RESEARCH STATEMENT

Fabian Waldinger, November 2026

I study how economies produce new knowledge and how institutions allocate the people who produce it. My research lies at the intersection of the economics of innovation and economic history, with close links to labor economics. The economics of innovation provides the central questions: how scientific and managerial talent is formed and matched to organizations; how ideas spread through professional networks and across national borders; and how political and organizational institutions shape the quantity, quality, and direction of innovation. Economic history is particularly valuable for answering these questions. It offers opportunities for credible identification and the long time horizons needed to study innovation, whose effects often unfold over years or decades. But the historical episodes I study are more than settings for empirical analysis. Understanding the economic consequences of these episodes is also an important contribution of my research.

Four main findings emerge from my research. First, exceptional scientists matter less through productivity spillovers to established colleagues than through training young researchers and attracting new talent. I find this pattern in German universities, for U.S. inventors after the arrival of émigré chemists, and in the long-run hiring of universities that lost star scientists. Second, discrimination and other barriers to entry lead to a costly misallocation of talent: the removal of Jewish managers from German firms destroyed market value equivalent to about 1.8% of German GNP, while barriers related to gender and socio-economic background affect who enters and succeeds in science. These barriers also influence which ideas are produced, as scientists from poorer backgrounds introduce more novel concepts in their research. Third, the international movement of scientists and the exchange of ideas are important drivers of innovation. My research shows that high-skilled migration stimulates innovation, that professional networks shape the international allocation of talent, and that losing access to foreign frontier research substantially reduces scientific productivity. Fourth, institutions play an important role in the allocation of scientific talent and the production of knowledge. Making scientific quality more observable improves the allocation of talent across universities, and political institutions affect the size and productivity of the scientific sector and the breadth of scientific discovery.

A central feature of my research is the construction of new datasets, as most of the questions I study cannot be answered with existing data. I therefore collect archival records on a large scale and link them to publication and citation data, patents, biographical sources, firm records, historical stock prices, and population censuses. In several projects, this has required identifying and digitizing archival sources that had not previously been used in economics or economic history. My early work was among the first in economic history to use large-scale individual-level data to study highly skilled workers, whose careers had previously been examined mainly through individual case studies. For my early research on German universities, I reconstructed the universe of science professors in interwar Germany by digitizing faculty rosters spanning more than half a century and reconstructing department-level measures of wartime destruction from primary sources. In subsequent work on managerial talent, my coauthors and I reconstructed the careers of tens of thousands of senior managers at all firms listed on the Berlin Stock Exchange and linked these records to more than 240,000 historical stock prices and measures of firm performance. Over the past decade, I have extended this approach to the international scientific system, most notably through the World of Academia Database, which I have built with coauthors. It is the largest worldwide database of academic careers, containing more than half a million observations from 7,477 universities in 151 countries. The construction of these datasets is an important part of each project's contribution. Because the new data enable me to follow individuals over large parts of their careers, I can study knowledge production, the dynamics of

scientific and managerial careers, and the allocation of talent in ways that conventional sources do not permit.

Answering some of my research questions also requires novel measures of objects central to knowledge production but not directly observable in conventional data, e.g., the content of academic papers, the distance between research fields, and the novelty of academic research. To construct these measures, my coauthors and I draw on machine-learning and natural language processing methods, which we began using before they were widely adopted in economics. In Iaria, Schwarz, and Waldinger (2018), one of the first papers in the economics of science and innovation to use modern natural language processing as a central measurement tool, we use latent semantic analysis to measure the semantic similarity of scientific papers. We also link newly emerging scientific concepts to the full text of more than 2.5 million U.S. patents to trace their use in technological invention. In more recent work, we develop this approach further. In research on gender gaps in academia (Iaria, Schwarz, and Waldinger 2026), we develop a machine-learning procedure that predicts a paper's expected citations from the words in its title. This enables us to examine whether gender gaps in citations arise because men and women work on systematically different topics.

New data and measures do not, however, resolve the central identification problems in the study of knowledge production. Productive researchers sort into the best departments, firms select talented managers, scientists endogenously choose their collaborators, and countries and regions that attract talent differ from others along many dimensions. To estimate causal effects, I therefore exploit historical shocks and institutional changes that provide exogenous variation. Among others, I study the dismissal of Jewish scientists and managers in Nazi Germany, Allied bombing during World War II (WWII), the breakdown of international science after World War I (WWI), the introduction of the first citation index, and sharp changes in political institutions. Using these episodes for causal identification requires a detailed understanding of each historical setting. My empirical work closely engages with the historical literature on the episodes that I study. I work extensively with primary sources, and several of my projects contribute new evidence to further our understanding of the historical episodes themselves. For example, our work on Jewish managers provides an estimate of the economic costs of their forced removal from major German firms (Huber, Lindenthal, and Waldinger 2021), a question that historians had previously examined but not quantified. This careful historical research is crucial for the empirical analysis as it helps to evaluate the identifying assumptions and to better understand the mechanisms through which the shocks affect economic outcomes.

The remainder of this statement describes the four interconnected parts of my research program. Section I presents my research on the role of human capital in the production of knowledge. Section II describes how discrimination and unequal access shape the allocation of talent in academia and in firms. Section III covers my research on the international diffusion of knowledge through migration, professional networks, and access to frontier research. Finally, Section IV discusses my work on how scientific and political institutions affect the allocation of talent and the production of knowledge.

I. HUMAN CAPITAL AND THE ORGANIZATION OF KNOWLEDGE PRODUCTION

Universities and firms differ enormously in the knowledge they produce, and these differences are often attributed to the quality of their researchers. Talented researchers can raise output through several distinct channels: their own discoveries, the training of the next generation, and spillovers to their colleagues. Yet knowledge production also depends on physical inputs such as laboratories, equipment, and buildings. Because the most talented researchers tend to sort into the best organizations, which typically also have superior facilities, correlations between peer quality, infrastructure, and productivity reveal little about the causal contribution of each input.

My early research exploits two historical shocks that provide unusually sharp variation in human and physical capital. After the Nazi government came to power in 1933, German universities were forced to dismiss Jewish and politically opposed academics. Depending on the discipline, between 13% and 18% of researchers were dismissed. The upheaval affected some of Germany's most prominent academics, including Nobel laureates such as Albert Einstein and Fritz Haber, leading mathematicians such as Emmy Noether, and world-class researchers across almost all disciplines. The dismissals, however, varied substantially across university departments. Some departments lost more than half of their researchers, while others were left untouched. This changed faculty quality for reasons unrelated to the departments' own hiring decisions. A few years later, Allied bombing during WWII destroyed university buildings and laboratories. The extent of destruction varied widely across universities and departments, in ways unrelated to their scientific strength.

I use these shocks to study three questions: how important human capital is relative to physical capital, how faculty quality affects the formation of new scientists, and whether high-quality peers raise the productivity of their established colleagues. The two shocks enable me to compare the contributions of human and physical capital within the same setting, something that is rarely possible because the two inputs usually move together. I find substantial differences between the two inputs. Losing star scientists weakens departments for decades, whereas departments recover quickly from the destruction of physical capital. The persistent effects of losing human capital, however, do not operate through spillovers to established colleagues. Instead, star scientists matter primarily by training the next generation and attracting other strong researchers.

The first question concerns the relative importance of human and physical capital. The few existing papers study either the loss of people *or* the destruction of physical capital in isolation. This makes comparisons across studies difficult because differences in inputs are confounded with differences in context. In **Bombs, Brains, and Science: The Role of Human and Physical Capital for the Creation of Scientific Knowledge (Waldinger 2016, ReStat)**, I study both shocks in the same setting. I construct a panel of German and Austrian science departments by digitizing faculty rosters spanning more than half a century. I also measure wartime destruction at the department level using archival records of bomb damage to university buildings and laboratories. With these data, I can estimate the effect of each input and trace how quickly departments recovered from each shock.

I find that both human and physical capital losses reduce scientific output, but the effects of human capital losses are substantially larger and more persistent. Departments recover quickly from the destruction of buildings and laboratories, and their output even increases as facilities are upgraded during reconstruction. In contrast, scientific output remains depressed for decades after the dismissal of high-quality scientists. An important mechanism is subsequent hiring. Departments that lose leading scientists become less successful at attracting high-quality researchers in later years, particularly when the dismissed scientists were stars. These findings highlight an important difference between the two types of capital. Physical capital can be rebuilt, whereas the loss of exceptional scientific human capital can weaken an organization's ability to attract talent and reduce its research capacity for decades.

My findings highlight the central role of human capital in the production of new knowledge. This raises the question of how high-quality researchers affect the work of those around them. The most direct channel is the training of the next generation of researchers. Faculty quality is widely thought to be crucial for training new researchers, but identifying its causal effect is difficult because talented students select, and are selected by, the best departments. In **Quality Matters: The Expulsion of Professors and the Consequences for PhD Student Outcomes in Nazi Germany (Waldinger 2010, JPE)**, I address this problem using the dismissal of professors after 1933, which generated exogenous changes in faculty quality and department size across universities and student cohorts. To study these questions, I reconstruct the universe of mathematics PhD students in Germany between 1923 and 1938

and trace their subsequent careers, including dissertation publications, professorial appointments, and lifetime citations. I link these student-level data to annual faculty rosters for each mathematics department, which I reconstruct from primary sources. Since the dismissals affected some departments and cohorts but not others, I can exploit variation in both the quality and the size of the faculty to which students were exposed, independent of how students selected into departments.

Faculty quality has large and lasting effects on PhD students' careers. A one standard-deviation increase in faculty quality raises the probability that a student's dissertation is published in a top journal by about 13 percentage points, the probability of later becoming a full professor by about 10 percentage points, and the probability of having positive lifetime citations by about 16 percentage points. In contrast, I find no comparable effects of faculty size on these outcomes. What matters for the formation of new researchers is therefore the quality, rather than the quantity, of more established researchers. Importantly, these effects are not limited to performance during or immediately after the PhD. Because I can follow students over their entire scientific careers, I can examine how the quality of their PhD training affects long-run outcomes.

Beyond training the next generation of researchers, high-quality scientists may also raise the productivity of their established colleagues. Such peer effects are a common explanation for why highly skilled workers cluster in the same universities, research laboratories, and innovative regions. Identifying peer effects is difficult, however, because productive scientists sort into departments with productive peers. In **Peer Effects in Science: Evidence from the Dismissal of Scientists in Nazi Germany (Waldinger 2012, ReStud)**, I use the dismissals to provide the first causal evidence on peer effects among highly skilled workers. Unlike studies of coauthors, in which a star's influence operates through joint production, I examine spillovers to departmental colleagues who need not collaborate with the star. I construct a panel of scientists at German universities, combine it with annual information on the size and research quality of their departments, and compare the subsequent productivity of scientists who lost high-quality peers with that of scientists in unaffected departments.

In contrast to the effects on PhD students, I find no evidence that established scientists become less productive when high-quality colleagues are dismissed, even when they lose particularly productive peers. The strong correlation between peer quality and individual productivity across departments therefore need not reflect causal spillovers. Instead, much of this correlation appears to arise from the sorting of productive scientists into high-quality departments.

Taken together, these papers indicate that star scientists matter less through spillovers to established colleagues than through attracting other strong researchers and training the next generation of researchers. The findings help explain why some scientific organizations remain at the frontier for decades, while others fail to recover after losing their leading researchers. For organizations that compete for talent, the value of hiring a star therefore lies less in raising the output of existing colleagues than in training junior researchers and attracting new talent.

II. DISCRIMINATION, UNEQUAL ACCESS, AND THE MISALLOCATION OF TALENT

The research described in Section I uses discrimination as a source of exogenous variation in human capital. My second strand of research studies discrimination and unequal access as economic phenomena in their own right. If talent were allocated purely by ability, characteristics such as gender, family background, or religion would play no role in careers in knowledge-intensive occupations. Yet discrimination and unequal access based on these characteristics strongly affect who enters these occupations and how far they advance. Such distortions raise concerns not only about equity and equality of opportunity but also about efficiency, because excluding able individuals leads to a misallocation of talent. In knowledge-producing sectors such as academia, they create an additional inefficiency:

the unique lived experiences of underrepresented groups offer valuable perspectives that could diversify and enrich the scope of ideas that are explored.

Measuring such distortions is difficult, however, because standard data cover only those who succeed and rarely record their backgrounds. To study these questions, my coauthors and I assemble data on the full population of academics, whether or not they publish, and trace U.S. academics back to their childhood households. This lets us study entry and later career outcomes within the same population. In related work on firms, we measure the costs of discrimination when highly qualified managers are forced out of the largest German corporations.

In **Gender Gaps in Academia: Global Evidence over the Twentieth Century (Iaria, Schwarz, and Waldinger 2026)**, we study how gender gaps in academia evolved over the 20th century using data with unprecedented historical and geographic coverage. These data come from the World of Academia Database, which my coauthors and I have assembled over more than a decade and which is, to our knowledge, the largest worldwide database of academics to date. We hand-collect and digitize complete faculty rosters from historical university directories and archived university websites, yielding more than half a million observations across all academic disciplines, 7,477 universities, and 151 countries. We link these records to detailed publication and citation data and harmonize academic ranks and disciplines across countries. Beyond its scope, a key advantage of the database is that it covers the full population of academics, whether or not they publish. Publication databases and compilations of prominent scientists, by contrast, include only selected academics. Analyses based on such sources therefore condition on outcomes that may themselves differ by gender.

Using these data, we examine four gender gaps throughout the academic career path: entry into academia, publications, citations, and promotions. We also study how gaps at different stages interact. All four gaps decline over the 20th century, but their magnitude varies substantially across periods, countries, and disciplines. There is therefore no single gender gap in academia, and the richness of our data allows us to document this heterogeneity. Women are less likely to enter academia, particularly at prestigious universities and in STEM, and those who enter publish fewer papers. The publication gap, however, varies systematically with female representation. When very few women enter academia, those who do are exceptionally positively selected, a pattern we refer to as "Marie Curie periods," and the publication gap is small. As female representation rises, this selection effect weakens, and the publication gap widens. At higher levels of representation, improved publishing opportunities for women begin to dominate, an empowerment effect, and the gap narrows again. Women's relative publication output therefore follows a U-shape in female representation.

We also document a gender gap in citations, but interpreting this gap raises an important concern: men and women may work on research topics with different citation potential. We therefore develop a machine-learning procedure that applies natural language processing methods to paper titles to predict each paper's expected citations. Controlling for these predicted citations leaves the gender citation gap essentially unchanged, indicating that differences in research topics do not explain the lower citation counts of women's papers. Finally, women are less likely to be promoted to full professor, and most of the promotion gap remains after controlling for their publication and citation records. Overall, the results show how barriers at successive stages of the academic career shape both how many women enter academia and how they are subsequently allocated, recognized, and promoted.

The previous paper indicates that gender gaps in academia narrowed substantially over the 20th century. Much less is known about whether other barriers to academic careers have declined similarly, with socio-economic background being a particularly interesting case. Unlike gender, family background is not directly observable, so barriers associated with it may differ from those faced by women and need not have declined with social and institutional changes that reduced gender gaps. Limited observability makes family background difficult to study, as neither faculty rosters nor publication

data carry information on family backgrounds. In **Climbing the Ivory Tower: How Socio-Economic Background Shapes Academia (Abramitzky, Greska, Pérez, Price, Schwarz, and Waldinger 2026)**, we overcome this limitation and examine how family background determines who becomes an academic, how this relationship has evolved over time, and whether scientists from different backgrounds differ in their productivity, the ideas they produce, and the recognition they receive.

Answering these questions requires information on the households in which academics grew up. We obtain this information by matching faculty rosters from the World of Academia Database to individual-level microdata from historical full-count U.S. censuses. By linking individuals across census years, we can reconstruct the family backgrounds of 46,139 academics at 1,026 U.S. universities. We then link these records to publication and citation data, as well as measures of scientific recognition.

We find that academics disproportionately come from privileged backgrounds. Around half of U.S. academics grew up in families in the top quintile of the parental income distribution, with even greater overrepresentation at elite universities. This imbalance has hardly changed over seven decades, despite the expansion of U.S. higher education and the substantial increase in women's representation over the same period. Differences in cognitive ability, proxied by Army General Classification Test scores from WWII enlistment records, explain only part of this pattern. Socio-economic background also predicts the disciplines in which academics work, suggesting that barriers related to social origin affect not only who produces knowledge but potentially also the direction of scientific research.

The underrepresentation of scientists from poorer backgrounds also has consequences for the quantity and direction of research. The relatively few scientists from the bottom quintile of the socio-economic distribution are disproportionately productive: they publish about one additional paper over an eleven-year period, roughly 20% more than scientists from the top quintile. They also introduce more novel scientific concepts, which subsequently spread to other scientific papers and patents. Yet academics from poorer backgrounds receive less recognition for their work, including fewer citations, Nobel nominations, and awards. Unequal treatment thus persists even among those who overcome the barriers to entering academia. These findings suggest that barriers related to family background exclude highly productive researchers and limit the range of ideas produced by the scientific community.

My research on gender and family background shows that entry barriers and obstacles at later career stages shape who produces scientific knowledge and which ideas are pursued. The costs of discriminating against highly qualified individuals, however, extend well beyond academia. Much of the literature on discrimination focuses on its consequences for wages and employment of those who face discrimination. In **Discrimination, Managers, and Firm Performance: Evidence from "Aryanizations" in Nazi Germany (Huber, Lindenthal, and Waldinger 2021, JPE)**, my coauthors and I instead study its consequences for the firms that discriminate. We identify these effects using the forced removal of Jewish managers from the largest German firms after the Nazis seized power in 1933.

From historical records, we reconstruct approximately 30,000 senior management positions at all 655 firms listed on the Berlin Stock Exchange. We link these data to more than 240,000 historical stock prices and to information on dividends, accounting outcomes, and managers' human capital and professional networks that we extract from primary sources. These data enable us to compare firms that lost Jewish managers with firms that did not, and to study how the dismissals affected board composition, stock prices, dividends, and return on assets. Since stock prices reflect expected future profitability, this approach allows us to quantify the economic costs of losing managerial talent.

We find that firms that lost Jewish managers experienced large and persistent declines in performance. Their stock prices fell by about 10% relative to firms without Jewish managers and did not recover for at least a decade. Dividends and returns on assets also declined. The losses were particularly large in firms whose Jewish managers were highly educated or well connected to other firms through board

interlocks. A back-of-the-envelope calculation suggests that losing Jewish managers lowered the aggregate market valuation of firms listed in Berlin by 1.8% of German GNP.

This research also contributes to our understanding of the determinants of firm performance and the role of management. While influential research emphasizes management practices as a technology that firms can learn and adopt, our research highlights a complementary channel: firm performance also depends on the human capital of individual managers, whose skills and professional networks are difficult to replace. More broadly, discrimination against senior managers can impose high and persistent economic costs that extend well beyond the individuals directly affected.

Taken together, this research indicates that ability alone does not determine who enters knowledge-intensive careers. Gender and family background affect access to academia, productivity, and recognition. Because family background also influences the research questions scientists pursue, barriers to entry not only affect who produces knowledge but also which ideas are developed. The study of Jewish managers in Nazi Germany shows that discrimination can have substantial economic consequences, with firms suffering large and persistent losses in market value. These findings highlight that discrimination and unequal opportunity are not only questions of equity: they can also reduce the production of valuable ideas and impose substantial costs on universities, firms, and the broader economy.

III. MIGRATION, NETWORKS, AND THE DIFFUSION OF KNOWLEDGE

The research described above examines how human capital shapes knowledge production within organizations and how discrimination affects access to knowledge-intensive careers. A third strand of my research investigates how scientific talent and ideas influence knowledge production across organizational and national borders. Because knowledge is non-rival, discoveries can increase the productivity of researchers and inventors elsewhere. Yet realizing these benefits requires knowledge to spread, and frictions may limit diffusion. Some knowledge is tacit and only travels if researchers physically move. Other knowledge flows may be limited by political barriers. I exploit major historical disruptions to the movement of scientists and ideas, as well as variation in university students' opportunities to study abroad, to investigate the determinants and consequences of international mobility and knowledge diffusion. This research shows how migration and international scientific exchange shape the production of knowledge.

In **German Jewish Émigrés and US Invention (Moser, Voena, and Waldinger 2014, AER)**, we provide some of the earliest causal evidence that high-skilled migration can increase innovation in destination countries. We exploit the dismissal and subsequent emigration of chemistry professors from German and Austrian universities during the Nazi dictatorship. Identifying the causal effect of migrants on innovation is challenging because migrants select into destinations that offer particularly promising opportunities. Even in the case of forced migration, the choice of destination remains endogenous. To overcome this issue, we exploit variation in exposure to émigré research across scientific fields rather than geographic destinations. We reconstruct the migration histories of chemistry professors at German and Austrian universities and hand-link these records to historical U.S. patents. We then compare changes in patenting by U.S. inventors in the fields of émigré chemists with those working in fields of other chemists who remained in Germany. Because émigrés may have selected into particularly promising research fields after arriving in the United States, we instrument field-level exposure to émigré scientists' research with the pre-1933 research fields of chemists *dismissed* by the Nazi regime. These earlier research fields were determined before the Nazis came to power and were therefore not chosen in anticipation of innovation opportunities in the United States after 1933.

We find that the arrival of émigré scientists substantially increased U.S. invention. Patenting by U.S. inventors increased by 31% in research fields exposed to émigré scientists, with instrumental-variable estimates suggesting an increase of 71%. Importantly, this increase was driven primarily by the entry

of new inventors into these fields, rather than by productivity increases among incumbent inventors. Most entrants had not previously patented in the research fields we study, suggesting that the émigrés generated additional inventive activity rather than merely redirecting existing inventors. This finding closely parallels my earlier research on German universities: star scientists contribute to knowledge production not primarily by increasing the productivity of established colleagues, but by influencing younger researchers and attracting new talent. The paper thus establishes not only that high-skilled migration can stimulate innovation, but also an important mechanism: immigrant scientists attract new inventors into their fields and facilitate knowledge diffusion. Their contribution can extend far beyond their own scientific output, affecting both the quantity and the direction of technological change.

While this paper establishes that high-skilled migration can increase innovation in destination countries, a related question is what determines whether talented individuals migrate and where they go. In **Persecution and Escape: Professional Networks and High-Skilled Emigration from Nazi Germany (Becker, Lindenthal, Mukand, and Waldinger 2024, AEJ: Applied)**, we study how professional networks affect the international mobility and allocation of scientific talent. Networks may be particularly important for high-skilled migration because they transmit information about job opportunities and individual abilities that is difficult to obtain across national borders. Identifying these effects is challenging, however, because professional networks are endogenous: well-connected academics may differ systematically in their ability or willingness to emigrate.

We address this identification problem by exploiting differences in the timing of Nazi dismissals of Jewish academics. When the Nazi government began dismissing Jewish academics in 1933, certain groups, including WWI veterans, were initially exempted from the dismissals. These exemptions were subsequently revoked, creating exogenous variation in the timing of dismissals. We show that academics dismissed in 1933 or 1934 were more likely to emigrate by 1935, compared to academics dismissed in later years. We can therefore use the number of colleagues dismissed early as an instrument for the number of early émigrés (by 1935) in an academic's professional network. To measure these networks, we reconstruct detailed employment histories of academics with Jewish heritage in Weimar Germany, allowing us to trace their professional connections over time. Importantly, even academics working in the same department in 1933 had different networks because they had worked with different colleagues in previous years. This allows us to compare academics within the same department who were exposed to different numbers of early émigrés through their professional networks. We also manually reconstruct the post-1933 migration histories of 1,327 scholars dismissed from German universities, drawing on an extensive range of primary and secondary sources. With these data, we can follow the fate of all dismissed scholars, including those who emigrated, those who remained in Germany, and those who were murdered in Nazi concentration camps.

We find that professional networks substantially affect both whether academics emigrate and where they go. Furthermore, connections to émigrés in particular countries increase the probability of moving to precisely those destinations. The strength of these effects depends on the nature of the connections. Recent professional ties are considerably more important than older ones, and network effects are particularly large in fields where scientific quality is difficult to assess from publicly available information. This pattern is consistent with networks transmitting private information about scientific ability and opportunities abroad. Professional connections also matter more than broader community networks and at least as much as family ties. Our findings show that the international allocation of scientific talent depends not only on economic opportunities across countries but also on the professional networks connecting high-skilled individuals in different countries.

Earlier international experiences may also reduce barriers to migration. In **Studying Abroad and the Effect on International Labour Market Mobility: Evidence from the Introduction of ERASMUS (Parey and Waldinger 2011, EJ)**, we study whether spending part of one's university education

abroad increases subsequent international labor market mobility. To address the selection of internationally oriented students into studying abroad, we develop a novel identification strategy that exploits the staggered introduction and expansion of the ERASMUS exchange program across German universities and subjects. We reconstruct the availability of ERASMUS scholarships by university, subject, and year and use this variation as an instrument for studying abroad. We find that studying abroad increases the probability of subsequently working in another country by approximately 15 percentage points. The effects are particularly large for financially constrained students from less-educated families, and students who graduate in Germany often move to the countries where they had previously studied abroad. These findings suggest that international study experiences can have lasting effects on subsequent migration decisions.

Beyond networks and prior international experience, differences in the economic returns to skills also shape migration decisions of high-skilled individuals. In **The Selection of High-Skilled Emigrants (Parey, Ruhose, Waldinger, and Netz 2017, ReStat)**, we study how such differences in returns across countries affect who migrates and where. The Roy–Borjas model predicts that migrants to countries with more unequal earnings distributions should be positively selected, while those moving to more equal countries should be negatively selected. Empirical evidence on these predictions remains limited, as much of the existing literature focuses on migration from Mexico to the United States, often involving less-educated migrants who face substantial migration costs. Using longitudinal data on German university graduates that follow individuals even after they move abroad, we predict each graduate's earnings potential in Germany based on university quality, grades, field of study, and other personal characteristics. We then compare cumulative distribution functions of predicted earnings for migrants to more and less equal countries and graduates who remain in Germany. This approach allows us to study selection across the entire distribution rather than simply comparing average characteristics. To address potential selection bias in estimating earnings potential, we use the introduction and expansion of ERASMUS as an exogenous shifter for migration in a Heckman selection model. We find strong support for the Roy–Borjas predictions for this sample of university graduates who face only limited migration costs. Migrants moving to more unequal countries are positively selected, while those moving to more equal countries are negatively selected. These findings show that differences in the returns to skills help determine which highly qualified individuals migrate and where their human capital accumulates.

The preceding papers examine how knowledge spreads across borders through the migration of scientists. Yet knowledge can also diffuse internationally without researchers themselves moving. In **Frontier Knowledge and Scientific Production: Evidence from the Collapse of International Science (Iaria, Schwarz, and Waldinger 2018, QJE)**, we study how access to foreign frontier knowledge affects scientific productivity and the creation of new ideas. Identifying these effects is difficult because scientists who draw on foreign research may differ systematically from those who rely primarily on domestic knowledge. We address this challenge by exploiting the breakdown of international scientific exchange during and after WWI. Before the war, science was highly international, but the conflict and subsequent boycott against scientists from the Central Powers severely restricted knowledge flows between scientists in the Allied and Central Powers.

To study this disruption, we use the 1900 and 1914 waves of the World of Academia Database to reconstruct the population of university scientists worldwide. We combine these data with publications and citations, Nobel Prize nominations, and the text of more than 2.5 million U.S. patents. These data allow us to measure how strongly scientists in different countries and fields depended on foreign frontier research before WWI and to follow their scientific output afterward. We compare scientists in fields that relied heavily on frontier research from the opposing political camp with scientists in fields that relied primarily on domestic research. This allows us to identify the effects of losing access

to international knowledge while accounting for broader disruptions associated with the war.

We document the sharp decline in international knowledge flows after 1914 using three types of evidence. First, historical records on the arrival of foreign scientific journals and attendance lists from major scientific conferences show that the war severely disrupted established channels of international scientific exchange. Second, we find that citations to recent research from the opposing political camp fell by approximately 85% relative to citations to domestic research. However, this decline may reflect political hostility rather than reduced knowledge flows. Third, we therefore examine the actual content of scientific papers. In one of the earliest applications of natural language processing methods in economics, we use latent semantic analysis to measure the similarity of scientific papers based on their titles. We find that papers from opposing camps became substantially less similar after 1914, providing further evidence that the war disrupted the international diffusion of scientific knowledge.

We then show that reduced access to foreign frontier research had substantial consequences for scientific productivity. Scientists in fields that had relied heavily on frontier knowledge from the opposing camp experienced significant declines in publications in leading scientific journals, Nobel Prize-nominated research, and the introduction of novel scientific concepts. The effects were particularly pronounced at the very top of the knowledge distribution: scientists who had relied on the top 1% of foreign research experienced productivity declines approximately twice as large as those who had relied on the top 3%. The most productive scientists also experienced the largest absolute declines, suggesting complementarity between researchers' own abilities and access to frontier knowledge. Finally, we develop a novel text-based measure linking basic science to technological innovation by tracing scientific concepts into the full text of U.S. patents. Combined with the disruption of international knowledge flows, this allows us to provide some of the clearest causal evidence that basic science is a fundamental driver of technological progress.

Taken together, these papers show how the international movement of scientific talent and ideas shapes knowledge production, and how frictions in both processes can limit innovation. High-skilled migration can stimulate invention far beyond migrants' own research contributions, primarily by attracting new inventors into their fields rather than raising the productivity of existing researchers. Who migrates and where depends on professional networks, previous international experiences, and differences in the returns to skills across countries. At the same time, scientific knowledge can spread internationally without migration, but restrictions on access to frontier research can substantially reduce scientific productivity and technological innovation. These findings show that the benefits of nonrival knowledge depend critically on the mobility of scientific talent and the international exchange of ideas.

IV. INSTITUTIONS, KNOWLEDGE PRODUCTION, AND THE ALLOCATION OF TALENT

The creation of knowledge depends not only on scientific talent and access to ideas, but also on the institutions that govern research. Scientific institutions shape how research organizations evaluate researchers and make decisions about hiring, promotion, and research funding. Because scientific quality is difficult to observe, these decisions are often made under imperfect information, potentially leading to an inefficient allocation of talent. Political institutions, in turn, shape the resources devoted to science, the freedom of researchers to pursue new ideas, and the direction of scientific inquiry. In this strand of research, I examine how scientific institutions affect the allocation of talent and how political institutions influence the size, productivity, and direction of knowledge production.

IV.1. Scientific Institutions and the Allocation of Talent

Organizations make decisions about hiring, promotion, and resource allocation with imperfect information about individual productivity. These information frictions can lead to an inefficient allocation

of talent both within and across organizations. Performance metrics may improve these decisions by providing additional information about worker quality, but they can also create distortions if they capture only certain aspects of productivity.

In **Measuring Science: Performance Metrics and the Allocation of Talent (Hager, Schwarz, and Waldinger 2024, AER)**, we study the effect of performance metrics in academia, where citation and publication metrics have become central to decisions about hiring, promotion, and research funding. Their growing use has prompted concerns that universities and grant agencies rely too heavily on quantitative measures of scientific performance. Yet, despite this debate, there is little systematic evidence on how these metrics affect the allocation of scientific talent.

Identifying the causal effects of performance metrics is challenging because highly cited scientists tend to work in better departments, regardless of whether their citation counts are observable. We address this problem by exploiting the introduction of the Science Citation Index (SCI), the first systematic international citation index. Because the early SCI covered only selected citing journals and years, some citations to a scientist's work became visible to contemporaries, while other citations remained invisible. Modern databases record both visible and invisible citations, allowing us to compare their effects on scientists' careers. This comparison enables us to isolate the effect of making citation information available from differences in the underlying research quality of scientists.

To implement this strategy, we combine historical U.S. faculty rosters with detailed publication and citation records from the Web of Science, the successor to the SCI. We also digitize the lists of citing journals from the original SCI books, allowing us to reconstruct the citation information available to scientists and universities in the 1960s.

We find that visible citations are four times as predictive of scientists' department rankings as invisible citations. Specifically, scientists with a ten-percentile higher visible citation rank were, on average, placed at a department ranked 2.5 percentiles higher in 1969, compared with only 0.6 percentiles for an equivalent increase in invisible citation rank. The effects operated through both the retention of highly cited scientists in academia and their mobility to higher-ranked departments. Consistent with the importance of information frictions, the effects were particularly large for moves across greater geographical distances and between departments without previous intellectual connections. Highly cited researchers at lower-ranked universities, i.e., "hidden stars," benefited disproportionately, as did highly cited scientists from minority groups. These findings provide causal evidence that performance metrics can improve the allocation of talent by making scientific quality more observable.

Citation visibility also affected career advancement and research funding. A ten-percentile increase in visible citation rank raised the probability of promotion to full professor by 4.1 percentage points and of receiving an NSF grant by approximately 19%. Invisible citations had little effect on either outcome. These results suggest that performance metrics can generate cumulative advantages, as greater visibility leads to recognition, career opportunities, and research resources, consistent with so-called "Matthew effects." The findings extend beyond academia to other organizations where individual productivity is difficult to observe. Performance metrics can help organizations identify and reward talent that informal networks might overlook. However, our findings also reveal an important limitation: researchers of similar underlying quality experience different career outcomes depending on whether their performance is captured by the metric. Performance metrics can therefore distort the allocation of talent and resources by rewarding what is measured rather than underlying productivity.

IV.2. Political Institutions and the Production of Knowledge

While scientific institutions shape how researchers are evaluated and rewarded, political institutions determine the broader environment in which scientific knowledge is produced. Economic theory suggests competing forces. Because knowledge is non-rival and generates benefits beyond its original

producers, governments can promote scientific progress through public funding and the coordination of research efforts. At the same time, scientific discovery involves substantial uncertainty about which research directions will prove valuable, making academic freedom and decentralized experimentation potentially important for innovation. Political systems differ in their ability to mobilize resources and in the constraints they impose on scientific inquiry. Their effects on knowledge production are therefore theoretically ambiguous.

In **Dictators, Democracies, and Discoveries: Political Institutions and the Creation of Knowledge (Hager, Radde, Schwarz, and Waldinger 2026)**, we study how political institutions affect scientific discovery across countries and over time. We examine how institutions shape publications, highly cited publications, and Nobel Prize-winning discoveries. We also discuss the mechanisms through which institutions shape science, and how institutions affect breakthrough technological innovations.

To study these questions, we assemble a new global dataset covering universities, academics, scientific output, and major technological discoveries from 1900 to the present. We combine the World of Academia Database with newly digitized university directories to reconstruct the development of university systems over more than a century. We link these data to over 200 million scientific publications and their citations, construct a new dataset identifying the year and country in which Nobel Prize-winning discoveries were made, and incorporate information on path-breaking technological discoveries, including innovations that never appeared in academic publications. Finally, we combine these data with measures of political institutions from the V-Dem project.

Separating the effect of political institutions from other determinants of scientific production is challenging because democracies and autocracies differ along many dimensions. To move beyond cross-country correlations, we study the evolution of scientific output around sharp institutional changes. Specifically, we analyze 70 major improvements and 28 major deteriorations in political institutions, such as the fall of the Iron Curtain, the Arab Spring, or the rise of Fascist dictatorships in Europe.

Using an event-study design, we find that both types of shock have substantial and persistent effects on scientific output: democratic openings spark sustained increases in scientific output while institutional breakdowns trigger sharp and lasting declines in publications and frontier research. The event-study estimates also show that countries experiencing sharp institutional changes exhibit no differential pre-trends relative to countries without major changes in institutional quality. An instrumental-variable strategy exploiting regional waves of institutional change provides additional support for these findings. Importantly, these effects operate through both the size of the scientific workforce and productivity per researcher. Political institutions also affect the direction of research: autocracies concentrate scientific activity in a narrower range of fields, whereas democracies produce frontier research across a broader set of disciplines. Finally, we find that higher institutional quality increases the production of path-breaking technological discoveries, including those outside academic science. These results show that political institutions shape not only the resources devoted to science, but also scientific productivity, the breadth of research, and the creation of new ideas.

In related work, **War and Science in Ukraine (Ganguli and Waldinger 2024, EIPE)**, we examine how Russia's invasion of Ukraine disrupted scientific production. Using newly collected data, we document a decline in Ukrainian research output, the destruction of university infrastructure, and a sharp reduction in international scientific collaboration, highlighting how wars disrupt the human capital and international networks on which scientific research depends.

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