher Berlin University and Technische Hochschule, Stuttgart; 1930/33: Assistant Technische Hochschule, Stuttgart; since 1935: Electric and Musical Industries, Ltd., Hayes (Middlesex). SPEC.: *Experimental Physics. X-Rays; Cathode Rays; Cosmic Radiation.* Perm.

EINSTEIN, Dr. Albert, o. Professor; b. 79., married. (English.) 1913/33: o. Prof. Berlin University and Director Kaiser Wilhelm Institut für Physik; 1921 Nobel Prize; since 1934: Prof. Institute for Advanced Study, Princeton (N.J.).

EISENSCHITZ, Dr. Robert, Researcher; b. 98., married. (English, French.) 1924/27: Researcher Allgemeine Elektrizitätsgesellschaft, Berlin; 1927/33: Researcher Kaiser Wilhelm Institut für Physikalische Chemie und Elektrochemie, Berlin; since 1934: Researcher Royal Institution, London. SPEC.: *Theoretical and Experimental Physics; Spectroscopy; Viscosity; Application of Physical Theories to Chemical Problems.* Temp.

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Squares were added by the author to highlight the researchers who had already received the Noble prize or were to receive it after 1936.

Table A1: Specializations

Physics		Chemistry		Mathematics	
Specialization	% scientists in speciali-zation	Specialization	% scientists in speciali-zation	Specialization	% scientists in speciali-zation
Experimental Physics	48.5	Organic Chemistry	26.6	Analysis	45.9
Theoretical Physics	22.3	Physical Chemistry	23.8	Applied Mathematics	36.2
Technical Physics	20.6	Technical Chemistry	19.4	Algebra	19.7
Astronomy	14.7	Anorganic Chemistry	18.6	Number Theory	13.5
		Pharmacology	10.2	Metha Mathematics	5.2
		Medical Chemistry	8.0	Topology	4.8
		Biochemistry	6.7	Foundations of Math.	4.4

Percentages add to more than 100 percent because some physicists and chemists have two specializations. Mathematicians have up to four specializations.

Table A2: Top Researchers 1925-1932 (Citation weighted Publications Measure)

Name	University beginning of 1933	First Special-ization	Second Special-ization	Third Special-ization	Avg. Cit weighted Publ.	Avg. Publ.	Nobel Prize	Dis-missed 33-34
Physics								
Fritz London	Berlin	Theo. Phy.			149.3	1.3		✓
Lother Nordheim	Göttingen	Theo. Phy.			110.0	0.7		✓
Gerhard Herzberg	Darmstadt TU	Exp. Phy.			78.0	2.0	✓	
Carl Ramsauer	Berlin TU	Exp. Phy.			75.6	3.0		
Max Born	Göttingen	Theo. Phy.			62.5	1.3	✓	✓
Hans Falkenhagen	Köln	Theo. Phy.			57.5	1.9		
Arnold Sommerfeld	München	Theo. Phy.			44.4	1.8		
Eugen Wigner	Berlin TU	Theo. Phy.			44.3	0.5	✓	✓
Heinrich Kuhn	Göttingen	Exp. Phy.	Theo. Phy.		42.0	4.0		✓
Harry Dember	Dresden TU	Exp. Phy.			40.8	1.0		✓
Karl Herzfeld		Theo. Phy.			33.7	1.3		
Richard Gans	Königsberg	Exp. Phy.			29.4	1.6		
Walter Gerlach	München	Exp. Phy.			29.1	3.1		
Wolfgang Pauli		Theo. Phy.			28.0	3.8	✓	
Max Wien	Jena	Exp. Phy.			25.4	2.0		
Werner Heisenberg	Leipzig	Theo. Phy.			25.3	1.0	✓	
Ludwig Prandtl	Göttingen	Tech. P.			23.3	1.1		
Fritz Kirchner	München	Exp. Phy.			22.5	2.5		
Johannes Malsch	Köln	Exp. Phy.			22.0	1.5		
Emil Rupp	Berlin TU	Exp. Phy.			21.4	5.2		✓
Chemistry								
Werner Kuhn	Karlsruhe TU	Physical C.			262.0	7.0		
Max Bergmann	Dresden TU	Organic C.	Biochem.		250.2	6.8		✓
Karl Lohmann	Heidelberg	Medical C.			224.0	6.0		
Ernst Bergmann	Berlin	Physical C.			223.3	17.0		✓
Carl Neuberg	Berlin	Biochem.			184.9	15.1		
Carl Wagner	Jena	Physical C.			177.5	5.0		
Otto Meyerhof	Heidelberg	Medical C.			176.3	5.8	✓	
Otto Ruff	Breslau TU	Anorganic C.			133.4	7.2		
Wolfgang Ostwald	Leipzig	Anorganic C.			127.0	8.6		
Hermann Staudinger	Freiburg	Organic C.			126.8	8.5	✓	
Gustav Tammann	Göttingen	Physical. C.			118.4	19.0		
Michael Polanyi	Berlin TU	Physical. C.			116.8	5.6		✓
Max Volmer	Berlin TU	Physical. C.			114.0	4.2		
Karl Freudenberg	Heidelberg	Organic C.			111.8	7.0		
Ulrich Hofmann	Berlin TU	Anorganic C.	Physical C.		109.0	6.0		
Richard Johann Kuhn	Heidelberg	Physical C.	Medical C.		92.1	8.0	✓	
Max Trautz	Heidelberg	Physical C.			91.9	5.3		
Wilhelm Klemm	Hannover TU	Anorganic. C.			91.4	5.2		
Mathematics								
Johann von Neumann	Berlin	Applied Math	Foundations	Analysis	36.3	1.5		✓
Richard Courant	Göttingen	Analysis	Applied Math		22.3	1.3		✓
Richard von Mises	Berlin	Applied Math	Analysis		15.6	0.9		✓
Heinz Hopf		Algebra	Topology	Geometry	13.3	1.3		
Paul Epstein	Frankfurt	Geometry	Number Th.	Algebra	11.5	0.6		
Oskar Perron	München	Algebra	Analysis		10.6	1.5		
Willy Prager	Göttingen	Applied Math			10.0	0.4		✓
Gabiel Szegö	Königsberg	Applied Math	Geometry		9.4	1.4		✓
Werner Rogosinski	Königsberg	Number Th.	Analysis		9.1	0.6		
Wolfgang Krull	Erlangen	Algebra			8.9	1.4		
Erich Rothe	Breslau TU	Analysis	Applied Math		8.0	1.0		✓
Hans Peterssonn	Hamburg	Number Th.	Analysis		8.0	2.0		
Adolf Hammerstein	Berlin	Number Th.	Analysis		8.0	0.5		
Alexander Weinstein	Breslau TU	Applied Math			6.3	0.7		✓
Erich Kamke	Tübingen	Number Th..	Foundations	Analysis	6.3	0.8		
Hellmuth Kneser	Greifswald	Applied Math	Analysis	Topology	6.3	0.6		
Bartel van der Waerden	Leipzig	Algebra	Geometry		5.8	1.8		
Max Müller	Heidelberg	Analysis			5.3	0.3		
Richard Brauer	Königsberg	Algebra			5.0	0.6		✓
Leon Lichtenstein	Leipzig	Analysis	Applied Math		4.9	1.5		✓

The university in 1933 is missing for researchers, who retire before before 1933.

Table A3: Probability of Being Chaired Professor

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:						
Chaired Prof. Dummy	Physics		Chemistry		Mathematics	
Peer Group:	Department Level	Specialization Level	Department Level	Specialization Level	Department Level	Specialization Level
Number Dismissed	-0.000	-0.020	0.004	0.011	0.010	0.032
	(0.007)	(0.010)	(0.003)	(0.014)	(0.015)	(0.021)
Dismissal Induced	-0.009	0.000	0.001	0.002	-0.021	-0.035
↓ in Peer Quality	(0.005)	(0.002)	(0.003)	(0.002)	(0.035)	(0.023)
Age Dummies	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓
Observations	2261	2257	3584	3567	1538	1538
# of researchers	258	256	413	405	183	183
R-squared	0.90	0.90	0.89	0.89	0.92	0.92

Table A4: Robustness Checks Instrumental Variables Physics (Specialization Level)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full Sample	Full Sample	omitting 33 & 34	omitting 33 & 34	younger than 45	45 or older	younger than 45	45 or older	Full Sample	Full Sample
Dependent Variable	Publi-cations	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.	Publi-cations	Publi-cations	Cit. weight. Publ.	Cit. weight. Publ.	Publi-cations	Cit. weight. Publ.
Department Size	-0.018	-0.704	-0.044	-1.052	-0.013	-0.057	0.653	-1.847	-0.005	-0.430
	(0.028)	(0.494)	(0.033)	(0.610)	(0.052)	(0.022)*	(0.766)	(0.723)*	(0.039)	(0.588)
Peer Quality	-0.008	-0.231	-0.023	-0.471	0.041	-0.023	0.637	-0.357	-0.003	-0.212
	(0.024)	(0.414)	(0.029)	(0.434)	(0.037)	(0.030)	(0.586)	(0.602)	(0.025)	(0.454)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University specific. Time Trends									✓	✓
Observations	2257	2257	1863	1863	838	1419	838	1419	2257	2257
# of researchers	256	256	254	254	137	178	137	178	256	256
Cragg-Donald EV Statistic	116.53	116.53	61.68	61.68	24.19	89.61	24.19	89.61	131.53	131.53

**significant at 1% level *significant at 5% level (All standard errors clustered at the department level)

Table A5: Robustness Checks Instrumental Variables Chemistry (Specialization Level)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full Sample	Full Sample	omitting 33 & 34	omitting 33 & 34	younger than 45	45 or older	younger than 45	45 or older	Full Sample	Full Sample
Dependent Variable	Publi- cations	Cit. weight. Publ.	Publi- cations	Cit. weight. Publ.	Publi- cations	Publi- cations	Cit. weight. Publ.	Cit. weight. Publ.	Publi- cations	Cit. weight. Publ.
Department Size	-0.005	-0.430	0.003	-1.067	0.024	-0.528	-0.065	0.040	-2.284	-0.179
	(0.039)	(0.588)	(0.047)	(0.850)	(0.046)	(0.683)	(0.138)	(0.048)	(3.051)	(0.472)
Peer Quality	-0.003	-0.212	-0.005	0.010	-0.005	0.055	0.005	-0.007	-0.051	0.024
	(0.025)	(0.454)	(0.007)	(0.091)	(0.007)	(0.087)	(0.014)	(0.009)	(0.235)	(0.097)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University specific. Time Trends									✓	✓
Observations	2257	2257	3586	3567	2913	2913	1303	2264	1303	2264
# of researchers	256	256	405	405	404	404	203	290	203	290
Cragg-Donald EV Statistic	131.53	131.53	206.12	206.12	190.64	190.64	40.12	164.86	40.12	164.86

Table A6: Robustness Checks Instrumental Variables Mathematics (Specialization Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full Sample	Full Sample	omitting 33 & 34	omitting 33 & 34	younger than 45	45 or older	younger than 45	45 or older	Full Sample	Full Sample
Dependent Variable	Publi- cations	Cit. weight. Publ.	Publi- cations	Cit. weight. Publ.	Publi- cations	Publi- cations	Cit. weight. Publ.	Cit. weight. Publ.	Publi- cations	Cit. weight. Publ.
Department Size	0.101	-1.205	-2.141	25.734	0.045	-0.083	-1.228	-1.781	-0.002	-1.381
	(0.126)	(1.423)	(32.147)	(392.778)	(0.121)	(0.303)	(0.984)	(3.641)	(0.117)	(1.214)
Peer Quality	-0.045	0.778	0.751	-8.832	-0.026	0.055	0.613	0.932	0.006	0.858
	(0.059)	(0.505)	(11.462)	(139.978)	(0.040)	(0.136)	(0.349)	(1.661)	(0.078)	(0.773)
Age Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year Dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
University specific. Time Trends									✓	✓
Observations	1538	1538	1256	1256	672	866	672	866	1538	1538
# of researchers	183	183	183	183	106	119	106	119	183	183
Cragg-Donald EV Statistic	8.56	8.56	0.021	0.021	16.38	1.81	16.38	1.81	12.93	12.93

**significant at 1% level *significant at 5% level (All standard errors clustered at the department level)