The Return(s) of Superstar Scientists

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Abstract

This paper studies the long-run effects of high-skill return migration on scientific productivity and the direction of research, using U.S.-trained Chinese scientists during the 1950s Great Return Wave. Exploiting quasi-random variation in return opportunities from Cold War U.S. exit restrictions, we compare scholars who returned to China with observably similar scholars who stayed. Combining newly digitized historical archives with multilingual bibliometric data, we follow individual output and research agendas across the international and Chinese-domestic literatures over four decades. We find that return redirected output rather than reducing it: returnees published less internationally and more domestically, at no quality loss, and shifted toward applied, mission-oriented work. In the fields they entered, other domestic scientists' frontier-quality output rose over two decades. Our welfare analysis, priced through a cross-field citation network, shows the U.S. lost more than China gained, a gap driven by scientists' position in the knowledge network rather than their number.

JEL Codes: O15, J61, O33, N35, I23

Keywords: return migration, human capital, economics of science, knowledge diffusion, scientific productivity, China

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1 Introduction

The allocation of scientific talent across countries shapes where frontier knowledge is produced and how it diffuses, and is a central input into long-run growth (Romer, 1990, 1994). A large body of evidence shows that this allocation matters: the emigration or dismissal of elite scientists imposes persistent losses on the places they leave, while inflows of foreign talent raise innovation in the places they join (Waldinger, 2010, 2012, 2016; Borjas and Doran, 2012; Moser et al., 2014). This evidence, however, is almost entirely about *outward* mobility from advanced economies. Far less is known about the consequences of *return* migration, when scientists trained at the frontier move back to their home countries, even though such flows are large and, for developing economies, potentially transformative. Returning scientists may reshape not only their own productivity but the direction of domestic research, the diffusion of frontier ideas, and the formation of scientific capacity.

Evidence on the long-run effects of return migration remains scarce, for two reasons. First, who returns is endogenous: scientists sort on ability and field, and political and institutional forces shape both the decision to leave and the environment returnees face at home. Second, measuring the consequences requires tracking individual scientists across countries, languages, and publication systems over decades, and distinguishing a scientist who stops producing science from one whose work has merely moved into a different scientific community.

This paper studies the long-run effects of high-skill return migration on scientific productivity and the direction of research, using the return of U.S.-trained Chinese scientists during the Great Return Wave of the 1950s. After the founding of the People's Republic of China in 1949, the new government mobilized overseas-educated Chinese to return and help build a modern nation, while the United States, in the grip of the early Cold War, moved to restrict the departure of scientists with sensitive training. The most prominent returnee was Qian Xuesen (Tsien Hsue-shen), a Caltech-trained aerodynamicist and co-founder of the Jet Propulsion Laboratory, whose U.S. security clearance was revoked in 1950 and who, after five years of detention, was released to China in 1955 as part of the Geneva negotiations that followed the Korean War; he went on to found China's ballistic-missile and space programs (Chang, 1995). Qian was not an isolated case. The wave also carried Deng Jiaxian, who led the design of China's first atomic bomb, the Caltech physicists Guo Yonghuai and Zhao Zhongyao, and the mathematician Hua Luogeng, among a cohort that would staff the founding faculties of China's universities and lead its strategic-weapons program (Wang, 2014). More broadly, this episode is one instance of a recurring twentieth-century phenomenon: geopolitical ruptures repeatedly reallocated frontier-trained scientists across

national research systems, reshaping the international organization of science. The early Cold War split a generation of such scientists between two emerging superpower systems, and studying how one of them absorbed this talent speaks to how the global scientific order is reorganized when talent is forced across political divides. Because frontier scientific capability is itself a strategic national asset, its reallocation is also a dimension of international power, alongside the economic interdependence studied by Liu and Yang (2026).

We assemble a comprehensive new dataset, digitized from multiple historical archives, that reconstructs the population of U.S.-trained Chinese scholars of this period and tracks their training, return decisions, institutional placements, and scientific output over four decades. We combine annual directories of Chinese students in the United States, doctoral dissertation records, declassified U.S. government files on exit-permit decisions, biographical dictionaries of returnees, and two multilingual bibliometric databases: OpenAlex, which indexes the international, largely English-language literature, and CNKI, which indexes the Chinese-domestic literature. Following the same scientists into *both* literatures is central to our design: it lets us distinguish the *redirection* of scientific output across research systems from its *disappearance*, a distinction that studies of a single corpus cannot draw. To characterize not only the volume but the content of research, we represent each paper in a shared, cross-lingual semantic space using multilingual language models, which lets us measure how close a scientist's work sits to the research frontier and how its direction shifts over time.

Our identification strategy exploits the fact that return during the Great Wave was disrupted by sharp, historically contingent political constraints. Under early-Cold-War security policy, most notably the 1951 order preventing the departure of aliens with scientific and technical training, the United States selectively restricted the exit of Chinese scholars in fields deemed to have military or industrial value, so that some scientists returned promptly while others faced exogenous delays or were prevented from leaving despite their intent. We compare each returnee to observably similar scientists who remained in the United States, matched from the same training pipeline on broad field, entry cohort, and pre-return output, and trace the gap in their trajectories around the year of return. The matched groups have similar educational backgrounds, fields, and pre-return output, and event-study estimates show no divergence in their paths before return.

Our main findings can be summarized in four parts. First, return migration *redirected* scientific output rather than reducing it: relative to matched stayers, returnees publish about 11 percent less in the international, English-language literature after return and about 11 percent more in the domestic, Chinese-language literature, leaving their total publication count essentially unchanged, with citations moving in the same direction. Second, this reallocation came at no measurable cost to quality. The frontier alignment of returnees'

international publications is essentially unchanged after return, while their Chinese-language work moves significantly closer to the global frontier; what changed was the *direction* of research rather than its caliber, with a large-language-model reading of scholars' abstracts showing returnees shifting sharply toward applied, mission-oriented work. Third, returnees reshaped the science produced around them: in the fields they entered, the number of frontier-proximate papers by *other*, non-returnee Chinese scientists rose over the following two decades, the field-creating mechanism behind a returnee such as Qian Xuesen building an aerospace research program where little had existed. Fourth, pricing each scientist through a cross-field citation network, we find that the reallocation was net-negative for world science: China captured only about a third of the social value the United States gave up, a divergence cost that forced relocation destroys rather than transfers. These patterns are not driven by concurrent political disruptions such as the Cultural Revolution, and are robust across four alternative constructions of the matched returnee–stayer comparison. Taken together, these results point to a principle that headcount obscures: the consequences of relocating scientific talent turn not on how many scientists move but on which strategic fields they seed and their position in the knowledge network. A small cadre concentrated in core strategic fields such as nuclear weapons and aerospace conferred capabilities out of all proportion to its size, and our welfare accounting shows that a scientist's value is governed by network centrality rather than raw output.

This paper contributes to four literatures. First, it adds to the study of how migration shapes knowledge production and spillovers, which has focused on brain drain, diaspora networks, and displacement shocks, largely in frontier economies and for outward mobility (Borjas and Doran, 2012; Docquier and Rapoport, 2012; Moser et al., 2014; Kerr et al., 2016; Waldinger, 2012, 2016; Iaria et al., 2018). A parallel theoretical literature models the global race for talent and the spillbacks that return migrants generate onto home collaborators (Prato, 2025). We provide the first large-scale evidence on *return* migration into an economy with weak preexisting scientific institutions and, by following scientists into a second literature, separate the redirection of output from its disappearance.

Second, the paper advances the literature on upper-tail human capital and the production of useful knowledge. Growth models emphasize aggregate human capital and idea accumulation (Romer, 1990, 1994; Mokyr, 2005a,b), and recent work highlights the outsized role of scientific elites (Squicciarini and Voigtländer, 2015; Giorcelli, 2019; Bianchi and Giorcelli, 2020). We show that a single returning scientist can seed a field: the frontier-quality output of *other* domestic scientists rose in the fields returnees entered, a multiplier that individual-level productivity measures cannot capture. Our setting is a human-capital counterpart to the Soviet technology transfers that helped build China's industrial base in the same decade:

Giorcelli and Li (2026) study the Soviet-aided "156 Projects" that brought industrial technology to 1950s China, while we trace the parallel inflow of frontier-trained scientists.

Third, the paper links return migration to the endogenous direction of research. Political incentives and institutional constraints are known to shape scientific agendas (Jia et al., 2019; Acemoglu et al., 2024), and foreign education can transmit organizational norms with long-run consequences (Spilimbergo, 2009; Kung and Wang, 2025). We document that returnees sharply redirected the *content* of their research toward applied, mission-oriented work relative to matched stayers, a shift a language-model reading of their bilingual publications detects but citation counts and broad field labels do not, clarifying how human-capital flows let states steer science toward strategic objectives while building domestic capacity. More broadly, the setting offers a rare quantitative window into science under central planning, in which a state that could direct where its scientists worked concentrated returnee talent in strategic-priority fields.

Fourth, the paper speaks to the economics of the allocation of talent. A long literature shows that how talent sorts across activities and fields is a first-order determinant of aggregate output and growth (Murphy et al., 1991; Hsieh et al., 2019; Bell et al., 2019). We add a network dimension: the social value of a scientist depends not only on the activity they choose but on where they sit in the global knowledge network (Liu and Ma, 2026). A frontier scientist embedded in a dense, self-sufficient research system generates more downstream spillovers than the same scientist transplanted into a frontier-dependent one, so reallocating talent across borders is not a zero-sum transfer, and forced relocation can destroy social value rather than merely redistribute it.

Beyond its academic contributions, the setting speaks to a debate the United States is having again. The 2018–2022 China Initiative, the 2020 restrictions on entry for Chinese graduate students and researchers (Presidential Proclamation 10043), and recurring proposals to screen researchers by nationality rest on the same implicit trade-off that governed the 1950s exit restrictions: whether the security gains from excluding suspect scientists outweigh the scientific costs (Jia et al., 2024; The White House, 2020). Our estimates put a magnitude on those costs, show that they fall on the excluding country as well as its rival, and indicate that talent excluded from one research system is largely relocated rather than lost.

The remainder of the paper proceeds as follows. Section 2 describes the Great Return Wave; Section 3 the data and measurement; Section 4 the empirical strategy; Sections 5 and 6 the effects on individual scientists and on domestic scientific production; Section 7 the welfare accounting; and Section 8 concludes.

2 The Great Return Wave

2.1 Calling on Overseas-Educated Chinese for Nation-Building

Following the establishment of the People's Republic of China (PRC) in 1949, the new government confronted an economy that was overwhelmingly agrarian, technologically backward, and institutionally underdeveloped (Lardy, 1995). With limited domestic capacity in modern science and engineering, the state identified overseas-educated Chinese as a critical source of advanced human capital for industrialization and nation-building.

Beginning in late 1949, the PRC launched a coordinated campaign encouraging foreign-trained Chinese to return, commonly framed as a call to "serve the motherland and the people." The government established the Committee on Returned Students Affairs in December 1949 to facilitate return, providing travel subsidies, reception services, and centralized job placement in universities, research institutes, and state-owned enterprises (Zhang and Mo, 2018). These policies reflected a deliberate strategy to rapidly internalize frontier knowledge acquired abroad.

At the time, the stock of overseas Chinese students was sizable. In 1949, approximately 5,541 Chinese students were studying abroad, the product of earlier state-sponsored and private efforts to train elite students overseas (China Institute in America, 1954; Li, 2000). About 70 percent were enrolled in the United States, with the remainder primarily in the United Kingdom and Japan, and more than two-thirds pursued degrees in STEM fields.

2.2 Cold War Tensions and Barriers to Return

This initial momentum was disrupted by the rapid deterioration of relations between the PRC and the United States. After 1949, the United States refused to recognize the Communist government, severing diplomatic ties and leaving Chinese nationals without consular protection. The outbreak of the Korean War in 1950 further intensified security concerns and anti-communist sentiment.

Against this backdrop, U.S. authorities increasingly viewed Chinese students, especially those with advanced scientific and technical training, as potential national security risks. In October 1951, the United States implemented administrative restrictions on the departure of aliens with scientific and technical training. In particular, U.S. immigration authorities formally prohibited Chinese students and scholars from departing the United States without authorization, with violations punishable by fines of up to $5,000, imprisonment of up to five years, or both, reflecting security concerns over the transfer of sensitive scientific and technical knowledge to Communist China (Li, 2000). Declassified intelligence reports emphasized

the risk that returnees could transfer knowledge relevant to military, nuclear, and industrial programs (see Appendix for more details).

These policies generated substantial frictions to return. Archival records document interrogations by federal authorities, prolonged surveillance, repeated denials of exit permits, and pressure to adjust immigration status or naturalize (Han, 1993). While some students eventually returned after extended delays, others were prevented from leaving altogether despite documented intentions to do so. As a result, return outcomes during the early 1950s were shaped less by individual choice than by historically contingent political constraints.

2.3 The Geneva Conference

By the mid-1950s, the status of Chinese students in the United States became entangled with broader diplomatic negotiations. During the Geneva Talks of 1954–1955, Chinese students were discussed alongside American prisoners held in China, effectively becoming bargaining instruments in bilateral negotiations (Han, 1993). At this stage, many students were no longer viewed by U.S. authorities as strategically indispensable and had become administratively and politically costly.

The talks culminated in a joint announcement on September 10, 1955, affirming the right of nationals residing in the other country to return home if they wished. In principle, this agreement removed formal barriers to departure. In practice, return flows remained limited. U.S. records indicate that more than half of applicants withdrew their requests, reflecting persistent administrative obstacles, uncertainty, and the passage of time (Han, 1993). In parallel, the Refugee Relief Act of 1953 facilitated adjustment to permanent residence for many Chinese nationals, further reducing incentives to return.

By the late 1950s, return migration had largely ceased. Chinese departures from the United States fell sharply, reaching only two in fiscal year 1958 (Kung, 1973). Archival evidence summarized by Wang (2014) indicates that, despite encouragement or, in some cases, force to stay from the U.S. side and subsequent political contestation from China side, the majority of Chinese students and scientists trained abroad ultimately remained in the United States. Of an estimated cohort of roughly 5,000 individuals, about 4,000 stayed, including Chen-Ning Yang and Tsung-Dao Lee, who later received the 1957 Nobel Prize in Physics, while approximately 1,200 successfully contested U.S. restrictions and returned to China during the 1950s. Also, internal reports from Beijing Municipal Archives document that 1,954 Chinese students and scientists returned to mainland China between 1949 and 1958, of whom 1,244 (roughly 64 percent) returned from the United States. A majority of these returnees specialized in the natural sciences, broadly defined to include engineering,

with the remainder concentrated in the social sciences or other fields. Combined with domestic political turmoil in China, these developments effectively ended the Great Return Wave until diplomatic normalization and the resumption of overseas study after 1978. The cohort shaped by this episode provides the institutional setting for our empirical analysis. Figure 1 summarizes the wave: annual returns spike after 1945, collapse under the 1950–1955 exit ban, and rebound after the 1955 Geneva talks.

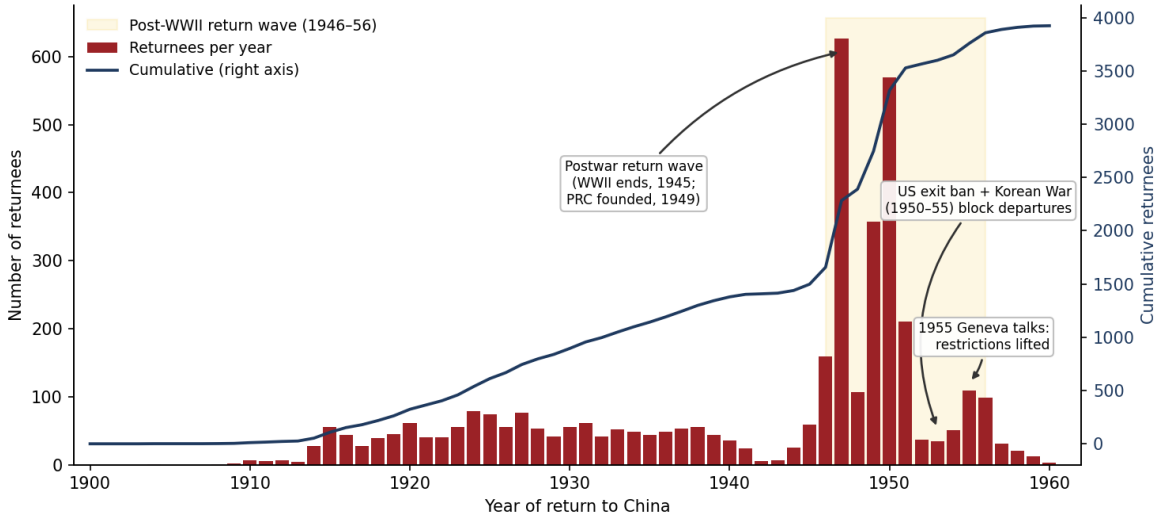


Figure 1: The Great Return Wave in numbers, 1900–1960

Notes: Annual number of overseas-educated Chinese scholars returning to China (bars, left axis) and the cumulative total (line, right axis), by year of return. The shaded band marks the post-war Great Return Wave (1946–1956). Returns surge after the end of World War II and the 1949 founding of the People's Republic, collapse during the 1950–1955 U.S. exit ban and the Korean War, and recover briefly after the 1955 Geneva talks lifted departure restrictions. Source: authors' biographical returnee database.

3 Data

In this section, we describe the data that we collected and digitized from several historical archives. Additional details can be found in the Appendix.

3.1 Directory of Chinese Students in the United States

To construct a comprehensive dataset of Chinese students who pursued higher education in the United States during the first half of the 20th century, we digitize and extract individual-level information from a series of historical directories compiled by Chinese student organizations and educational institutions. These directories, published annually or biennially,

were produced by associations such as the Chinese Students' Alliance, the Chinese Students Handbook Company, the Chinese Students' Christian Association, and later the China Institute in America. The directories span from 1911 to 1953, including the *Directory of the Chinese Students in the United States of America*, *The handbook of Chinese students in U.S.A.*, and the *Directory of Chinese Students in Colleges and Universities in the United States*. While the directories vary in format, we harmonize the data to create a unified structure that captures detailed information on students' names, universities attended, degrees obtained, and fields of study.

3.2 Dictionary of Chinese Scholars Who Studied Abroad and Returned to China

We manually collected and digitized individual-level data from three retrospective biographical compilations documenting Chinese scholars who studied abroad and returned to China between the 1840s and early 1960s. The first source, the *Dictionary of Chinese Scholars Who Returned from North America in the 1950s*, contains detailed records on 1,806 individuals, including their educational background, return dates, and post-return career trajectories. The second source, *the Comprehensive Survey of Scientific and Technical Personnel Studying Abroad and Returning to China, 1840–1949*, covers 3,500 early returnees and draws on biographical books, archival records, and institutional lists. The third source, *Scientific and Engineering Manpower in Communist China, 1949–1963*, profiles 1,200 prominent scientists and engineers using a broad range of official publications, yearbooks, and scientific periodicals. Together, these sources provide high-coverage, individual-level data on the timing, fields of study, and institutional affiliations of early returnees.

We use this dataset to identify individuals who pursued graduate or postgraduate studies abroad and returned to China in the late 1940s and 1950s, either voluntarily or under geopolitical pressure. In addition to biographical details, the data include information on disciplinary specialization, institutional roles, and leadership positions within Chinese universities and research institutes. This historical sample allows us to characterize the early cohort of returnee scientists and compare them to individuals who remained abroad.

3.3 Comparison Group of Scientists Who Remained in the United States

To construct a comparison group of observationally similar scientists who did not return, we compile a person-level list of U.S.-trained Chinese scholars drawn from the same training

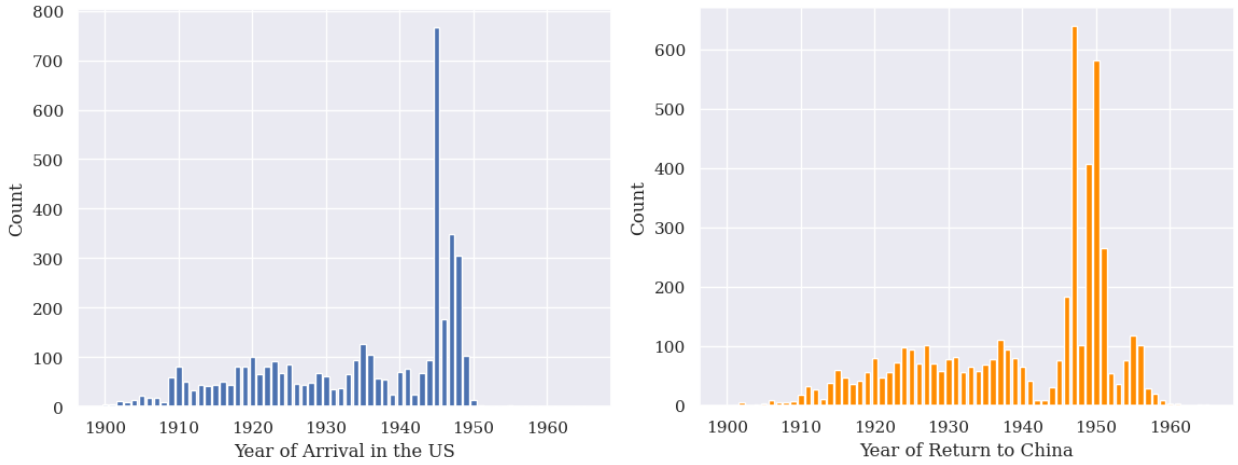


Figure 2: Year of arrival in the U.S. and year of return to China for the 4,671 U.S.-trained returnees in our sample.

pipeline as the returnees. We combine two sources: a comprehensive guide to doctoral dissertations by Chinese students at American universities (Yuan, 1961), which identifies scholars who completed U.S. graduate training in the relevant period, and the National Register of Scientific and Technical Personnel, a mid-twentieth-century registry of scientists and engineers in the United States. We harmonize the two pools into a common person-level schema, deduplicate across sources, and cross-filter against the returnee list to remove any individual recorded as having returned to China, yielding 9,478 stayers active before 1965. As with the returnees, each stayer is linked to their publication record in OpenAlex and CNKI. Comparing returnees to these stayers, who share the same educational pipeline but remained in the United States, is what allows us to isolate the effect of return migration from the characteristics of the scientists who returned.

3.4 Measures of Individual-Level Scientific Productivity and Research Agendas

We construct annual, individual-level measures of scholarly output by combining bibliometric, patent, and archival sources. Our measures capture not only the *volume* and *influence* of output, but also the *orientation* of research agendas, following methods developed in recent work on the economics of science and innovation.

Publications. We aggregate publications from two complementary databases. OpenAlex, the successor of the discontinued Microsoft Academic Graph, provides global coverage with standardized metadata and citation linkages (as in Moser et al., 2025), while the China

National Knowledge Infrastructure (CNKI) captures nearly all Chinese-language academic literature. For CNKI, we follow the construction in Acemoglu et al. (2024), collecting titles, abstracts, authors, publication years, venues, and citation counts. For each scholar, we query under three naming conventions (Chinese characters, Hanyu Pinyin, Wade–Giles) to address historical variation in name usage. We then apply a series of filters to manually disambiguate records using information on institutional affiliations, research fields, and years of birth and death, ensuring that each publication is uniquely and correctly assigned to a scholar in our database and that spurious matches are excluded. From these data we extract: (i) the total number of publications; (ii) field-normalized citation counts to adjust for disciplinary differences (see, e.g., Moser et al., 2014); (iii) the share of coauthors based in China, to capture domestic integration; and (iv) the share of publications in state-prioritized research areas, identified from contemporary industrial policy documents.

Field Classification and Research-Agenda Vectors. To characterize the *content* and *evolution* of research, we construct scholar-level research-agenda vectors using multilingual text embeddings. We adapt methods from Iaria et al. (2018), Bello et al. (2025), and Koffi (2025), combining English- and Chinese-language bibliometric sources to assemble a comprehensive corpus of publication titles and abstracts for each scholar–year. We first harmonize author identities, publication years, and venues across databases, and preprocess text by lowercasing, de-accenting, removing stopwords, and tokenizing. We then represent research content using state-of-the-art multilingual sentence embeddings. Specifically, we embed each paper's title and abstract using `SentenceTransformers`, which map texts in different languages into a shared semantic space. For each scholar i in year t, we define an *agenda vector* as the mean embedding of all publications authored in that year. This vector provides a continuous, high-dimensional representation of the scientist's research orientation. For robustness, we compare results to alternative representations based on WORD2VEC and latent semantic analysis (LSA) applied to TF–IDF–weighted text. To capture the *direction* of research along a dimension that embedding distances do not resolve—whether work becomes more basic or more applied—we complement these geometric measures with a direct-content measure in which a large language model reads each scholar's pre- and post-return titles and abstracts and scores both the magnitude and the basic-to-applied direction of the agenda shift (Section 5.1).

To assign research fields, we use two established subject taxonomies rather than constructing fields de novo. OpenAlex publications carry OpenAlex's native hierarchical classification, whose 244 subfields we adopt as the unit of analysis; Chinese-language CNKI publications carry FORD subject categories, which define the within-CNKI (domestic) fron-

tier. To place both corpora in a common field space, we embed every title and abstract with multilingual LaBSE vectors and assign each CNKI paper to the OpenAlex subfield whose reference-paper centroid is nearest in cosine similarity. These same embeddings, following the measurement approach of Hager et al. (2024) and Moser et al. (2025), furnish the paper-level frontier-alignment outcomes used throughout. Each paper is assigned uniquely to a subfield, enabling the construction of scholar–year field shares and dominant research fields.

Patents. To capture *applied* output, we match scholars to patent filings in domestic and international patent databases, following the linkage approach in Moser (2016) and Moser et al. (2025). Patents complement publication-based measures by reflecting contributions to technology transfer and industrial applications.

Outcome Variables. We construct the following dependent variables for each scholar–year:

1. **Productivity/Impact:** (a) publications per year; (b) forward citations; (c) field–year normalized citation percentiles; (d) top-venue share (field-specific journal/conference lists); (e) h-index within a fixed ten-year window around the return event.

2. **Agenda Outcomes (semantic):** (a) *stability*, the cosine similarity of an author's agenda vector between t and $t-1$; (b) *convergence to destination*, the similarity to the mean vector of colleagues at the Chinese host institution; (c) *retention of pre-return lines*, the similarity to the mean vector of pre-return coauthors; (d) *frontier alignment*, the similarity to the breakthrough centroid within subfield–year (Kelly et al., 2021); (e) *breadth/focus*, the entropy or Herfindahl of field shares across works; (f) *novelty*, the share of bigrams or terms not previously observed in the author's publication history (e.g., Moscona, 2024).

Together, these measures allow us to compare not only the productivity of stayers versus returnees, but also how their research agendas shift, persist, or reorient in response to the institutional and political environments in China.

Dual-Frontier Construction. A distinctive feature of our setting is that returnees publish in a domestic corpus (CNKI) while stayers publish in an international corpus (OpenAlex), and the two corpora point to different research frontiers. To leverage this, we construct *two* versions of every Kelly-style outcome. For each scholar's paper p in subfield s and year t, we compute backward similarity to papers in $s \times [t-5, t-1]$ and forward similarity to papers in $s \times [t+1, t+10]$ using semantic embeddings (LaBSE multilingual, with SciBERT

and sbert-chinese as robustness checks), and then form $r \log q_p$ following Kelly et al. (2021), residualized on year fixed effects; a pair of papers counts as similar only when its cosine exceeds a threshold θ, set to the 95th percentile of cosines between random reference-sample paper pairs (model-specific). Each paper is scored against a citation-neutral reservoir of 200 papers per subfield-year, sampled independently of citations, so the resulting importance score is textual rather than citation-based. The *breakthrough* papers in a subfield-year are the top decile of the residualized score, and the frontier is their mean embedding; a scholar's frontier alignment is the cosine of their agenda vector to this centroid. We verify robustness across three breakthrough definitions (top-decile importance, top-decile citations, and top journal) and across embedding models: three on the OpenAlex side (LaBSE, SciBERT, and a Chinese-language SBERT) and two on the CNKI side (LaBSE and the Chinese SBERT, since SciBERT is English-only). We construct $r \log q_p$ within each of two reference universes:

1. *Domestic frontier* (CNKI reference): the 106,000-paper stratified CNKI sample, with subfields defined on FORD subcategories. This measures how each paper relates to the leading Chinese-language papers in its subfield.

2. *Global frontier* (OA reference): OpenAlex's 3.5-million-paper stratified reference, with each Chinese-language paper nearest-neighbor assigned to one of 244 OA subfields via centroid cosine similarity. This measures how each paper relates to the leading international papers in the same field.

Because the same scholar's papers receive both scores, we can read the gap directly: a paper that is highly aligned with the Chinese frontier (high CNKI-reference alignment) but distant from the global frontier (low OA-reference alignment) is locally important but internationally peripheral. The complementary case, alignment with the global frontier, captures *catching-up* to international science. Table 1 previews the unconditional gap; Section 6 traces how it evolves around return.

Table 1: Frontier alignment of scholar publications: unconditional means by reference universe

Comparison	Mean	SD	N
OA scholars vs OA frontier	0.392	0.153	13,181
CNKI scholars vs CNKI frontier	0.604	0.122	4,710
CNKI scholars vs OA frontier (catching-up)	0.356	0.133	4,837

Notes: Mean LaBSE cosine similarity between matched scholar publications and the breakthrough centroid in the corresponding subfield-year, reported separately for the three reference universes used in the paper. Row 1: OpenAlex publications by matched scholars compared to the OpenAlex breakthrough centroid. Row 2: CNKI publications by matched scholars compared to the CNKI breakthrough centroid (within-corpus alignment). Row 3: CNKI publications compared to the OpenAlex breakthrough centroid, the catching-up measure used in Section 6. SD denotes the cross-paper standard deviation. N is the number of paper-year observations with non-missing alignment in each row.

Validating the Embedding Space. Before using these vectors as outcome measures, we verify that they recover the substantive structure of science across both corpora. Figure 3 shows three side-by-side t-SNE projections at the field (macro-domain) level: the left panel uses only OpenAlex matched scholar papers (76,326 papers, sampled to 30,000 for tractability), the middle panel uses the full set of CNKI matched scholar papers (16,481 papers, all shown), and the right panel pools both corpora (92,807 papers, sampled to 30,000). Figure 4 repeats the exercise at the OpenAlex subfield level. In all three projections, papers from the same field or subfield cluster tightly, and substantively related categories (e.g. atomic and condensed-matter physics; electrical and mechanical engineering) occupy adjacent rather than disjoint regions of the space. The clustering structure is recovered separately within each corpus and is preserved when the two are pooled, supporting the use of LaBSE distances as the substrate for the frontier-alignment outcomes that follow.

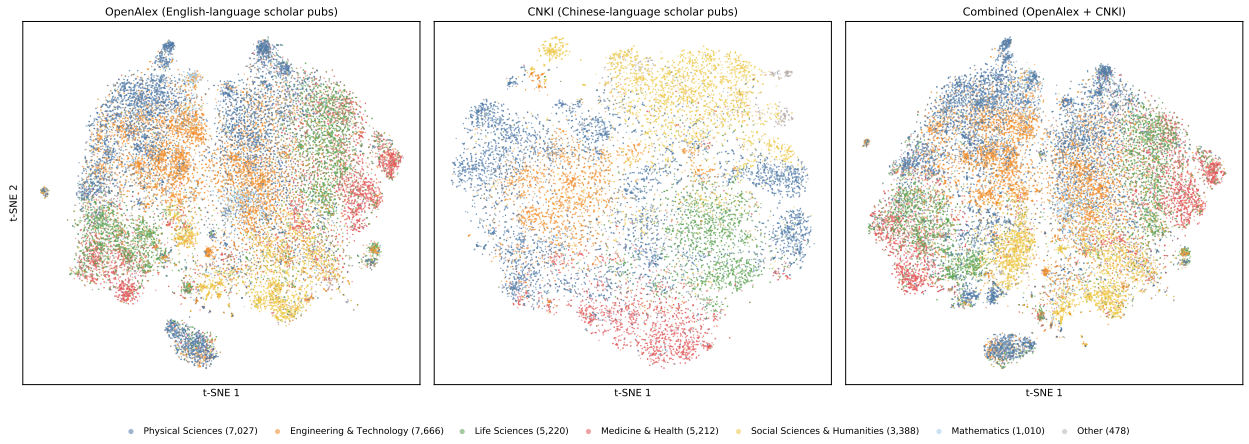


Figure 3: t-SNE map by macro-domain: OpenAlex, CNKI, combined

Notes: t-SNE projections of LaBSE paper embeddings, computed separately per corpus. Left: 30,000 OA matched scholar papers (stratified by field). Middle: all 16,481 CNKI matched papers. Right: pooled OA+CNKI, 30,000 stratified. Colors: macro-domain (CNKI FORD majors mapped to OA fields). Legend counts refer to the combined panel.

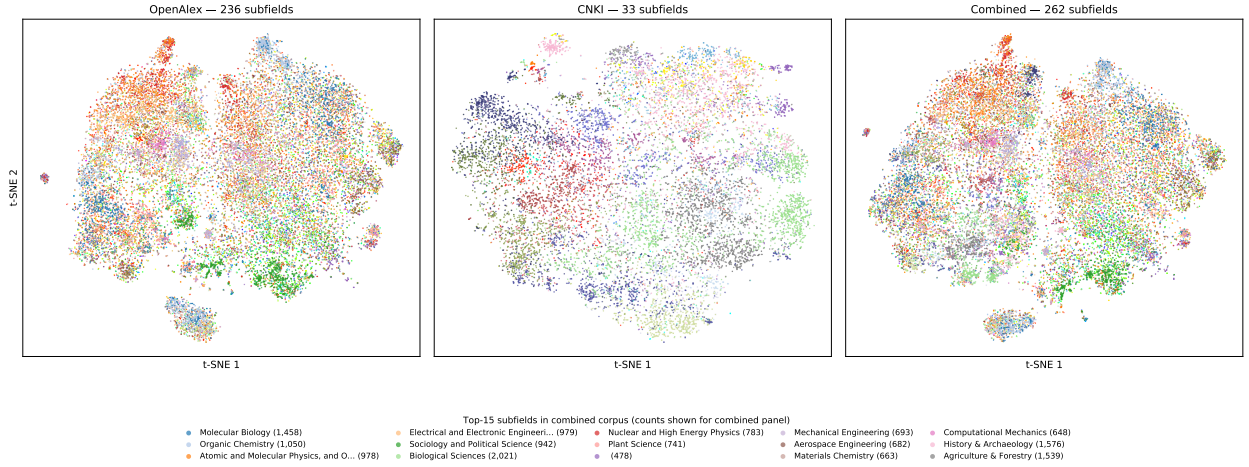


Figure 4: t-SNE map by OpenAlex subfield: OpenAlex, CNKI, combined

Notes: Same projections as Figure 3; points colored by OA subfield (every subfield assigned a distinct color; panel header reports the count). Legend lists the top-15 subfields in the combined corpus; remaining subfields are colored but unlabeled. CNKI subfields are mapped to OA subfields via centroid cosine similarity.

4 Identification Strategy

We begin with a simple cross-sectional OLS comparing the productivity of returnees and stayers up to 1976,[1]

$$y_i = \beta \, \text{Return}_i + X_i'\gamma + \mu_{f(i)} + \mu_{c(i)} + \varepsilon_i, \tag{1}$$

where y_i is individual i's scientific productivity accumulated by 1976 (e.g., total publications, citations, domestic coauthorship share, China-oriented topics), Return_i indicates returning to the PRC by 1957,[2] X_i includes pre-departure characteristics (e.g., gender, age, institutions attended), and $\mu_{f(i)}$ and $\mu_{c(i)}$ are field and cohort fixed effects (defined by decade of initial entry into U.S. study). This specification is equivalent to comparing average career outcomes of returnees and stayers with similar pre-departure individual characteristics within field–cohort cells. Although it does not address the endogeneity of return decisions, it provides a transparent baseline and motivates the need for our causal identification strategies.

Causal Identification via Permit/Denial. To address selection, we exploit quasi-random U.S. exit decisions. Among the 434 students who applied to depart between 1951–54, 310 were *permitted* while 124 were *denied* for security reasons (with a small number later leaving). Restricting the sample to these applicants, we estimate a two-stage least squares specification that uses permit status as an instrument for actual return:

$$\text{First stage:} \quad D_i = \pi_1 \, \text{Permitted}_i + \alpha_{f(i)} + \alpha_{c(i)} + \eta_i, \tag{2}$$

$$\text{Second stage:} \quad y_i = \beta_{\text{LATE}} \hat{D}_i + \alpha_{f(i)} + \alpha_{c(i)} + \xi_i, \tag{3}$$

where D_i is an indicator for being in China by 1957, y_i is lifetime productivity measured up to 1976, and $\alpha_{f(i)}$ and $\alpha_{c(i)}$ are field and cohort fixed effects. This IV design identifies β_{LATE}, the causal effect of return for compliers; that is, students whose return status was determined by U.S. security decisions.

Validation Within the Denied Group. As a robustness check, we focus on the 124 students who were initially denied exit between 1951–54. After restrictions were relaxed, some of these students eventually departed while others remained in the United States. Be-

[1] The Cultural Revolution ended in 1976, and the PRC began to normalize relations with the United States shortly thereafter. In 1978 the government launched the "reform and opening" policy, and by 1978–79 the first new cohorts of Chinese students were again sent abroad, mainly to the United States and Japan.

[2] We define returnees as those who departed for China by 1957 and stayers as those who remained in the United States thereafter. This cutoff ensures that students whose departure was delayed by U.S. restrictions but who ultimately returned are not misclassified as stayers. After 1957, very few students returned, owing to the domestic political turmoil of the late 1950s and 1960s.

Table 2: Chinese Students in the United States (1946–1954)

Item	**Number (approx.)**
1. Total number of Chinese who arrived in U.S. on student visas or as students on other visas	
1946–50	4,800
1951–54	1,500
Total	6,300
2. Departed from U.S. before June 1951 (Korean War)	800
3. Applied to depart 1951–April 1954 (restrictions in effect)	434
4. Permitted to depart 1951–54	310
5. Temporarily denied permission to depart because of U.S. security regulations 1951–April 1954	124
6. Of those in 5 above, number who wished to depart when canvassed June 1954	62
7. Of those in 6 above:	
a. Departed U.S.	15
b. Notified, but not yet departed	12
c. Not notified they could leave	35
8. Additional students applying for permission to depart since June 30, 1954 (cases in process)	36
9. Total departed U.S. 1946–54	1,100
10. Remaining in U.S. as of December 1954	5,200

Source: U.S. Department of State, "Memorandum for the President: Status of Chinese Students Who Have Been Refused Permission to Leave the United States," March 3, 1955, declassified memorandum.

cause all individuals in this group demonstrated a willingness to return by applying for exit, differences in realized return primarily reflect the external U.S. constraint rather than underlying preferences. We therefore re-estimate the baseline cross-sectional regression within this denied subsample:

$$y_i = \beta \, \text{Return}_i + X_i'\gamma + \mu_{f(i)} + \mu_{c(i)} + \varepsilon_i, \tag{4}$$

where y_i is lifetime productivity up to 1976 and Return_i indicates whether the student ultimately returned by 1957. This design focuses on a more homogeneous subset, reducing concerns about self-selection and providing an additional validation of the IV results.

Dynamics of Return. Finally, we examine how research agendas and productivity evolved *conditional on actual return*. To do so, we construct matched samples of returnees and stayers that allow us to trace event-time dynamics around the year of return. Each returnee is matched to one (or m) stayers by field, PhD cohort, and institution, with placebo $\tau = 0$ assigned to the matched stayers in the same calendar year. These designs do not use the permit/denial instrument because event-time alignment requires the realized year of return, but instead provide descriptive evidence on the mechanisms through which return reshaped careers.

For each returnee i, define $\tau = 0$ as the first year employed in China. We estimate the individual-level scientific productivity change upon return:

$$y_{i\tau} = \alpha_i + \lambda_\tau + \theta_{f(i),\tau} + \sum_{k \neq -1} \delta_k \mathbf{1}\{\tau = k\} \cdot \text{Returnee}_i + u_{i\tau}, \tag{5}$$

with $y_{i\tau} \in \{\text{pubs}, \ \text{cit_pctile}, \ \text{topvenue_share}\}$. These stacked difference-in-differences specifications document how return affected productivity trajectories relative to matched stayers with placebo event years. Similarly, we estimate the shift of research agenda:

$$\text{Sim}_{i\tau}^{(\cdot)} = \sum_{k \neq -1} \beta_k \mathbf{1}\{\tau = k\} \cdot \text{Returnee}_i + \gamma_i + \lambda_\tau + \theta_{f(i),\tau} + \varepsilon_{i\tau}, \tag{6}$$

where $\text{Sim}^{(\cdot)}$ denotes semantic outcomes such as stability, convergence, retention, and frontier alignment. Pre-trends ($k < 0$) test for parallel paths, while post-coefficients trace the dynamic reorientation of research agendas after return.

Spillovers to Domestic Scientific Production. Beyond individual careers, returned scholars plausibly reshaped China's domestic scientific system. During the early 1950s, many

U.S.-trained returnees entered fields that were nascent or effectively nonexistent in China, including modern physics, electronics, aeronautics, and applied engineering. Although returnees typically submitted preference lists for institutional placement, final assignments were determined by the central government under the planned economy. These assignments reflected national development priorities, with returnees often directed toward strategically important sectors such as defense, heavy industry, and applied sciences. After 1957, China experienced a prolonged period of international scientific isolation. With very limited access to Western frontier knowledge until diplomatic normalization and the "reform and opening" period beginning in 1978, domestic researchers faced severe constraints on exposure to global scientific advances. As a result, U.S.-trained returnees became a primary conduit through which advanced research methods, frontier topics, and tacit scientific knowledge entered the domestic academic system.

To quantify these institution-level effects, we exploit the staggered arrival of returnees across academic fields. We estimate field-level difference-in-differences specifications of the form

$$y_{jt} = \alpha_j + \vartheta_t + \delta \, \text{Post}_{jt} \times \text{Returnee}_j + \gamma X_{jt} + \varepsilon_{jt}, \tag{7}$$

where y_{jt} denotes scientific outcomes in field j at time t, such as the number of active scholars, publications, or citations. Returnee_j is an indicator for whether field j received U.S.-trained returnees (or, alternatively, the cumulative number of returnees in that field), and Post_{jt} equals one in years after the arrival of the first returnee. Field fixed effects α_j absorb time-invariant differences across disciplines, while year fixed effects ϑ_t control for aggregate shocks to the scientific system. Section 6 presents the domestic-spillover results; the subfield mean-alignment estimates that implement the binary and continuous-cumret versions of (7) are reported in Appendix 3.

Summary. Our empirical strategy combines four complementary designs. First, we exploit quasi-random permit/denial decisions as an instrument to identify the causal effect of return on scientific productivity. Second, we validate this approach within the denied subsample, where realized return is shaped by external constraints rather than preferences. Third, we use matched event studies to trace dynamic effects on agendas and productivity, and explore the mechanisms through which return reshaped individual careers and knowledge transmission. Fourth, we exploit the staggered arrival of returnees across academic fields to estimate the spillovers to domestic scientific production during a period of international isolation.

5 Effects on Individual Scholars

To compare returnees with observably similar scholars who stayed, we match each 1940–1957 returnee to U.S.-based stayers on broad research field, first-publication year, entry cohort, and pre-return output, yielding 802 matched pairs. Each matched stayer is assigned the placebo return year of its returnee, and we keep observations in event time $[-10, 15]$ around (placebo) return. On this matched sample we estimate the stacked difference-in-differences specification

$$y_{it} = \alpha_i + \lambda_t + \beta \left(\text{Returnee}_i \times \text{Post}_{it}\right) + \varepsilon_{it}, \tag{8}$$

with person and calendar-year fixed effects and standard errors clustered at the matched-pair level; the unit of observation is a person within a matched pair. We estimate (8) on six outcomes: log(publications + 1) and log(citations + 1), in each case computed three ways, using OpenAlex publications only, CNKI publications only, and the sum across both corpora. OpenAlex captures internationally circulating, English-language scholarship and CNKI captures Chinese-language journal articles, so this decomposition separates effects on international publishing from effects on domestic publishing.

Table 3 reports the results. Returnees publish 11.3% less in OpenAlex after return (column 1) and 11.5% more in CNKI (column 2), leaving total publications essentially unchanged: the corpus-sum effect is a -1.6% change that is economically negligible and flips sign across matching variants (column 3). Citation impact moves the same way: a 28.5% drop on the OpenAlex side (column 4) is partly offset by a 12.2% rise on the CNKI side (column 5), leaving citations 20.2% lower in total (column 6). Single-corpus panel comparisons that observe only one of the two channels would conclude that return sharply reduces both productivity and impact. Once both corpora are observed jointly, the effect on total publications essentially vanishes and the citation decline shrinks: return reallocates scholarly output across corpora far more than it reduces it.

Table 3: Effect of return on publications and citations

	log(publications + 1)			log(citations + 1)		
	(1) OpenAlex	(2) CNKI	(3) Total	(4) OpenAlex	(5) CNKI	(6) Total
Returnee × Post	−0.120***	0.109***	−0.016*	−0.335***	0.115***	−0.226***
	(0.008)	(0.006)	(0.009)	(0.022)	(0.009)	(0.023)
Observations	41,704	41,704	41,704	41,704	41,704	41,704
Mean of dep. var.	0.165	0.075	0.239	4.229	0.293	4.523
Person fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Stacked matched difference-in-differences estimates of equation (8) on the matched sample of 802 returnee-stayer pairs (returnees with return year in $[1940, 1957]$ matched to observably similar U.S.-based stayers on broad field, first-publication year, entry cohort, and pre-return output; corroborated-publication sample), in event time $[-10, 15]$ around return. The unit of observation is a person within a matched pair; person and calendar-year fixed effects are included and standard errors are clustered at the matched-pair level. Estimates are robust across the four matching variants (475–1,105 pairs): the redirection out of OpenAlex and into CNKI holds throughout, and the effect on total publications is economically negligible in every variant. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figures 5 and 6 trace the dynamics behind the average effects in Table 3. On the same 802 matched pairs, we estimate the event-study analogue of (8),

$$y_{it} = \alpha_i + \lambda_t + \sum_{k \neq -1} \beta_k \, \mathbf{1}\{\tau_{it} = k\} \cdot \text{Returnee}_i + u_{it}, \tag{9}$$

where τ_{it} is event time relative to the returnee's return year and the matched stayer is centered on the same calendar year as its returnee. We estimate (9) over event time $\tau \in [-5, 15]$, taking $\tau = -1$ as the omitted reference period, and cluster standard errors at the matched pair. The pre-return coefficients are individually and jointly indistinguishable from zero (Figure 5), consistent with parallel trends; the tighter matching variant, which additionally matches on institution, yields flat pre-trends over the full $[-10, 15]$ window.

The OpenAlex panel of Figure 5 shows flat pre-trends and a steady decline after return, reaching about -0.15 log points by $\tau = +15$. The CNKI panel rises sharply from $\tau = 0$ to about $+0.16$ by $\tau = +8$ and remains elevated thereafter. Combined, the total-publication gap stays small throughout and closes during the Cultural Revolution (1966–1976), when scientific publishing in China contracted. Citations follow the same dynamic structure with

larger magnitudes (Figure 6).

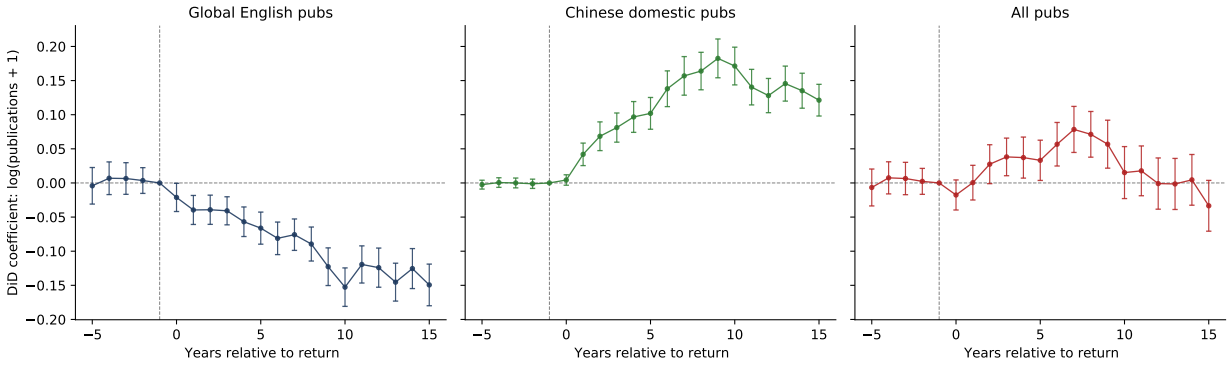


Figure 5: Event study, log(publications + 1)

Notes: Coefficients $\hat{\beta}_k$ from (9). 802 matched returnee-stayer pairs with return years in [1940, 1957]. Reference period $\tau = -1$. Bars: 95% confidence intervals from pair-clustered standard errors.

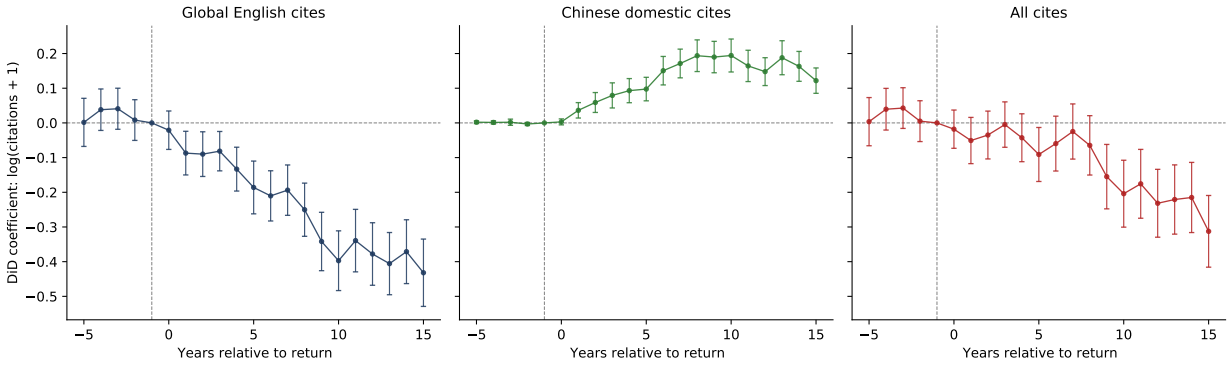


Figure 6: Event study, log(citations + 1)

Notes: Same specification as Figure 5, with log(citations + 1) as the dependent variable.

The cross-corpus reallocation could mask a quality decline if returnees published their best work in one channel and weaker work in the other, or if the average quality of their output fell after return. We re-estimate (8) replacing the count outcomes with semantic-similarity measures of paper-level frontier alignment (Kelly et al., 2021), where the reference frontier is the centroid of high-impact papers in the same subfield-year. Table 4 reports the estimates. The alignment of OpenAlex publications to the global frontier, where returnees and matched stayers are directly comparable, is essentially unchanged after return: the point estimate is a small −0.048 (s.e. 0.028) that is only marginally significant and economically

minor against a mean of 0.38. The alignment of CNKI publications to the global frontier, the catching-up measure, rises significantly (+0.134, s.e. 0.049). Returnees thus reallocate their publishing channel without lowering the frontier-alignment of their output, and their Chinese-language work moves measurably closer to the international frontier. Figure 7 traces the event-study dynamics behind these estimates.

Table 4: Effect of return on paper-level frontier alignment

	(1) OA pubs vs OA frontier	(2) CNKI pubs vs CNKI frontier	(3) CNKI pubs vs OA frontier
Returnee × Post	−0.048*	0.084	0.134***
	(0.028)	(0.057)	(0.049)
Observations	1,646	1,412	1,473
Mean of dep. var.	0.378	0.615	0.362
Person fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Subfield fixed effects	Yes	Yes	Yes

Notes: Stacked matched difference-in-differences estimates of equation (8) on paper-level frontier-alignment outcomes from Kelly et al. (2021), estimated on the same 802 matched pairs as Table 3. The dependent variable in column 1 is the LaBSE cosine similarity between OpenAlex publications and the OpenAlex breakthrough centroid in the corresponding subfield-year; column 2 is the analogous within-CNKI alignment; column 3 is the alignment of CNKI publications to the OpenAlex global frontier (the catching-up measure). Person, calendar-year, and subfield fixed effects; standard errors clustered at the matched-pair level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

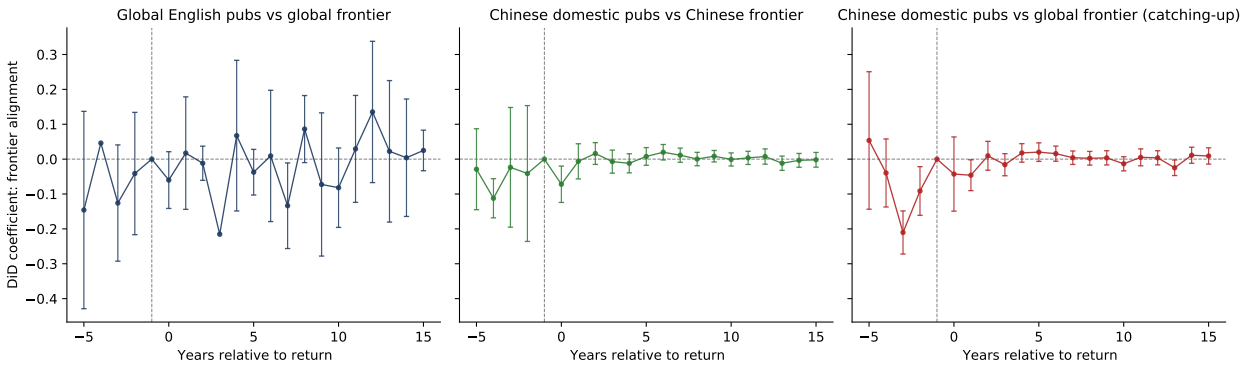


Figure 7: Frontier alignment around return

Notes: Left panel: matched DiD on the OpenAlex-side global-frontier alignment. Middle and right: within-returnee event-time means for CNKI-side alignment to the CNKI and OpenAlex frontiers, shown relative to $\tau = -1$. The matched stayer comparison is undefined for CNKI outcomes because U.S.-based stayers do not publish in CNKI. 802 matched pairs.

5.1 Redirecting the Research Agenda

The count and frontier-alignment results show that return reallocates *where* scholars publish without lowering how much or how close to the frontier they publish. They do not, however, speak to *what* returnees work on. The planning regime that directed returnee placements toward defense, heavy industry, and applied engineering (Section 6) plausibly redirected not just careers but the substantive content of research, pulling scholars away from the basic questions they pursued in the United States and toward mission-oriented, applied work. Semantic frontier-alignment, which measures distance to a subfield-year breakthrough centroid, is silent on this basic-versus-applied dimension: a paper can be equally frontier-proximate whether it develops fundamental theory or solves an applied engineering problem.

To measure the direction of research directly, we use a large language model to read each scholar's actual publications. For every scholar we assemble the titles and abstracts of their pre-return and post-return output, pooling English-language OpenAlex and Chinese-language CNKI text, and prompt `claude-sonnet` to compare the two bodies of work and return two scores: the *magnitude* of the agenda shift (0 = identical research program, 100 = unrelated) and its *direction* on a basic-to-applied axis (-100 = decisively more basic, $+100$ = decisively more applied). This direct-content measure is complementary to the embedding-based measures: rather than locating a scholar in a fixed semantic space, it asks a multilingual reader to judge how, and in which direction, the research program moved. We restrict the sample to the 244 scholars (171 returnees and 73 matched stayers) with

enough bilingual abstract text on both sides of return to support the comparison, and assign matched stayers the placebo return year of their returnee.

Table 5 reports the difference between returnees and matched stayers in the pre-to-post change. Returnees redirect their research decisively toward applied work: the returnee-stayer gap in the applied-direction score is +21.7 ($p < 0.01$), against a stayer mean change of only +13.6. Returnees also change their agenda somewhat more in overall magnitude (+8.1, $p < 0.05$), and are 16 percentage points more likely to move toward the applied end of the spectrum. The redirection is thus not simply that returnees revise their research more than comparable stayers as careers mature; it is that the revision is systematically *toward* applied, mission-oriented science, exactly the margin that citation counts and frontier-alignment cannot see.

Table 5: Return redirects research toward applied work

	(1) Agenda shift (0–100)	(2) Toward applied (−100/+100)
Returnee × Post	8.10**	21.73***
	(3.53)	(4.30)
Stayer mean change	59.1	13.6
Observations	244	244

Notes: Each scholar's pre-return and post-return publications (pooled English-language OpenAlex and Chinese-language CNKI titles and abstracts) are read by `claude-sonnet`, which returns the magnitude of the agenda shift (column 1; 0 = unchanged, 100 = unrelated) and its direction on a basic-to-applied axis (column 2; −100 = more basic, +100 = more applied). The sample is the 244 scholars (171 returnees, 73 matched stayers) with sufficient bilingual abstract coverage on both sides of return; matched stayers are assigned the placebo return year of their returnee. Each entry is the estimated returnee-stayer difference in the pre-to-post change, with heteroskedasticity-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 8 traces the dynamics. We ask the same reader to score, for each three-year event-time bin, how far a scholar's output in that bin has drifted from their own pre-return research baseline and how far it has moved toward applied work, and estimate the event-study analogue of (9) on these scores. The applied-direction path is flat before return and jumps sharply at return, ruling out a pre-existing divergence in research style and locating the redirection precisely at the moment of return.

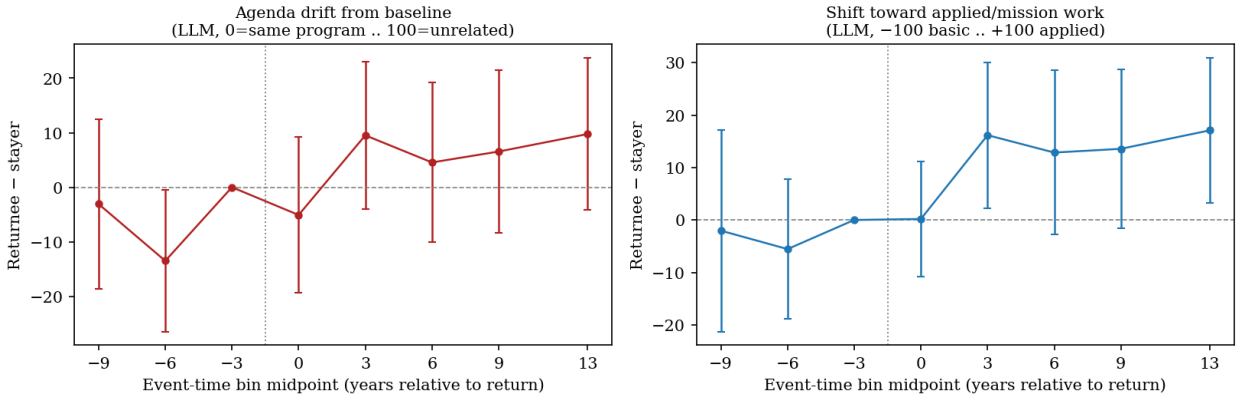


Figure 8: Research-agenda redirection around return

Notes: Returnee-minus-stayer event-study coefficients from (9) on the language-model agenda scores, binned into three-year event-time intervals and normalized to the pre-return baseline. Left panel: drift from the scholar's own pre-return research baseline (0–100). Right panel: movement toward applied work (−100 to +100). Person and event-bin fixed effects; standard errors clustered at the scholar level. Bars are 95% confidence intervals.

At the topic level, this redirection is a movement *within* a scholar's research, from its basic toward its applied end, rather than a change in *which* topics they pursue.

The single clearest case is Qian Xuesen, whose career motivates the exercise. At Caltech his research was *basic* aerodynamics, propulsion, and structural mechanics; after his 1955 return it pivots to *applied*, mission-oriented work: cybernetics, systems science, and the methodology of "technical science", the intellectual scaffolding for China's missile and space programs (Table 6). His broad subfield, aerospace engineering, is unchanged across return, so a subfield-level measure registers no movement; the redirection is visible only in the content of the work itself.

Table 6: Qian Xuesen's research before and after return

Before return, Caltech, 1939–52 *Basic aerodynamics & structures*	**After return**, China, 1956–65 *Applied control & mission science*
1939. Two-Dimensional Subsonic Flow of Compressible Fluids	1957. Engineering Cybernetics
1942. A Theory for the Buckling of Thin Shells	1957. On Technical Science
1946. Similarity Laws of Hypersonic Flows	1957. Methodological Problems in Technical Science
1948. Wind-Tunnel Testing Problems in Superaerodynamics	1957. Introduction to Physical Mechanics
1952. Applications of Jet Propulsion Power Plants	1957. Long-Range Spaceflight
	1964. Large-Scale Scientific Experimentation

Notes: Representative publications of Qian Xuesen (H. S. Tsien) before and after his 1955 return to China, illustrating the basic-to-applied redirection measured in Table 5. Chinese-language titles are given in English translation. His OpenAlex subfield (aerospace engineering) is identical on both sides; the shift is in research content, not field.

6 Effects on Domestic Scientific Production

Returnees do not publish less in total or produce lower-quality work after return. We turn next to whether their arrival reshaped the broader Chinese scientific system, the strategic fields returnees entered and, crucially, the output of the *other* domestic scientists who worked alongside them. During the early 1950s many U.S.-trained returnees entered fields that were nascent or effectively nonexistent in China, and after the onset of scientific isolation in 1957 they became a primary conduit through which frontier methods and topics reached the domestic system.

6.1 Spillovers to the Rest of the Domestic Community

Our estimates so far track returnees' own publications and those of their direct collaborators. A sharper test of whether returnees built *capacity* asks what happened to the output of *other* domestic scientists, those who never trained abroad, in the fields returnees entered. We measure this on the full CNKI corpus of 564,632 Chinese-language papers, of which the

matched returnee panel observes only a small fraction. For each OpenAlex subfield we define the returnee "dose" as the standardized number of returnees active in that field, and relate the subsequent output of non-returnee scientists to that dose, with subfield and year fixed effects and pre-trends verified to be flat.

The right test of capacity building is not whether the *average* domestic paper moved closer to the frontier. A field-creating returnee does not raise the proximity of papers that would have been written anyway; the mean frontier alignment of others' papers is, in fact, essentially unchanged. The question is whether returnees caused new frontier-proximate work to *exist*. We therefore measure the *extensive* margin: the count of non-returnee papers whose research content lands close to the returnees' own imported research agenda, the direction they carried back from the United States. This count rises sharply, but only after a long delay (Figure 9). It is flat and statistically insignificant before returnees enter a field, consistent with no pre-existing divergence; it begins climbing roughly eight years after the first returnee's entry, crossing +1 standard deviation per standard deviation of returnee dose by year eight and reaching a peak of about +1.7 around year seventeen, with a post-entry plateau near +0.9. Returnees seed an agenda and the surrounding community fills in the space around it. This is the mechanism behind a returnee such as Qian Xuesen founding an aerospace research program where essentially none had existed, an effect that individual-level publication counts, which never observe the non-returnee scientists, cannot capture.

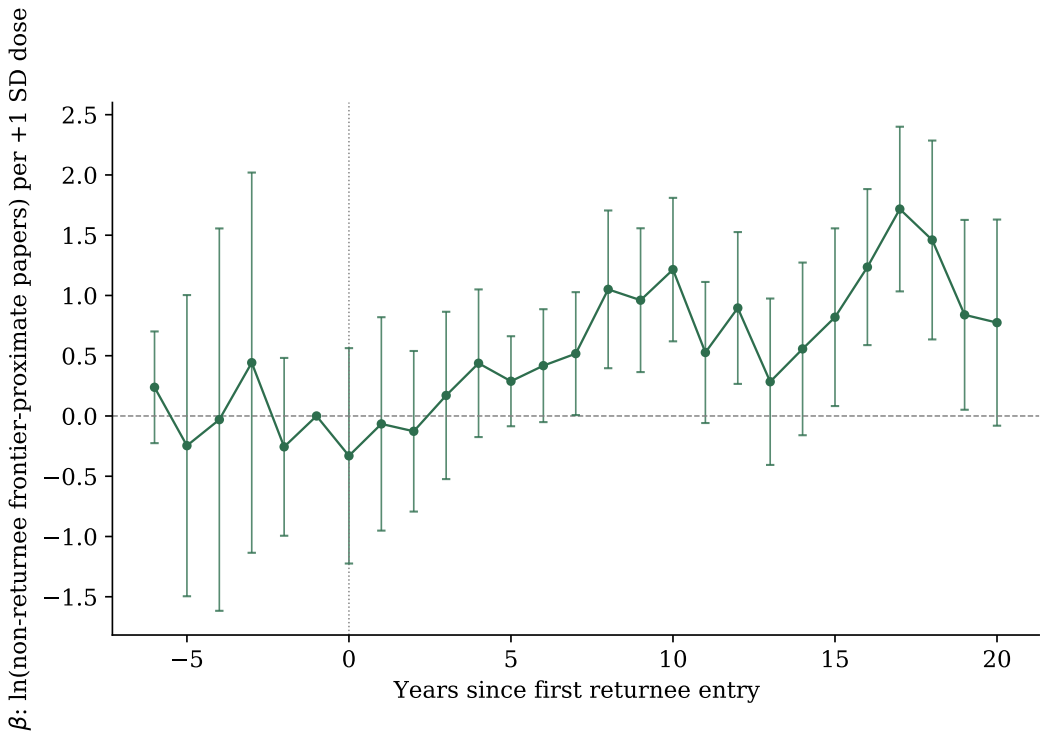


Figure 9: Extensive-margin spillover to non-returnee domestic scientists

Notes: Full-corpus CNKI event study. The outcome is $\ln(1 + \text{count})$ of *non-returnee* papers in a subfield-year whose in-language (Chinese SBERT) embedding lands in the top decile of similarity to the returnees' own research-agenda centroid, regressed on the standardized returnee dose (the number of returnees in the subfield) interacted with event-time dummies, with subfield and calendar-year fixed effects and standard errors clustered by subfield. Event time is years since the first returnee entered the subfield; the reference period is $\tau = -1$. Coefficients are flat and statistically insignificant before entry and rise after a delay of roughly eight years, peaking near +1.7 around $\tau = 17$. Bars are 95% confidence intervals. Source: authors' analysis of the full 564,632-paper CNKI corpus.

6.2 Heterogeneity Across Strategic Subfields

The spillover is concentrated exactly where a directed research regime would place it. Following the historical record on the Twelve-Year Plan for Science and Technology (1956), we isolate six strategic subfields explicitly prioritized by the Chinese government during the Great Return Wave: Aerospace Engineering, Nuclear and High Energy Physics, Atomic and Molecular Physics, Condensed Matter Physics, Electrical and Electronic Engineering, and Mechanical Engineering. Figure 10 traces mean frontier alignment by period (1940–1954, 1955–1964, 1965–1979) for each subfield, separately for OpenAlex and CNKI publications.

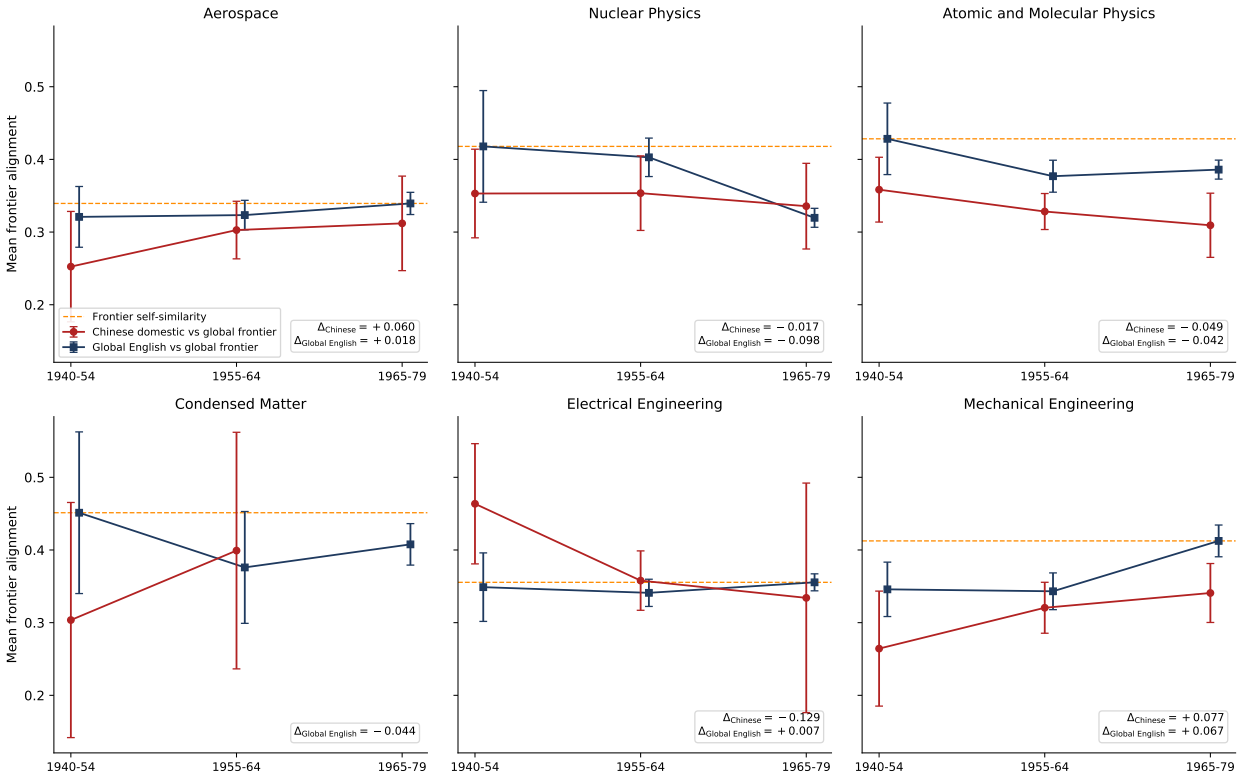


Figure 10: Convergence in direction across strategic subfields

Notes: Mean alignment of subfield-period publications to the OpenAlex global frontier. Red: CNKI publications. Blue: OpenAlex publications. Dashed orange: maximum OpenAlex alignment across periods (frontier self-similarity benchmark). Δ_{CN} and Δ_{OA} are the corresponding changes between 1940–1954 and 1965–1979.

Between 1940–1954 and 1965–1979, the OpenAlex-side alignment rises in the three engineering subfields, Mechanical ($\Delta_{\text{OA}} = +0.067$), Aerospace (+0.018), and Electrical and Electronic (+0.007), while the three physics subfields (Nuclear and High Energy, Atomic and Molecular, Condensed Matter) drift away from the global frontier. The CNKI-side shows the same concentration: the largest domestic gains are in Mechanical ($\Delta_{\text{CN}} = +0.077$) and Aerospace (+0.060) Engineering, whereas the physics subfields are flat to negative and Condensed Matter Physics has too few Chinese-language papers in the final period to measure. The catching-up signal thus loads on the applied engineering fields, most visibly aerospace and mechanical engineering, consistent with the planning regime concentrating returnee placement and domestic-publishing infrastructure in fields directly relevant to industrialization and the strategic-weapons program, and with aerospace being the field Qian Xuesen was directed to build.

To visualize where in the semantic space of science Chinese domestic output concentrated

relative to the international frontier, we project paper-level LaBSE embeddings to two dimensions using t-SNE and bin them into a hexagonal density grid. Figure 11 shows four panels: panel (a) maps the global English-language frontier; panels (b)–(d) map the corresponding Chinese-language output for the three sub-periods 1940–1954, 1955–1964, and 1965–1979. The Chinese mass migrates over time toward the regions of the embedding space that are densest at the frontier, with the largest visible shift between 1955–1964 and 1965–1979 in the engineering and applied-physics regions of the map.

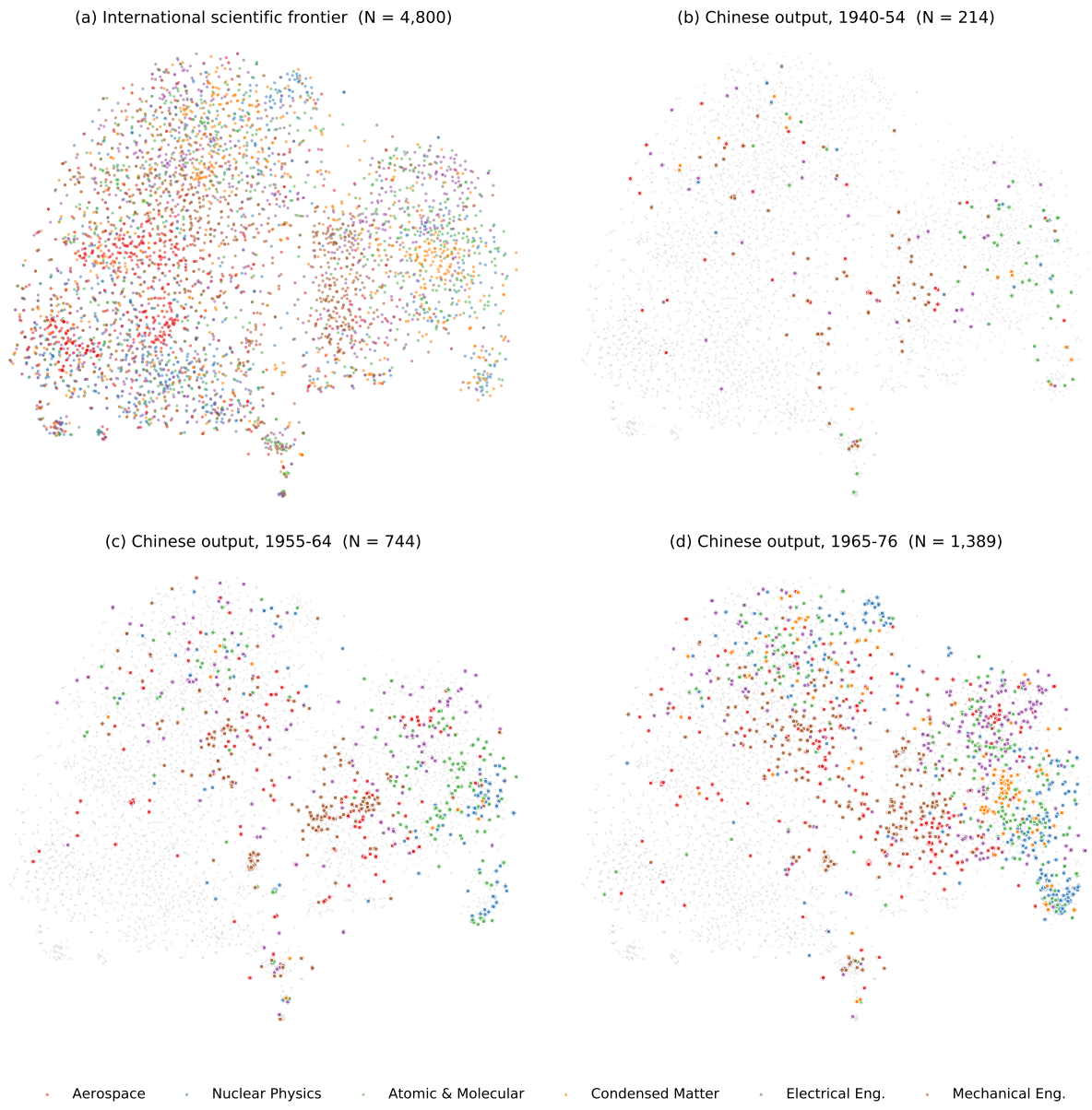


Figure 11: Volume of scientific output in the semantic space of strategic subfields

Notes: Two-dimensional t-SNE projection of LaBSE paper embeddings restricted to the six strategic subfields. Panel (a): the global English-language frontier (top-cited OpenAlex papers, all years). Panels (b)–(d): hexagonal density of Chinese-language CNKI publications during 1940–1954, 1955–1964, and 1965–1979. Color intensity in each panel reflects the local density of papers in that two-dimensional region. The Chinese-output mass converges over time toward the densest regions of the international frontier, particularly between 1955–1964 and 1965–1979 in the engineering and applied-physics regions of the map.

7 The Welfare Cost of Redirection

The reduced-form results establish that return redirected scientific output from the international to the domestic corpus without lowering per-paper frontier alignment, and that returnees seeded frontier activity among the domestic scientists around them. We now ask what these movements were worth in aggregate: when a scientist is reallocated from the U.S. research system to the Chinese one, is world science better off, worse off, or merely rearranged? To answer this we adapt two structural frameworks that price the social value of a researcher inclusive of the downstream spillovers their work triggers, and feed them our data.

Framework. Our welfare accounting is based on the innovation-network model of Liu and Ma (2026). Technological fields are nodes in an *innovation network* Ω, whose (f, g) entry ω_{fg} is the share of field f's citations directed to field g. In their model the value of R&D in a field is governed by its position in Ω: a field's *innovation centrality* measures how much its discoveries feed innovation elsewhere in the network, and the growth-optimal allocation of R&D weights each field by the network-adjusted marginal social value

$$\gamma' = \tfrac{\rho}{\rho+\lambda}\,\beta'\big(I - \Omega/(1+\rho/\lambda)\big)^{-1}, \tag{10}$$

where β is the vector of direct field values and ρ and λ are the discount and innovation-arrival rates. We construct Ω directly from citations: a scan of the pre-1979 OpenAlex snapshot yields 38.7 million cross-field citation edges among 244 subfields. Following the open-economy extension in Liu and Ma (2026), we stack the network into (country $\times$ field) nodes and assign each country a field-level self-sufficiency x_c, the share of the knowledge it uses that is generated at home rather than imported from the frontier. We estimate China's field-level self-sufficiency from the cosine similarity between the CNKI and OpenAlex field centroids and set the U.S. benchmark to the frontier value $x_{\text{US}} \approx 0.70$ from Liu and Ma (2026). A returnee is a unit of R&D reallocated from a (U.S. $\times$ field) node to a (China $\times$ field) node, and the social value of the move is the difference between the two nodes' marginal social values γ_f. This static, network-based accounting complements the dynamic two-country migration-growth model of Prato (2025), in which return migrants transmit cross-border knowledge and origin countries gain through spillbacks onto home collaborators; we do not implement its full dynamic transition here and leave that extension to future work.

Result. Because the United States sat at the frontier and was largely self-sufficient ($x_{\text{US}} \approx 0.70$) while China was frontier-dependent, most of all in the strategic fields returnees entered

(aerospace $x_{\mathrm{CN}} \approx 0.13$, nuclear physics ≈ 0.12), the same scientist generated more home-grown spillovers inside the U.S. system than inside the Chinese one. A returnee was worth to China only about a third of what the United States gave up: a gain of roughly 0.019 against a loss of roughly 0.057 in comparable units of social value, for a net loss to world science of about 0.038 per scientist (Figure 14). The ratio is robust across the self-sufficiency band we vary (China gain relative to U.S. loss between 0.30 and 0.41). Figure 12 visualizes the two ingredients: the cross-field citation network ordered by innovation centrality, and the asymmetric U.S. $\rightarrow$ China knowledge flow it implies, with China drawing heavily on the U.S. frontier while the reverse flow is small. Figure 13 plots China's field-level self-sufficiency, everywhere below the U.S. benchmark and lowest in exactly the strategic fields the returnees entered.

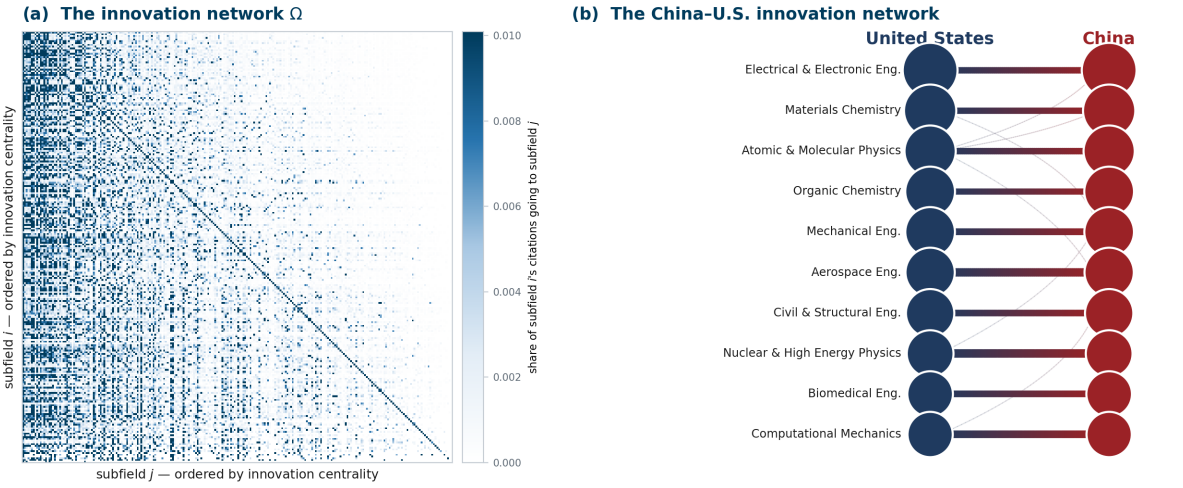


Figure 12: The innovation network and cross-country knowledge flow

Notes: Left: cross-field citation network Ω built from 38.7 million pre-1979 citation edges among 244 subfields, as a heatmap with fields ordered by innovation centrality; darker cells denote larger knowledge flows from one field to another. Right: the same knowledge as it flowed between the two countries, with each connector running from the source (the U.S. frontier, navy) to the recipient (China, crimson) and its width proportional to China's frontier reliance. China drew heavily on the U.S. frontier; the reverse flow was small. Source: authors' analysis.

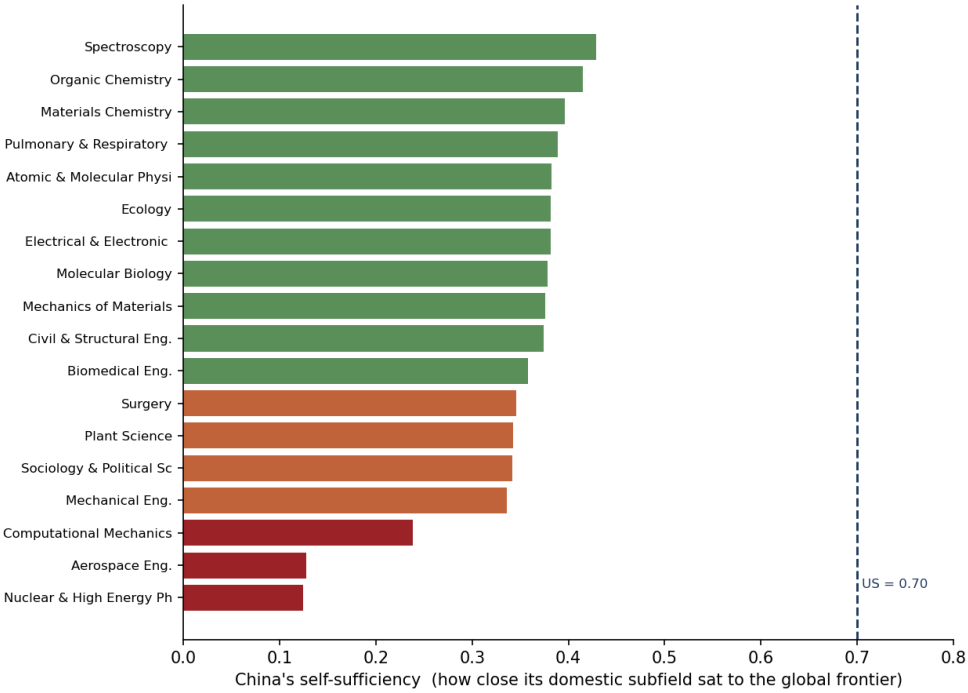


Figure 13: China's field-level self-sufficiency

Notes: Each bar is China's self-sufficiency x_{CN} in a field, the share of that field's knowledge China generated domestically rather than importing from the frontier. Every value sits below the U.S. benchmark of 0.70, and the strategic fields the returnees entered (aerospace, nuclear physics) sit lowest. The more frontier-dependent the field, the less a returnee added to China and the more the United States gave up. Source: authors' analysis.

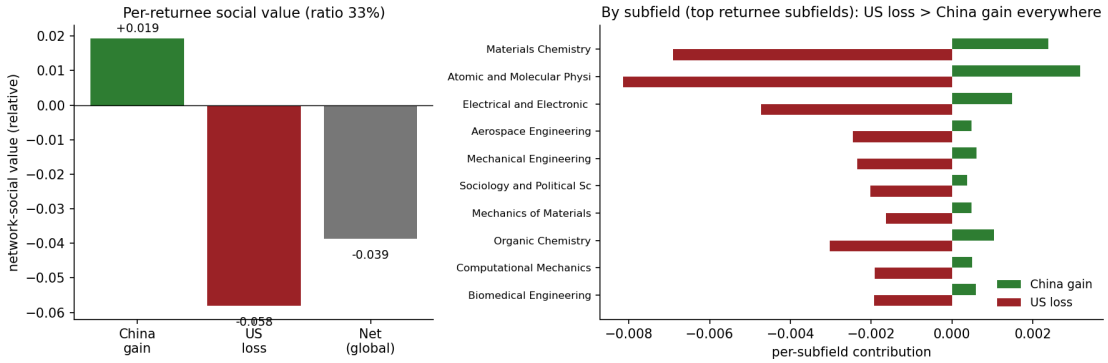


Figure 14: China's gain versus the U.S. loss per returnee

Notes: Per-returnee social value in the relative units of the model: China's gain (left) is about a third of the U.S. loss (center), and the net world effect (right) is negative. The right panel decomposes the effect by field; in every field the returnees concentrated in, the U.S. loss exceeds the China gain. Source: authors' analysis.

Table 7 shows the same pattern field by field: in every field the returnees concentrated in, the U.S. loss exceeds the China gain, and the gap is widest where China sat furthest from the frontier.

Table 7: What a returnee was worth, by field: China's gain versus the U.S. loss

Field	China self-sufficiency x_{CN}	China gain	U.S. loss
Materials Chemistry	0.40	0.0024	0.0068
Atomic and Molecular Physics	0.38	0.0028	0.0071
Electrical and Electronic Eng.	0.38	0.0014	0.0046
Organic Chemistry	0.42	0.0010	0.0028
Mechanical Engineering	0.34	0.0006	0.0023
Surgery	0.35	0.0006	0.0016
Aerospace Engineering	0.13	0.0005	0.0024

Notes: Per-returnee social value, in the relative units of the model, for the fields returnees most concentrated in. "China self-sufficiency" x_{CN} is the share of a field's knowledge China sourced domestically (the U.S. benchmark is 0.70). In every field the U.S. loss exceeds the China gain; the gap is widest where China was furthest from the frontier (e.g., Aerospace). Values are computed on the stacked (country $\times$ field) network of Liu and Ma (2026). Source: authors' analysis.

Robustness: a scarcity premium. The obvious objection is that frontier knowledge is worth more where it is scarce, exactly the Qian Xuesen case of building a field from nothing.

We add a scarcity premium that credits a returnee $\gamma_f \cdot (1 + \pi \cdot \text{gap}_f)$, where gap_f is field f's distance to the frontier. The net-world-loss narrows as π rises but does not reverse until $\pi^\star \approx 8.1$, a roughly ninefold marginal-value premium on the scarcest field, well outside any plausible range (Figure 15). Across the entire plausible range the sign holds: the receiving country gains less than the sending country loses.

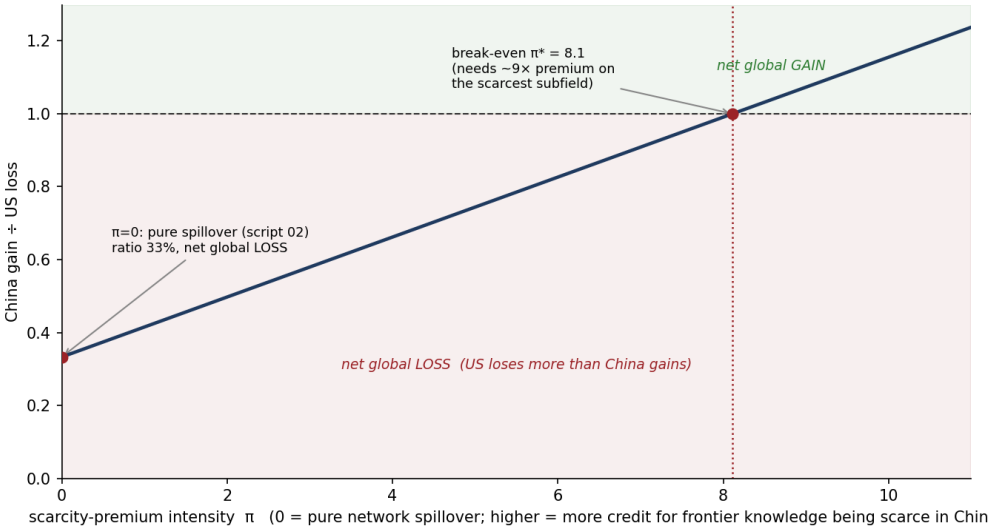


Figure 15: The net loss survives a scarcity premium

Notes: The ratio of China's gain to the U.S. loss as scarce frontier knowledge is credited more (larger π). The ratio rises but stays below one, a net world loss, until an implausibly large premium $\pi^\star \approx 8.1$. Source: authors' analysis.

Interpretation and caveats. We interpret these magnitudes as illustrative rather than as welfare estimates in a national-accounting sense: they are obtained by calibrating the innovation-network model of Liu and Ma (2026), in which a field's social value reflects the cross-field knowledge spillovers it sets off, to the citation network and text embeddings we construct. Accordingly, we base our conclusions on the sign and the ratio of the effect, both of which are robust to the modeling choices we vary, rather than on the precise point estimates. The exercise values only internalized knowledge spillovers measured through publications: the institutions returnees built, the students they trained, and classified mission work appear in no bibliographic record, so the China-side gain is if anything understated. The identifying wedge relative to this literature is that our setting supplies quasi-exogenous variation in *who* returns, the 1951–1954 exit restrictions, whereas both the innovation-network and the migration-growth frameworks take the allocation of talent as given.

8 Conclusion

The Great Return Wave of 1940–1957 brought more than 1,300 U.S.-trained Chinese scientists back to a country in the middle of building a planned research system. We track their publications across the international (OpenAlex) and domestic (CNKI) bibliographies through 1976 and measure each paper's alignment to the international research frontier using multilingual semantic embeddings. The cross-corpus, person-level design lets us decompose effects on scientific output that single-corpus analyses cannot separate.

Three findings stand out. First, return reallocates publishing channels rather than reducing total scholarly output: returnees publish 11.3 percent less in OpenAlex and 11.5 percent more in CNKI, leaving total publications essentially unchanged. Citations fall by 28.5 percent on the international side and rise by 12.2 percent on the domestic side, for a combined decline of 20.2 percent. Second, the reallocation does not lower paper-level alignment to the international frontier, and the Chinese-language output of returnees moves significantly closer to it, so the channel switch does not come at a measurable quality cost. Third, the spillover beyond the individual scientist is concentrated where it would be expected under a directed research regime. Subfields that received a 1940–1957 returnee experience a positive post-arrival shift in international-frontier alignment, and the effect is most pronounced in the engineering subfields explicitly named in the Twelve-Year Plan for Science and Technology of 1956. Beyond the returnees' own subfields, the full domestic corpus shows the field-creating margin directly: as returnee presence in a field rises, the *count* of non-returnee papers whose research content lands close to the returnees' own imported research agenda increases over the following two decades, even though the average paper's proximity to that agenda does not.

Finally, pricing the reallocation through the cross-field citation network turns these reduced-form patterns into a welfare statement. A returnee was worth to China only about a third of what the United States lost, because a frontier scientist generates more knowledge spillovers embedded in a dense, self-sufficient research system than transplanted into a frontier-dependent one. Forced relocation therefore did not simply transfer scientific value across the Cold War divide; it destroyed some of it in transit. This divergence cost, robust to a generous scarcity premium, is the aggregate counterpart to the field-level catching-up we document: China gained, the United States lost more, and world science was left poorer.

These results speak to a longstanding question in the economic history of socialist science: whether centrally planned research systems can absorb foreign frontier knowledge, and where in the field-space the absorption occurs. Soviet-era emulation strategies described by Lardy (1995) and the science-policy template the early PRC inherited from them (Wang, 2014)

predicted convergence in disciplines tied to industrial and military priorities, and convergence stalls at the periphery. Our subfield estimates match that prediction: the catching-up signal loads on engineering and applied physics, not on basic physics or the humanities. The pattern is consistent with a broader literature documenting how political institutions shape the direction, rather than only the level, of innovation (Acemoglu et al., 2024; Moscona, 2024; Moser et al., 2025), and complements work tracing the long-run effects of mass cross-border knowledge transfers in market economies (Moser et al., 2014; Giorcelli, 2019). Returnees in our setting were not a marginal input that the planner could deploy uniformly; they were the binding constraint on absorptive capacity in the priority subfields, and the data trace exactly that pattern. The lesson extends beyond this setting. When a rising power draws frontier scientists into a planned research system, what it gains, and what the losing system forgoes, is governed by the strategic fields those scientists seed and their position in the global knowledge network, not by their number: a strategically concentrated cadre built the atomic bomb and the missile program, capabilities that are themselves a source of international power, complementing the economic interdependence emphasized by Liu and Yang (2026). Forced relocations of this kind reorganize the international scientific order, and, as our accounting shows, typically at a net loss to the world.

The empirical strategy used here is portable, and three extensions are natural. The first is to follow the 1978 reopening cohort, where the same individuals are observed in a market environment and the channel-substitution mechanism should weaken if the planner's preferences were what concentrated catch-up in engineering. The second is to apply the dual-frontier measure to other socialist science systems with bilingual bibliographies (the post-1949 USSR, the GDR, post-1949 Cuba), where the predicted heterogeneity across subfields differs by planning regime. The third is to map the coauthor network that returnees built around themselves. The cross-corpus panel records every domestic collaborator on every CNKI paper and every international collaborator on every OpenAlex paper, so each returnee appears simultaneously as the seed of a Chinese coauthor cluster and as a persisting node in the U.S. network they trained in. Tracing how those two networks evolve, whether the domestic cluster widens as it absorbs the returnee, whether the international tie persists or atrophies under closure, and whether bridging scientists drive the subfield-level catching-up we document, is the natural next step, and the embedding-based outcomes used here generalize directly to coauthor-pair similarity. Whether returnees pull a domestic system toward the frontier, and where in the field-space they do so, appears to depend less on the scientists themselves than on the institutional environment that decides where to put them and on the networks that form around them once they arrive.

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Appendix

1 Data Sources

Directories of Chinese Scholars in the United States

Across the early twentieth century, different organizations voluntarily took on the responsibility of creating a record of Chinese students at American universities. These organizations oftentimes used these directories for the two-pronged purpose of fostering community ties among Chinese students and amplify marketing efforts. As the responsibility for creating directories for Chinese students was informally passed from organization to organization, the methods of collection began to change as well. Due to the lack of a centralized database, statistics on Chinese students were often a collation of information gathered from different methods, including outreach to universities, personal interviews, and records from local student clubs. The prevalence of name changes and ambiguity around classifications of origin made it difficult to maintain consistent records over the years. Table 8 summarizes the directories we draw on; Figure 16 and Table 9 report the annual counts of recorded students.

Table 8: **Chinese Student Directories in the United States (1911–1952)**

Organization	**Years Covered**	**Variables Available**	**Data Collection Methods**
Chinese Students' Alliance in the U.S.A.	1911–12, 1914–15, 1921, 1929–33	Name, School, Major/Field of Study, Degree Pursued, Mailing Address	Compiled and edited by a handbook committee and local club officers, with support from alumni and professional societies.
Chinese Students' Christian Association	1935–40	Name, School, Major/Field of Study, Mailing Address	Aggregated registrar records, correspondence with individual students, collaboration with student groups, institutional catalogs, and bulletin mailings.
The China Institute in America	1941–45, 1949–52	Name, School, Degree Program, Graduation Year, Student Status (undergrad/grad), Major Field	Data obtained from schools (winter semester returns), Chinese student groups, and independent graduate surveys. Limitations noted: incomplete due to mid-year enrollment changes, name inconsistencies, and exclusions based on origin.

The first step of our data collection focused on the retrieval of all directories of Chinese students in the United States, which served as a time stamp of their activity abroad. We

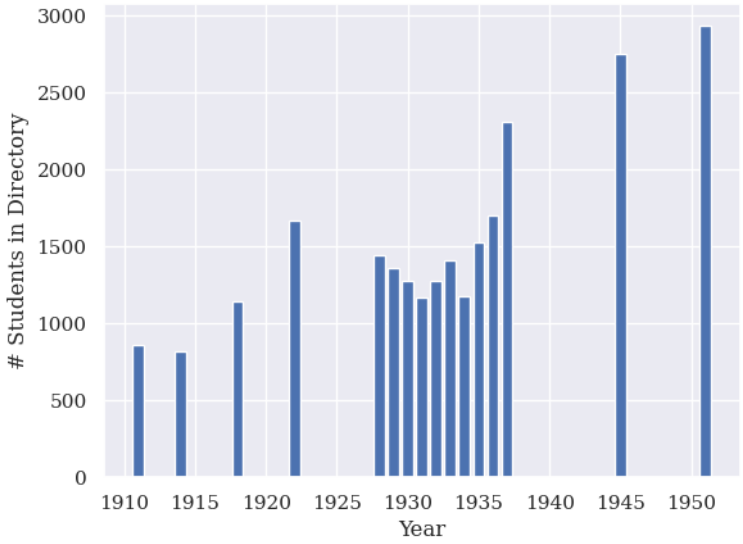


Figure 16: Annual Count of Students in Directory

year	No. of Entries	Truncated Names
1911	861	387
1914	821	593
1929	1357	586
1930	1281	375
1931	1168	433
1932	1281	374
1933	1413	420
1935	1702	275
1937	2312	682
1945	2750	1078
1951	2934	292

Table 9: Count of Students by Directory

then constructed a dataset of all scholars by concatenating the directories.

Below are a few challenges that we experienced in trying to merge data across disparate sources:

- truncated or anglicized names (more common for first names), which created significant misalignment between the dataset of returnees and the dataset of Chinese scholars in the US
- heterogeneity in academic schema, making it difficult to group scholars under field of study
- unclear timelines across directories; although we could not find overlapping directories across organizations, we also did not find any formal documents corroborating our claim that each organization operated dis-jointly
- multi-year gaps in directories left huge holes in our data, making it difficult to corroborate timelines of certain scholars whose time abroad fell within one of these periods

Returnees

We compile a panel dataset of Chinese scholars who studied abroad and returned to China using three primary archival sources covering 1840–1963. The Comprehensive Survey of Scientific and Technical Personnel Studying Abroad and Returning to China, 1840–1949 profiles 3,500 scientific and technical personnel, documenting pre-departure domestic education, foreign study details, and post-return employment; the data, originally structured in tabular form by field, were digitized and cleaned for misspellings and syntactical inconsistencies. The Scientific and Engineering Manpower in Communist China, 1949–1963 contains information on 1,200 prominent scientists and engineers, including birth year, educational background, specialization, political status, and Chinese Academy of Sciences (CAS) membership, compiled from a wide range of official and published materials. Finally, the Dictionary of Chinese Scholars Who Returned from North America in the 1950s covers 1,806 returnees, with detailed variables on education, migration dates, post-return careers, political roles, and notable life events, based on interviews, organizational records, personal communications, and archival materials. For the Dictionary, we parsed archival records using GPT-4 API calls to classify variables related to time abroad and post-return activities. Table 10 summarizes the scope, variable coverage, and data collection methods for each source.

Table 10: **Primary Sources on Returnee Scholars to China (1840–1963)**

Source	**Time Period Covered**	**Variables Available**	**Data Collection Methods**
A Comprehensive Survey of Scientific and Technical Personnel Studying Abroad and Returning to China, 1840–1949	1840–1949	Name, Domestic School (before going abroad), Year of Departure, Country of Study Abroad, Foreign Institution, Academic Discipline, Major, Year of Return, Domestic Work Location (after return)	Profiles 3,500 scientific and technical personnel in mainland China that had studied abroad. Compiled from biographical books, publications, and archival materials on students who studied abroad, particularly those in science and engineering.
Scientific and Engineering Manpower in Communist China, 1949–1963	1949–1963	Name, Year of Birth, Educational Background (highest degree held), Academic Position (as of 1964), Special Field (basic training), Social and Political Status (as of 1964), CAS Membership Indicator	Profiles 1,200 prominent scientists and engineers in mainland China. Data compiled from Chinese official documents and books, periodicals and newspapers, statistical yearbooks, scientific journals, leadership speeches, and translated materials.
Dictionary of Chinese Scholars Who Returned from North America in the 1950s	1950s	Name, Year of Birth, Year of Death, Domestic Education (Affiliation, Degree, Year, Location), Foreign Education (U.S. Affiliation, Degree, Year, Location), Date of Arrival in the U.S., Date of Return to China, Post-return Employment and Destination, Employment in China before Studying Abroad, Academic Discipline, Academic Specialization, Political Roles, CAS Academician Status, Whether Detained, Whether Died During Cultural Revolution	Profiles 1,806 returnees. Based on five types of sources: (1) Interviews, (2) information from acquaintances, (3) records from organizations, (4) public materials (e.g., memoirs), (5) archival letters/photos.

Publication Data

To measure scholar productivity and characterize research specialization, we assemble a comprehensive publication panel by merging English- and Chinese-language bibliometric sources. Our construction proceeds in two steps: (i) for each scholar, we recover a broad candidate set of publications using multiple name variants; (ii) we remove false matches using a text-based classifier and structured metadata checks, yielding a clean scholar–year corpus of titles and abstracts.

Publications. For each scholar, we collect publications from OpenAlex and CNKI. From OpenAlex we retain `work_id`, title, abstract, publication year, venue (journal/proceedings), document type, authorship roster (including `author_id` and author order), author affiliations (institution identifiers and countries), concepts/keywords (with hierarchical levels), `referenced_works` (outgoing citations), and `cited_by_count`. From CNKI we add Chinese-language works with titles, abstracts, venues, publication years, and author affiliations. Table 11 summarizes the core fields retained from OpenAlex.

Table 11: Core Publication Fields Retained

Entity	**Fields**
Work	id, title, abstract, year, venue, type, concepts (id, level), referenced_works, cited_by_count
Authorship	work_id, author_id, author_position, affiliation_id, affiliation_country
Author	author_id, canonical name, aliases, ORCID (if any)
Institution	inst_id, name, country, historical name variants

Name Variants and Candidate Retrieval. Scholars frequently published under multiple romanization systems. To maximize recall, we query OpenAlex under three naming conventions: Chinese characters (when available), Hanyu Pinyin, and Wade–Giles. We store all returned candidates and retain an `author_alias` table mapping each observed name variant to a canonical scholar identifier. Figure 17 shows the distribution of publication counts across matched scholars.

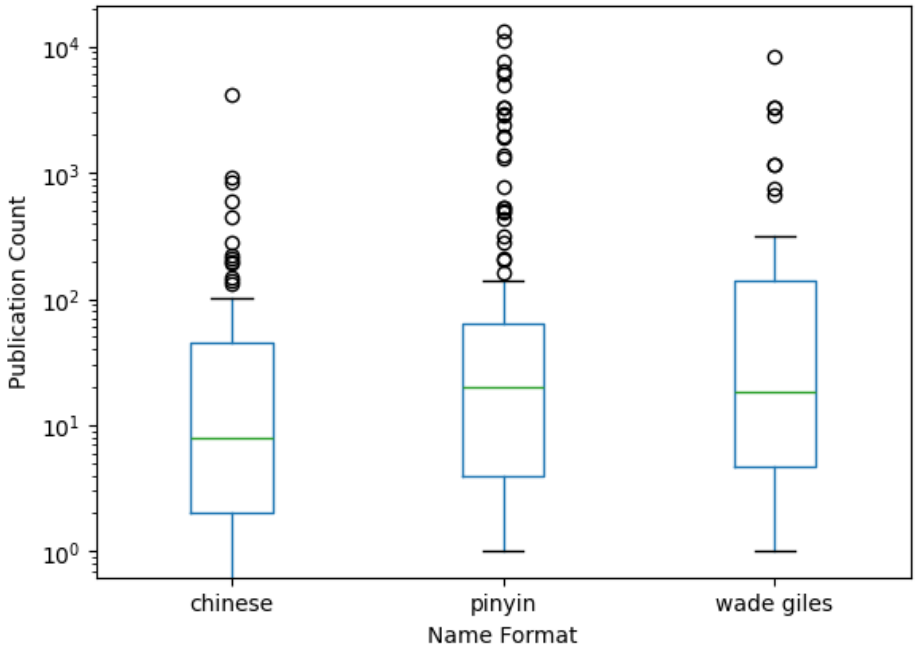


Figure 17: Publication Counts for Matched Scholars

Filtering False Matches. High recall necessarily produces false positives, particularly for common surnames and short romanized names. We therefore filter candidate publications using a supervised text-based classifier. Specifically, we use a BERT-style model to score whether a candidate work plausibly belongs to a given scholar based on the title/abstract embedding, coauthor overlap, affiliation consistency, field proximity, and temporal plausibility. We complement the classifier with rule-based exclusions (e.g., incompatible affiliations, implausible publication years) and manual adjudication for high-stakes cases (e.g., CAS fellows, department chairs). The resulting output is a clean scholar–year corpus of publications with harmonized metadata across OpenAlex and CNKI.

Dissertations. We complement publication data with a historical record of dissertations completed by Chinese scholars in the United States (Yuan, 1961). We cross-reference dissertation authors to our scholar roster and use dissertation fields, institutions, and years as additional anchors for identity verification and cohort construction.

Author Disambiguation and Matching. Our disambiguation protocol combines (i) rule-based romanization normalization (segmenting given/family names; removing hyphens/tones; harmonizing common variants), (ii) network evidence from coauthor and affiliation co-occurrence, and (iii) manual adjudication for ambiguous cases. We audit matching accuracy

through pairwise spot checks, with targeted review of the most prolific scholars and the most common names.

Citation Construction. To avoid snapshot bias in citation counts, we construct annual incoming citations by scanning `referenced_works` in later publications and assigning citations to the year they occur. We then compute cumulative forward citation counts and field-normalize citation outcomes by publication year and field.

Frontier-Measurement Sensitivity. We assess robustness to the embedding and frontier-definition choices in two ways. First, we recompute the embedding-based outcomes under alternative sentence-embedding models: the OpenAlex (global-frontier) outcomes under three (multilingual LaBSE, SciBERT, and a Chinese-language SBERT) and the Chinese-language domestic-frontier outcomes under two (LaBSE and the Chinese SBERT, since SciBERT is English-only), which differ in how they encode cross-lingual and technical text. Second, we vary the breakthrough definition used to build each subfield-year frontier (top-decile Kelly importance, top-decile citations, and top-venue publication). The main results are stable across these alternatives.

Venue Lists and Top-Venue Share. We construct field-specific top-venue lists (journals and conference proceedings) and allow venue rankings to evolve over time. We report robustness to alternative top-N thresholds and to excluding venues with changing scope or editorial standards.

2 U.S. Exit Restrictions on Chinese Students during the Early Cold War

This subsection documents the policy rationale and implementation of U.S. exit restrictions on Chinese students during the early Cold War. Drawing on declassified CIA, State Department, and FBI materials, we show that U.S. authorities treated the overseas training of Chinese students, particularly in technical and scientific fields, as a potential national security risk and acted deliberately to restrict their return to the People's Republic of China (PRC).

Fields Deemed Strategically Sensitive. Across intelligence and diplomatic documents, a consistent set of disciplines was identified as posing heightened risk if U.S.-trained Chinese students returned to China. These fields were closely linked to weapons development, military-industrial capacity, and advanced infrastructure.

Table 12: Fields Targeted by U.S. Security Concerns

Category	**Fields Mentioned or Inferred**
Nuclear Science	Nuclear physics, nuclear engineering
Weapons and Missile Technology	Aeronautics, aerospace engineering, guidance systems
Advanced Engineering	Mechanical, electrical, civil engineering
Electronics and Computing	Electronics, communications, radar, control systems
Chemical and Biological Sciences	Chemistry, chemical engineering, biomedicine
Metallurgy and Materials	Metallurgy, materials science
Mathematics and Physics	Mathematics, applied physics
Geophysics	Geophysics (e.g., military mapping and exploration)

Sources: CIA, *Science and Technology in Communist China* (1966); National Intelligence Estimate 13-2-62, *Chinese Communist Advanced Weapons Capabilities* (1962); State Department and FBI memoranda.

Government Actions. Declassified State Department and FBI documents from the early 1950s show that U.S. authorities deliberately detained or blocked the departure of technically trained Chinese students. These actions were motivated by three main considerations:

- preventing the transfer of U.S.-acquired technical knowledge to China's weapons and industrial programs;

- using detained students as leverage in negotiations over American prisoners held in China;
- responding to intelligence assessments warning that returnees trained in sensitive disciplines posed a national security risk.

Surveillance and Enforcement Criteria. Students were subject to heightened monitoring and scrutiny if they:

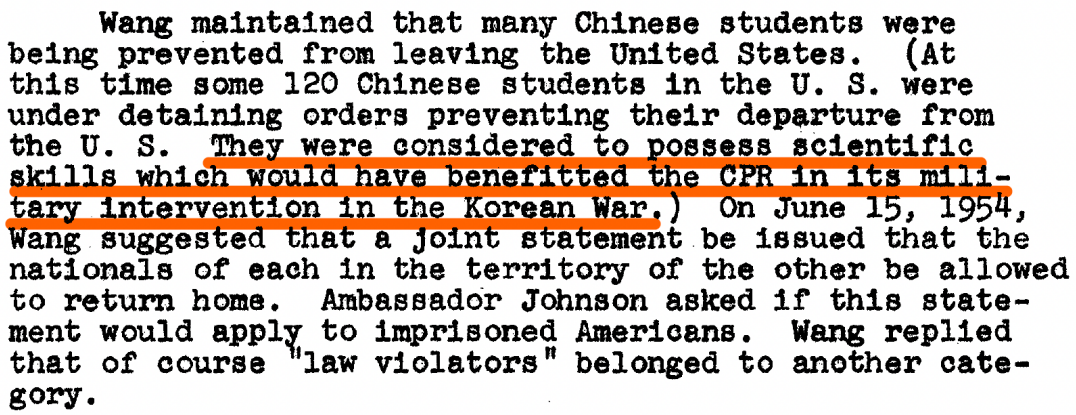
- pursued advanced training in strategically sensitive fields;
- were suspected of affiliation with the Chinese Communist Party or participation in pro-PRC student organizations;
- expressed intentions or made observable preparations to return to mainland China;
- accessed or conducted research linked to U.S. military or classified projects.

Strategic Motivation. The overarching objective of these restrictions was to limit the repatriation of U.S.-acquired technical expertise that could accelerate China's military and industrial modernization. U.S. authorities explicitly linked student return to concerns over nuclear weapons development, missile technology, and long-run strategic competition during the early Cold War.

Chinese Activity

The September 15, 1954, Summary mentioned a letter being sent to President Eisenhower by a group of Chinese students in this country urging permission to return to China. The students are being restrained temporarily from leaving the United States pursuant to a Presidential directive dated January 17, 1953, aimed at preventing the departure to Communist-dominated countries of alien students possessing scientific and technical training deemed of possible military value to a potential enemy. This topic also has figured prominently in news releases bearing on relations between the United States and Communist China, particularly in dispatches of the past few days pertaining to the recent visit of Dag Hammarskjold, Secretary General of the United Nations, with CHOU En-lai, Premier of Communist China.

Figure 18: FBI memorandum expressing concern over Chinese students "possessing scientific and technical training deemed of possible military value to a potential enemy." J. Edgar Hoover to Harold E. Stassen, January 19, 1955.



Wang maintained that many Chinese students were being prevented from leaving the United States. (At this time some 120 Chinese students in the U. S. were under detaining orders preventing their departure from the U. S. They were considered to possess scientific skills which would have benefitted the CPR in its military intervention in the Korean War.) On June 15, 1954, Wang suggested that a joint statement be issued that the nationals of each in the territory of the other be allowed to return home. Ambassador Johnson asked if this statement would apply to imprisoned Americans. Wang replied that of course "law violators" belonged to another category.

Figure 19: State Department analysis of negotiations with Chinese representatives, June 1954–September 1955, concerning the detention and release of Chinese nationals in the United States.

Implications for Identification. This historical record underscores that U.S. exit restrictions were (i) sharply targeted toward specific technical fields, (ii) implemented through administrative discretion rather than individual behavior, and (iii) motivated by geopolitical considerations external to scholars' productivity or preferences. These features support our use of permit and denial decisions as plausibly exogenous variation in return migration and motivate field-based heterogeneity analyses in the main text.

3 Subfield Mean-Alignment Spillover

As an additional test of domestic spillover, we ask whether returnee arrival raised the *mean* frontier alignment of a subfield's publications, complementing the extensive-margin and strategic-convergence results in Section 6. We implement equation (11) at the subfield-year level: Returnee_j is an indicator for whether subfield j ever received a 1940–1957 returnee, and Post_{jt} equals one in years on or after the first 1940–1957 returnee's arrival in j. Subfields without a 1940–1957 arrival enter as never-treated controls. The pre-1940 returnee stock $\text{cumret}_{j,t}^{\text{pre-1940}}$ enters as a covariate X_{jt}:

$$y_{jt} = \alpha_j + \vartheta_t + \delta\,\text{Post}_{jt} \times \text{Returnee}_j + \gamma\,\text{cumret}_{j,t}^{\text{pre-1940}} + \varepsilon_{jt}, \tag{11}$$

where y_{jt} is the mean frontier alignment of subfield-j publications in year t, computed separately for OpenAlex and CNKI publications against the OpenAlex global frontier. Standard errors are clustered at the subfield level. As a continuous specification, we replace the indicator with the cumulative count of 1940–1957 returnees who had published in j by year t,

denoted $\text{cumret}_{j,t}^{1940\text{-}57}$:

$$y_{jt} = \alpha_j + \lambda_t + \gamma\, \text{cumret}_{j,t}^{\text{pre-1940}} + \delta\, \text{cumret}_{j,t}^{1940\text{-}57} + \varepsilon_{jt}, \tag{12}$$

with both regressors and outcome standardized so that δ is interpretable per standard deviation of cumulative-returnee exposure.

Table 13 reports the estimates. The binary specification of (11) produces a positive coefficient of 0.019 on the alignment of OpenAlex publications to the global frontier (column 1, $t = 1.40$) and a smaller, indistinguishable-from-zero coefficient of 0.011 on the alignment of CNKI publications (column 2). The continuous specification of (12) delivers similar magnitudes: a one-standard-deviation increase in cumulative 1940–1957 returnees raises OpenAlex-side alignment by 0.020 standard deviations (column 3) but does not move the CNKI-side alignment (column 4). The point estimates are economically modest at the aggregate panel level; restricting to subfields whose first 1940–1957 returnee actually arrived during the cohort window and to the event-time window $[-10, 15]$ around that arrival, the OpenAlex coefficient on $\text{cumret}_{j,t}^{1940\text{-}57}$ rises to 0.069 ($t = 1.68$, $p = 0.09$). The mean-alignment spillover therefore operates primarily through the international-publishing arm of returnees' own work and the work of their domestic collaborators who appear in OpenAlex; the field-creating spillover onto other domestic scientists shows up instead on the extensive margin, as documented in the main text.

Table 13: Subfield-level spillover: 1940–1957 returnees and frontier alignment

	Eq. (11): Binary Post×Returnee		Eq. (12): Continuous (per SD)	
	(1)	(2)	(3)	(4)
	OA vs OA fr.	CNKI vs OA fr.	OA vs OA fr.	CNKI vs OA fr.
Treatment	0.019	0.011	0.020	−0.005
	(0.014)	(0.021)	(0.014)	(0.020)
Pre-1940 cumret control	Yes	Yes	Yes	Yes
Subfield fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Subfields	211	176	211	176
Observations	5,427	2,427	5,427	2,427

Notes: Subfield-year regressions. Columns 1–2 estimate equation (11): $\text{Returnee}_j = 1$ if subfield j ever received a 1940–1957 returnee, $\text{Post}_{jt} = 1$ in years on or after the first such arrival. Subfields with no 1940–1957 arrival serve as never-treated controls. Columns 3–4 estimate equation (12) with the cumulative count of 1940–1957 returnees in subfield j by year t, standardized; the outcome is also standardized so that the coefficient is per standard deviation. Columns 1 and 3 take the mean alignment of OpenAlex publications to the OpenAlex global frontier as the outcome; columns 2 and 4 take the mean alignment of CNKI publications to the same frontier. All specifications include subfield and year fixed effects and partial out the pre-1940 returnee stock. Standard errors clustered at the subfield level (columns 1–2) or analytic OLS (columns 3–4) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.