Foreign Investment and the Long Road to Development: Knowledge Diffusion in Early Twentieth-Century China

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August 28, 2026

Abstract

This paper evaluates the role of foreign direct investment as a strategy for economic development through knowledge spillovers. Leveraging the unique historical setting of China's first opening to foreign investment in the early twentieth century, we examine how Japanese FDI affected knowledge diffusion and, in turn, domestic firm entry. Our identification strategy employs event-study designs that exploit plausibly exogenous variation in the timing of the first Japanese investment across prefectures. We find a significant difference in timing: knowledge diffusion begins immediately after the arrival of Japanese FDI, whereas domestic firm entry responds only several years later, after knowledge has accumulated. We then unpack each stage of this process. From FDI to knowledge diffusion, we find that Japanese FDI, particularly manufacturing FDI, significantly lowered the cost of accessing knowledge, as measured by the entry of local Chinese journals. This effect was stronger in areas with greater exposure to foreign trade, consistent with the interpretation that trade increased awareness of foreign knowledge while FDI facilitated its actual transmission. By contrast, we find no comparable effect of German FDI, highlighting the importance of linguistic proximity in facilitating knowledge diffusion through FDI. Consistent with this interpretation, lexicon-level evidence shows that exposure to Japanese FDI in a given product category increased discussion of product-specific scientific knowledge and promoted the adoption of Japanese knowledge codifications. Many of these codifications remain in use in contemporary Chinese, leaving a lasting imprint on China's scientific knowledge base. Turning from knowledge to production, we find that domestic firm entry increases only after knowledge accumulation passes a critical threshold. We document a J-shaped relationship between knowledge accumulation and domestic firm entry. These findings help reconcile the limited immediate effects of FDI on domestic production documented in the literature. The absence of an immediate response by domestic firms does not imply that knowledge spillovers failed to occur; rather, knowledge can begin to diffuse upon the arrival of FDI but affect production only after sufficient accumulation.

1 Introduction

Many developing economies place a high priority on attracting foreign direct investment (FDI), in the hope that its benefits extend beyond the activities of foreign firms themselves. Through knowledge spillovers, FDI may promote domestic production. Yet, existing empirical evidence provides limited support for positive impacts of FDI on domestic productivity in developing countries (Haddad and Harrison, 1993; Aitken and Harrison, 1999; Djankov and Hoekman, 2000; Konings, 2001). One explanation is that turning foreign knowledge into realized productivity gains involves at least two distinct steps. First, foreign firms must transfer knowledge to local intellectuals, entrepreneurs, and workers. Second, local actors need to apply this knowledge in actual economic activities.

This paper studies these two steps in the context of China's first opening to FDI in the early 20$^{\text{th}}$ century. We first examine whether exposure to FDI changed the local knowledge base. We then ask whether, and when, this accumulated knowledge turned into domestic industrial activity. In summary, we find a sharp contrast between the two steps: knowledge diffusion begins soon after the arrival of FDI, whereas domestic industrial activity responds only after a substantial delay, once local knowledge has accumulated sufficiently. We also show that the effectiveness of FDI as a channel of knowledge transfer depends on linguistic proximity, which facilitates the understanding and direct borrowing of foreign knowledge codifications.

China's first opening to FDI in the early 20$^{\text{th}}$ century (1900–1930) provides a particularly useful setting for studying how knowledge brought by FDI diffuses and eventually turns into domestic industrial activity. Foreign investors were not allowed to establish factories in China until 1895, when China was forced to allow foreign manufacturing following its defeat in the First Sino-Japanese War. Foreign investment subsequently expanded rapidly, with Japan emerging as one of the most important foreign investors in China. At the same time, the early twentieth century witnessed a rapid expansion of scientific knowledge and domestic industrial activity. We therefore trace the link from the arrival of foreign firms to the evolution of local knowledge and, subsequently, to the emergence of domestic producers,

with a particular focus on Japanese FDI.

Our main identification strategy exploits variation in the timing of the first arrival of Japanese FDI across prefectures in a staggered event-study design. Early Japanese investors operated in a new and unfamiliar economic environment and faced substantial uncertainty about local conditions, making the precise timing of first entry into a prefecture plausibly idiosyncratic. We compare prefectures receiving their first Japanese investment at different times with prefectures that had not yet received Japanese FDI. The event-study estimates show no evidence of differential pre-trends prior to the arrival of Japanese FDI. The effects on knowledge emerge immediately after entry, whereas the effects on domestic firm entry become significant only about ten years later. Together, these patterns support a causal interpretation of the effects of Japanese FDI and reveal a clear temporal distinction between knowledge diffusion and its translation into domestic industrial activity.

FDI's impact on local knowledge. In the first step, we examine whether Japanese FDI facilitated knowledge diffusion. Knowledge is central to economic growth: sustained growth depends on the creation, diffusion, and accumulation of new ideas and knowledge (Romer, 1990; Jones, 2003; Helpman, 2006). While frontier economies may generate knowledge through domestic investment, developing economies can also draw on knowledge created elsewhere through international interactions, including FDI and trade (Eaton and Kortum, 1999; Ethier and Markusen, 1996; Comin and Hobijn, 2011). A key question, however, is whether foreign knowledge becomes accessible to local actors. Following Mokyr (2005), we conceptualize this process in terms of the "access costs of knowledge." When access costs are low, individuals can more readily acquire existing knowledge, knowledge circulates more easily, and further knowledege accumulation is easier to sustain.

We examine the role of Japanese FDI in reducing the costs of accessing knowledge in early twentieth-century China (1900–1930). Following Mokyr (2005), we use journals (periodicals) as a key indicator of knowledge access and diffusion: journals provide vehicles for knowledge dissemination, expand the stock of available knowledge, make existing knowledge easier

to access, and facilitate its further diffusion and accumulation.[1] We find that exposure to Japanese FDI increased both the entry of new journals (which captures the emergence of new vehicles for knowledge) and the total number of existing journals (which captures the existing stock of knowledge). The effects extend beyond natural science journals to social science journals, suggesting that FDI transmitted social and managerial knowledge in addition to technical knowledge. The effects are highly localized, becoming statistically insignificant outside the prefecture receiving Japanese FDI. The effects are also stronger for manufacturing than for non-manufacturing FDI. These patterns are consistent with knowledge diffusion occurring through direct exposure to foreign production. Qualitative evidence further points to labor contact and factory visits as two important channels of transmission.

We further unpack the step from FDI to knowledge by examining what determines the effectiveness of knowledge transfer. We first contrast FDI with foreign trade, another major form of international economic contact. Foreign trade alone had no positive effect on knowledge diffusion and, if anything, had a negative effect. However, the interaction between Japanese FDI and foreign trade is positive and significant. We interpret this pattern as reflecting a fundamental distinction between the two forms of international exposure. Trade exposes local actors to foreign products and thereby increases awareness of foreign knowledge and the gap to the technological frontier, but exposure to products does not necessarily provide access to the knowledge required to produce them, as the underlying production knowledge can be difficult to infer from finished products alone. FDI, by contrast, brings foreign production into the local economy and reduces the costs of acquiring and applying the relevant knowledge. Trade and FDI can therefore be complementary even though trade alone does not generate knowledge diffusion. We formalize this intuition in a simple model of knowledge accumulation.

We also examine whether the effectiveness of knowledge transfer varies across source countries by comparing Japanese and German FDI. While German FDI also had positive

[1]Throughout the paper, we use the term "journals" to refer to periodical publications following Mokyr (2005), primarily covering the natural sciences, social sciences, and literature. A detailed description of these publications is provided in Section 3.

effects on knowledge diffusion, the estimates are smaller in magnitude and statistically insignificant in most specifications. One important distinction between the two sources of FDI is *linguistic proximity*. Despite differences between the two languages, Chinese and Japanese shared many written characters even before the arrival of Japanese FDI in 1895, creating a degree of linguistic proximity, particularly in their written forms.

To investigate this mechanism more directly, we conduct lexicon-level analyses. We first show that exposure to product-specific Japanese FDI increased discussions of the corresponding product-specific scientific knowledge in local journals. At this granular level, we can control for prefecture-year fixed effects and identify the effect of FDI by comparing across product groups within the same prefecture and period, providing more direct evidence of knowledge transfer through FDI. More importantly, Japanese FDI changed how knowledge was codified in China. Exposure to Japanese FDI increased the adoption of Japanese scientific terminology. Linguistic proximity allowed Chinese scholars and practitioners to borrow existing Japanese codifications. Many of these borrowed terms replaced earlier Chinese translations, became embedded in the Chinese language, and remain in use today. Because codification is central to the transmission, verification, storage, and reproduction of knowledge (Partha and David, 1994; Juhász et al., 2024), the adoption of these codifications can leave a lasting imprint on China's knowledge base and shape its subsequent knowledge exchange with other countries.

Knowledge's impact on domestic economic activity. After establishing the link from FDI to knowledge, we turn to the second step and examine whether and when this knowledge turned into domestic industrial activity, which we measure using domestic firm entry. We find a markedly different temporal pattern. Unlike the immediate effects on knowledge diffusion, the effect of FDI on domestic firm entry becomes significant only about ten years after its first arrival, suggesting that translating knowledge into economic activity takes time.

To understand this delay, we examine whether domestic firm entry depends on the extent of knowledge accumulation. We define treatment based on whether the knowledge accumulated in a given product category has crossed a specified threshold and examine its effect

on product-specific domestic firm entry. At low thresholds of 10% and 20%, crossing the threshold has no significant effect on firm entry. At the 40% threshold, significant effects emerge only six years after treatment, whereas at the 60% threshold, the effects appear immediately. None of these specifications exhibits significant pre-trends. We complement these event studies with a nested-threshold specification that traces how domestic firm entry varies across successive levels of knowledge accumulation. The cumulative estimates exhibit a clear J-shaped pattern: the effects remain small and insignificant at low levels of knowledge accumulation but increase sharply once a sufficiently large body of knowledge has been accumulated. Together, these findings suggest that knowledge does not turn into economic activity incrementally. Rather, a sufficiently large body of complementary knowledge must first accumulate before substantial domestic economic activity emerges.

Newly Digitized Data. This paper leverages multiple newly digitized archival datasets that measure economic activity and knowledge in early 20$^{\text{th}}$-century China. First, we compile Japanese FDI data from a historical survey titled Survey of Japanese Businesses Overseas (Zaigai Nihonjin Jitsugyōsha Chōsa), compiled by the Bureau of Commerce of the Japanese Ministry of Foreign Affairs. To the best of our knowledge, this dataset has not been used in the literature. The survey provides detailed firm-level information on Japanese businesses operating abroad, including location, firm name, owner name, owner hometown, business description, and, in some cases, capital, revenue, employment. We use LLMs to classify business descriptions into sectors (e.g., manufacturing) and products (e.g., textiles).

We also collect data on scientific terminology from dictionaries issued by the Jiangnan Arsenal before the 1880s. These dictionaries provide a baseline for Chinese scientific terminology before exposure to FDI. Our journal data are drawn from the *National Index to Chinese Newspapers & Periodicals*, a comprehensive collection of newspapers and periodicals from the late Qing and Republican periods. For each journal, the data include location, publication period, and title, which we use to classify journals into natural sciences, social sciences, and literature and art using LLMs. We further conduct keyword searches to capture discussions of product-specific knowledge.

Literature Review. This paper contributes to the growing literature on foreign direct investment and knowledge diffusion (e.g., Branstetter, 2006; Abebe et al., 2022; Ahn et al., 2026; Fu, 2012). Our findings parallel the existing literature in several ways. FDI facilitates knowledge transfer, its effects are geographically localized, and both technical and social knowledge can diffuse through FDI. However, we also add to this literature in several important ways. First, we highlight the importance of linguistic proximity in shaping the effectiveness of FDI as a channel of knowledge transfer. More importantly, we directly unpack the process through which knowledge transferred by FDI is ultimately turned into economic activity, rather than relying on downstream economic outcomes as proxies for knowledge diffusion. Conventional measures, such as TFP growth or patent citations, may also reflect factors such as market power, legal institutions, and technical efficiency, which can substantially confound the measurement of knowledge diffusion, particularly in developing economies. Our use of journal data and changes in knowledge codification more directly captures the process of knowledge diffusion and enables us to distinguish two essential stages: the diffusion and accumulation of foreign knowledge, and the subsequent translation of that knowledge into actual economic activity. The delay between knowledge diffusion and its translation into actual economic activity helps reconcile the mixed findings in the literature on the economic effects of FDI.

Moreover, this paper provides valuable empirical evidence on the process of economic standardization. A classic literature has examined how common standards emerge from competing alternatives and how early adoption can shape the eventual standard (David, 1985). This process has been studied in settings such as railway systems (e.g., Scott, 2001; Puffert, 2002). We provide a new application by examining the standardization of scientific vocabulary in China. We show that Japanese FDI contributed to the convergence of Chinese scientific vocabulary toward a common set of terms by promoting the adoption of Japanese codifications. These Japanese codifications have remained in use ever since, despite subsequent changes in Sino-Japanese relations and the declining importance of Japan as an economic partner of China. These findings show how short-run cross-border economic

interactions can shape the formation of common standards and their continued use in the long run.

Finally, our paper contributes to the literature on the drivers of technological growth in developing countries. Technological progress in developing countries often relies on knowledge inputs from advanced economies transmitted through international interactions. From this perspective, the literature has emphasized the roles of both international trade and FDI. Our paper is among the relatively few studies that consider foreign trade and FDI jointly. We highlight the distinct channels through which the two forms of international interaction affect domestic producers. Foreign trade can increase domestic producers' awareness of foreign products and shape their incentives through changes in prices (e.g., Amiti and Konings, 2007; Goldberg et al., 2010; Pavcnik, 2002), but it does not necessarily transfer the knowledge required to produce those goods, as production technologies may be difficult to reverse engineer from imported products alone. FDI, by contrast, is more likely to demonstrate production technologies and facilitate direct knowledge transfer. However, its effects on domestic producers need not be immediate, as domestic producers may require time to absorb and accumulate the transferred knowledge.

The rest of the paper is organized as follows. Section 2 provides the historical background on economic activity in early 20^{th}-century China and Japan's FDI effort during this period. Section 3 describes the newly digitized data on Japanese FDI, dictionaries, journals, and other sources. Section 4 presents the empirical framework and results, including the baseline regression estimates and the event-study analysis. Section 5 discusses the potential mechanisms underlying knowledge diffusion. Section 6 concludes and discusses the broader implications of our findings.

2 Historical Background

2.1 Economic Activities in Early 20th-Century China

During most of the Qing dynasty (1644–1911), China remained a largely closed economy, with only limited foreign interaction permitted through one or two designated ports and intermediaries. The first major turning point came in 1840, when China was defeated by Britain in the First Opium War (1839–1842). Following the defeat, China was forced to open five cities as gateways for foreign trade, which later became known as treaty ports. Despite the establishment of the Treaty Port system, foreign direct investment (FDI) remained highly restricted. In particular, foreigners were not permitted to establish factories in China, and domestic private industrial activity was also not allowed. Over the following decades, additional treaties were signed between the Qing government and foreign powers, and by 1900 nearly 50 treaty ports had been established.

Between 1861 and 1895, the Qing government initiated the Self-Strengthening Movement, a state-led effort to modernize China's military (Goetzmann and Koll, 2005). During this period, the government established a few state-owned enterprises, including the Jiangnan Arsenal, one of the largest. With the assistance of foreign missionaries, the Jiangnan Arsenal translated a substantial body of Western scientific knowledge into Chinese and produced dictionaries that we use in this study. However, the Qing government showed little interest in large-scale industrialization (Goetzmann and Koll, 2005). Both FDI and the domestic private sector remained restricted from establishing factories.

The second major turning point occurred in 1895, when China was defeated by Japan in the First Sino-Japanese War. Following the defeat, China was required to allow foreign countries to establish factories in treaty ports and concession areas. This marked China's first opening to FDI in the modern sense. In 1904, in response to the growing presence of foreign industrial enterprises, the Qing government further relaxed restrictions on the domestic private sector, allowing Chinese firms to engage in industrial production.

In 1911, the Qing dynasty collapsed, followed by the Republican period (1912-1949).

Although the early Republican Era (1912-1928) was characterized by domestic political instability, China still experienced substantial industrial growth. Both foreign factories, particularly Japanese enterprises, and domestic industrial sector expanded rapidly. In principle, the treaties signed after 1895 remained in effect after 1911, and foreign direct investment was still largely confined to treaty ports. In practice, however, enforcement became even looser after 1911. As a result, foreign investment could also be found in many other cities. Japanese FDI, for example, became widespread in Manchuria.

The next critical turning point came in 1931, when Japan invaded Manchuria, three provinces in northeastern China. This event marked the beginning of direct military conflict between China and Japan, which continued until Japan's surrender in 1945.

2.2 Japan's FDI Effort in Early-20th-Century China

Following the Meiji Restoration of 1868, Japan rapidly industrialized and, within a few decades, transformed itself from a recipient of Western technology into an active exporter of capital. As domestic industries such as cotton spinning matured and accumulated capital, Japanese firms increasingly looked abroad for cheaper inputs, new markets, and investment opportunities. This outward expansion was reinforced by the state, which viewed overseas economic activity as integral to Japan's broader ambition of projecting power and securing resources in Asia. Japanese capital therefore flowed to regions such as China, Korea, and Taiwan, often following territorial and strategic interests.

The Treaty of Shimonoseki (1895) granted all treaty powers the right to operate factories in the treaty ports, but Japan was able to exploit it the most, due to several reasons. Firstly, it is geographically close to China and entrepreneurs could easily move between the two countries. Secondly, Japan is ambitious to project both economic and political power in China. Japanese FDI in China expanded steadily and rapidly between 1900 and 1930. Remer (1933) estimates that Japanese investment rose from roughly US$1 million in 1899 to US$220 million in 1914 and over US$1.1 billion by 1931. Peter Duus characterizes this FDI expansion as the rise of a Japanese "informal empire" in China, which exerted strong

economic, cultural, and military influence in China without direct colonial administration, ultimately supplanting Western powers in the region. By 1930, Japan was one of the largest foreign investors in China, alongside Britain.

Japanese direct investment in China rested on two centers. The first was the South Manchuria Railway Company (南満洲鉄道, "Mantetsu"). It was established in 1906 in the wake of the Russo-Japanese War and capitalized at 200 million yen. It was far more than a railway. Not only did it operate coal mines and ironworks, it also has a research department that systematically surveyed the economy of Northeast China. Due to Mantetsu and Japan's political ambition in the region, a big share of Japanese capital was concentrated in Manchuria, a region that attracted little investment from other foreign powers.

The other center for Japanese direct investment in China was cotton mills in Shanghai. Naigaiwata and Co. began building mills in Shanghai in 1911, and the collapse of European textile imports during the First World War turned the industry into a boom. By 1922 some two dozen Japanese mills operated in Shanghai, with further clusters in Qingdao (Kiaochow), as Japan took over Germany's former sphere of influence in Shantung after WWI. In general, we view Japanese FDI strategies in China as reflecting a combination of political and economic objectives: expanding political influence, potentially in support of broader military ambitions, while also seeking access to profitable markets.

Several features made Japanese investment particularly well suited to transmitting knowledge into Chinese local knowledge base and economy. First, it was overwhelmingly direct investment embedded in production on Chinese soil (e.g. Japanese entrepreneurs actually organizing business in China physically) rather than loans or portfolio holdings that characterized much Western finance. Due to the geographical proximity, Japanese firms brought migrants who were managers, engineers, and technicians that could operate factories in China. Secondly, as we show in Figure 1b, Japan's FDI was geographically dispersed in China. Unlike Western FDI that usually concentrates in a few large cities, in particular Shanghai, Japanese enterprises spread across Manchuria, Shandong, and Yangtze cities and numerous smaller prefectures in southern China. Lastly, Japan was linguistically and cul-

turally proximate. Compared with Latin- or Germanic-based languages, the shared use of written characters made Japanese relatively more accessible and easier to understand for Chinese people. These features distinguish Japanese FDI from that of the Western powers and motivate our focus on it as a vehicle for knowledge diffusion.

3 Data

3.1 Japanese FDI in China

The Japanese FDI data are drawn from a historical survey titled Survey of Japanese Businesses Overseas (Zaigai Nihonjin Jitsugyōsha Chōsa), compiled by the Bureau of Commerce of the Japanese Ministry of Foreign Affairs. The survey provides detailed firm-level information on Japanese enterprises operating abroad, including location, firm and owner names, owner's hometown, business description, capital, revenue, and, in some cases, employment. We digitize observations for the years 1903, 1906–1909, 1912–1915, 1918–1919, 1921, 1924, and 1926.[2]

We geocode firm locations and match them to prefectures in the CHGIS 1911 V6 Dataverse. China's administrative boundaries only changed slightly during the early Republican period. We therefore consistently use the 1911 prefectural boundaries.

The business description field typically records the primary economic activities of each firm, along with related products. We use this information to classify firms into one or more of the six sectors listed in Table 1. We further classify firms into one or a few of the ten product categories listed in Table 1.

For example, a firm with the business description "皮革製造販賣" (leather manufacturing and trade) is classified into both the manufacturing and the banking and commerce sectors, as it engages in both production ("製造") and trade ("販賣"). It is assigned to the product category "leather and its finished products" based on the term "皮革" (leather). Table 1 reports the number of Japanese firms by sector and product type.

[2]The survey was not conducted in the intervening years, and thus no data are available for those periods.

It is important to note that each firm may be assigned to multiple sectors and multiple product groups. Firms whose descriptions are insufficiently detailed to infer their sectors or product groups are left unclassified.

Table 1: Number of Firms by Sector and Product Type

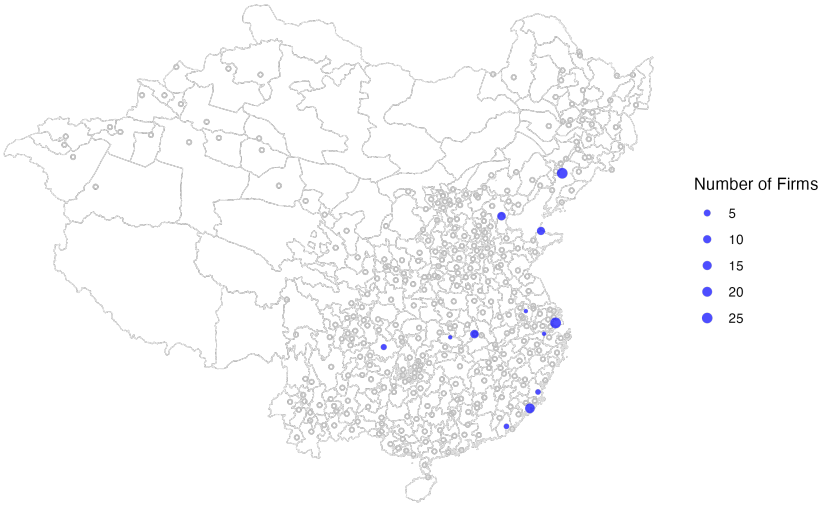
Category	Number of Firms
Panel A: Sectors	
Banking and Commerce	5,119
Manufacturing	1,423
Transportation	654
Agriculture and Forestry	103
Fishery	9
Panel B: Products	
Food and Beverages	1,919
Textiles and Their Products	1,330
Chemicals and Allied Products (Including Pharmaceuticals)	1,087
Metals and Metal Products	778
Lumber and Its Remanufactures	673
Stone, Clay, and Glasses	406
Transportation Equipment	379
Paper and Printing	338
Tobacco Manufactures	193
Leather and Its Finished Products	172

Figure 1 shows the distribution of Japanese firms in 1903 (Panel A) and 1926 (Panel B), respectively. A comparison of the two panels indicates that Japanese firms not only increased substantially in number but also expanded geographically across China.

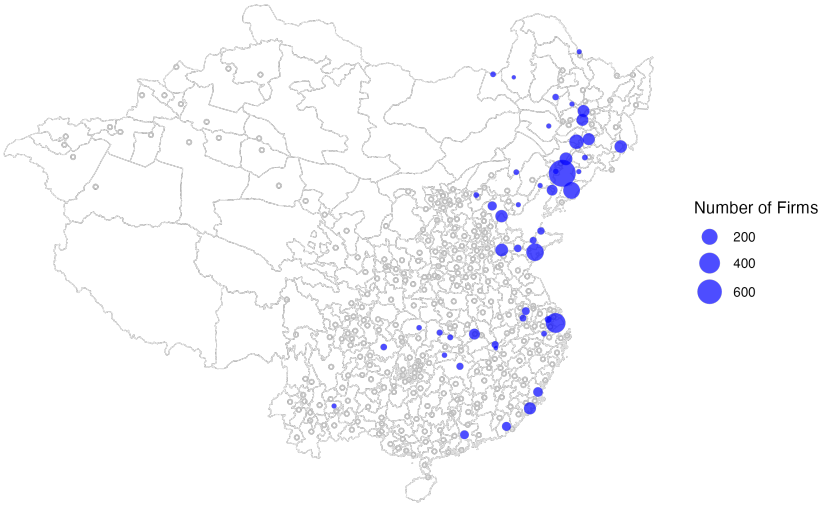
3.2 Dictionaries

A central part of our analysis is to gauge Japanese influence on the Chinese knowledge base by examining language itself, specifically, whether Chinese journals adopted Japanese trans-

Figure 1: Distribution of Japanese Firms, 1903 and 1926



(a) Japanese Firms in 1903



(b) Japanese Firms in 1926

Notes: Each panel maps the geographic distribution of Japanese firms in China; Panel A corresponds to 1903 and Panel B to 1926. Each point denotes the location of a Japanese firm. A comparison of the two panels shows that Japanese firms grew substantially in number and expanded geographically across China over this period.

lations of scientific terms in place of earlier Chinese ones. Doing so requires a baseline of how key scientific concepts were rendered in Chinese before exposure to Japanese FDI. We therefore digitize English–Chinese dictionaries issued by the Jiangnan Arsenal, published between 1860 and 1880. During this period, both China and Japan undertook efforts to translate Western scientific knowledge, with the assistance of foreign missionaries. We do not argue that translation activities in the two countries between 1860-1880 were fully independent, as Chinese and Japanese already shared substantial linguistic connections and missionaries traveled between the two countries. Nevertheless, the resulting translations exhibit substantial differences. While some terms were shared, many differed between two countries. For example, the term "sulphuric acid" was translated in China as 硫强水 (*liu qiang shui*, literally "strong sulfur water"), whereas it was translated in Japan as 硫酸 (*liu suan*, sulfuric acid). 硫酸 is the form that is used in Chinese today, while 硫强水 is no longer used. Therefore, we treat the translations in these dictionaries as a baseline for Chinese scientific terminology prior to exposure to Japanese FDI. We refer to this variant as the "Jiangnan" variant throughout the paper.

Appendix B provides additional details on the Jiangnan dictionaries and compares the translations in these dictionaries with their counterparts in contemporary Chinese. In general, fewer than 10% of these Jiangnan translations remain in use in contemporary Chinese. Contemporary Chinese scientific terminology is generally shorter in terms of the number of characters and more likely to rely on semantic rather than phonetic translation. However, a precise assessment of the linguistic quality of these translations is beyond the scope of this paper.

We select 125 terms based on the frequency of their English equivalents in Google Ngram Viewer during the period 1880–1890.[3] This approach allows us to select terms based on their global importance, which is exogenous to China. For each term, we link it to its Japanese translation (the "Japanese" variant) and its Chinese translation today (the "Contemporary

[3]We select the 200 most frequent terms. However, we exclude 75 terms because their corresponding Chinese translations have multiple meanings, which makes it infeasible to implement the word-search in the journals described in the next subsection.

Chinese" variant). For many terms, the contemporary Chinese translation is identical to either the Japanese or the Jiangnan variant. We do not interpret this dataset as a comprehensive collection of knowledge codification; however, we view it as a representative sample that captures the general trends.

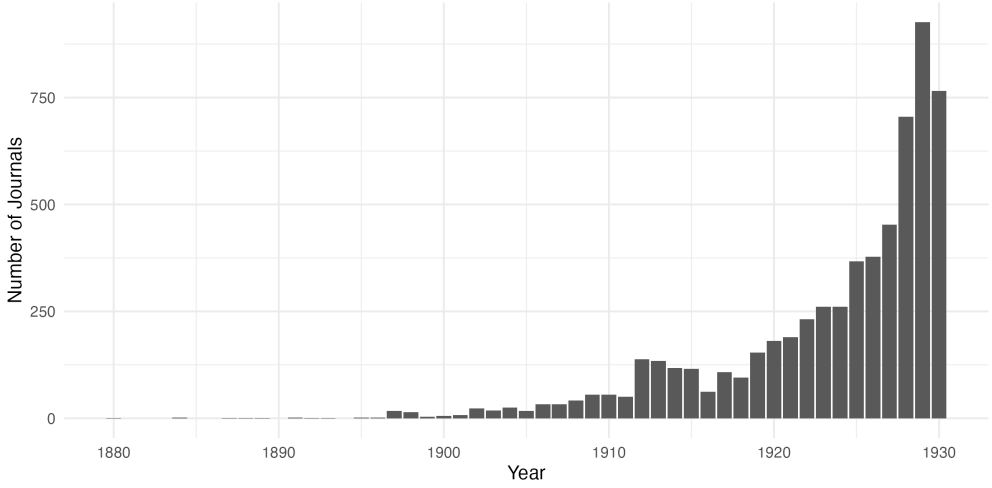
3.3 Journals in China

We construct journal-level data from the National Index to Chinese Newspapers & Periodicals (CNBKSY). Established in 1955 and maintained by the Shanghai Library, CNBKSY is a comprehensive bibliographic database that covers a wide range of modern Chinese publications. It includes more than $20,000$ periodicals, $4,000$ Chinese and English newspapers, and $120,000$ books, as well as over $10,000$ current periodicals, providing extensive coverage of books, newspapers, periodicals, and related materials.

Among all available publications, we focus on journals (periodicals). Journals were one of the primary vehicles of knowledge in society (Mokyr, 2005). In 18^{th}-century Europe, periodicals helped establish connections between the sphere of learning and the sphere of production, becoming an important component of the so-called Industrial Enlightenment, which ultimately played a crucial role in the emergence of modern economic growth (Mokyr, 2016). One of the core activities of scientific societies in Europe was the publication of journals, which not only facilitated the exchange of ideas among members, but also disseminated knowledge to the broader public during the Industrial Revolution (Galofré-Vilà, 2023).

Journals differ fundamentally from other types of information goods, making them particularly important for the diffusion of knowledge. Compared with books, journals place greater emphasis on timeliness and regular publication, facilitating the circulation of scientific and technical discussions. Compared with newspapers, journals generally possessed greater reliability because of their editorial processes. Newspapers primarily focused on reporting events and conveying what had been said, rather than verifying underlying theories, methods, and data (Kronick, 1978). Newspapers in China at the time were filled with inaccurate and often misleading portrayals of scientific knowledge. Although the editorial process in early

Figure 2: The Number of New Journals by Year



Notes: This figure plots the number of newly established journals in China by year of first publication. New journals begin to appear in large numbers after 1900. The journal data are constructed from the National Index to Chinese Newspapers & Periodicals (CNBKSY).

20th-century China was in no way comparable to that of contemporary academic journals, journals nevertheless remained among the most important vehicles for the dissemination of scientific and social knowledge requiring some degree of accuracy.

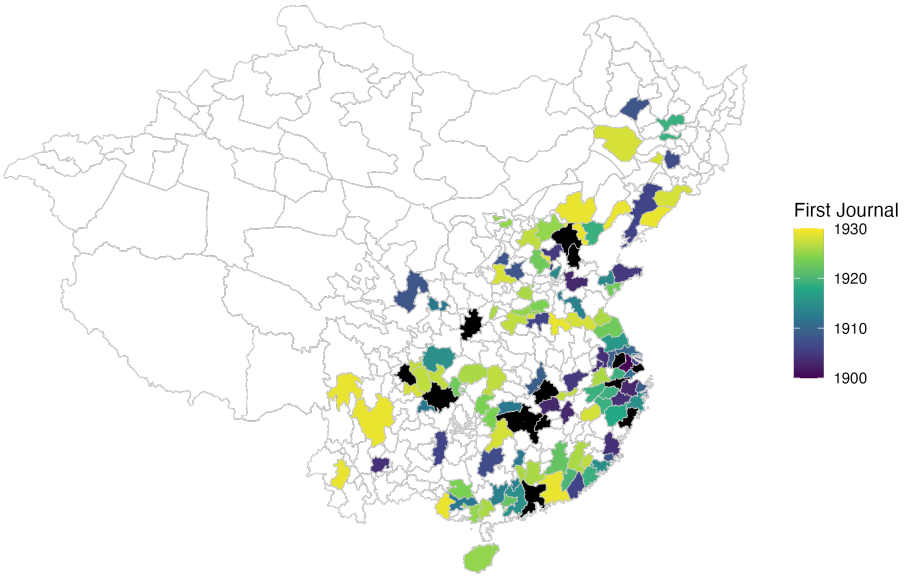
We begin by collecting data on journals from the late Qing period through the end of the Republican era in 1949. For each journal, we record its publication years, location, title, and summary. We then use an LLM to classify each journal into one or more of three categories based on its summary: (1) natural science; (2) social sciences; and (3) arts and literature. Finally, we match journal locations to prefectures in the CHGIS 1911 V6 Dataverse.[4]

Figure 2 reports the number of new journals by year. After 1900, new journals began to emerge in large numbers. Figure 3 further illustrates the spatial distribution of these new journals. Between 1900 and 1930, many prefectures published their first journals. Overall, the early 20th century witnessed a rapid expansion of knowledge in China.

Similar to journals in 17th- and 18th-century Europe, many journals in early 20th-century

[4]The CHGIS dataset is available at https://chgis.fas.harvard.edu/. We use the administrative boundaries from 1911.

Figure 3: Timing of Journal Entry Across Prefectures, 1900–1930



Notes: This figure shows the timing of first journal entry by prefecture. Blank areas indicate prefectures with no journal appearing before 1930, while black areas denote prefectures where journals had already appeared before 1900. For the period 1900–1930, prefectures are shaded according to the year of first journal entry, with darker shades indicating earlier entry.

China were secondary publications that primarily served the transmission of information rather than innovation. This can be verified through an analysis of journal summaries. The summary of each journal usually describes the publishing organization, the objective of the journal, and its content. Using these descriptions, we employ LLMs to classify each journal into one of four categories: (1) diffusion dominated; (2) innovation dominated; (3) mixed and balanced; and (4) unclear. Among all journals issued during 1900 and 1930, roughly 48% are diffusion dominated, while 21% are innovation dominated and 23% are mixed.

For editors and authors, the summaries suggest that journals were often local in nature. Some journals even ceased publication after their editors or major contributors moved elsewhere. Some journals affiliated with universities also stated that many of their contributors were faculty members and students affiliated with the same institution. The local concentration of contributors suggests that the knowledge recorded and circulated in these journals largely reflected the knowledge and expertise of the local communities in which they were produced. For example, *Mianye Nianbao* (*Cotton Industry Annual*, 棉业年报) was founded in Nantong, Jiangsu, in 1924. One of its major contributors was Zhang Tongwu (张通武), who was then managing a livestock farm experimenting with modern animal husbandry practices in Nantong. Zhang later became an important industrial entrepreneur in the 1940s. Similarly, *Beiyang Daxue Xiao Jikan* (北洋大学校季刊), an academic journal covering engineering and applied sciences, was founded in Tientsin in 1915. Its major contributors included Jin Wenzhu (金问洙) and Hua Deming (滑德铭), both of whom were students at Beiyang University at the time. Jin later held positions at several universities and in provincial administration, while Hua went on to become a prominent hydraulic engineer. Admittedly, biographical information is unavailable for many contributors, and many authors published under pseudonyms. Nevertheless, among those whose identities can be traced, contributors were typically based in or closely connected to the locality in which the journal was published and, rather than being purely academic scholars, many also had strong practical or industrial orientations.

In terms of audience, most journals indicate in their summaries that their goal was

to disseminate knowledge to a broad public. Although reading journals certainly required literacy, the threshold was not very high. Many journals explicitly stated in their summaries that they placed particular emphasis on using simple sentences so that general readers could understand the content. Many also indicated that their goal was to deliver knowledge that could be applied to actual industrial production.

Appendix A presents several detailed examples of journals.

We then perform a word search for the selected terms in journals. For each term, we search for all its Jiangnan, Japanese, and contemporary Chinese variants. We record the year in which each variant appears and the journal in which it appears. Because the source lists overlap (for example, many Japanese-coined terms later became the contemporary Chinese standard), we assign each variant to a single origin category using a priority rule: a variant that appears in the Jiangnan Arsenal dictionaries is classified as Jiangnan; of the remaining variants, any that appears in Japanese sources is classified as Japanese; all remaining variants are classified as contemporary Chinese coinages.

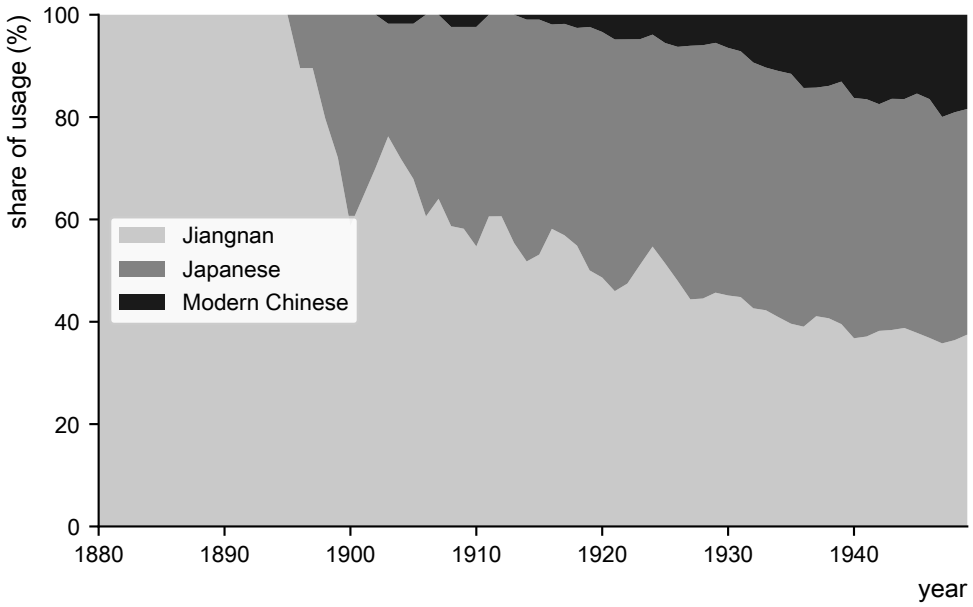
Figure 4 illustrates the evolution of scientific terminology in China. Prior to 1895, Chinese scholars primarily used Jiangnan (traditional) translations. After 1895, Japanese variants began to appear in Chinese journals. From the 1920s onward, Chinese scholars also began to develop new, native scientific terminology on a large scale.

3.4 Other Data

The data on Chinese domestic producers are drawn from Du (1991). Domestic industrial producers are defined as firms engaged in mechanized production and are thus indicative of industrialization. The data cover the period from 1870 to 1927 and are compiled from a variety of historical sources.[5] For each producer, the dataset records the year of establishment,

[5]Du (1991) synthesized data from various sources, including but not limited to Chinese government reports (e.g., *The Statistics of the Ministry of Agriculture, Industry, and Commerce* (农商统计表)), foreign government reports (e.g., *Overview of Chinese Industry* (支那工業総覧)), newspapers (e.g., *Journal of the General Chamber of Commerce of Shanghai* (上海总商会月报)), and local gazetteers (e.g., *Jiangsu Provincial Yearbook* (江苏省年鉴)).

Figure 4: Share of Journal Usage by Translation Origin



Notes: This figure shows the share of scientific-term usage in Chinese journals accounted for by each translation origin (Jiangnan, Japanese, and contemporary Chinese). Each English term is weighted equally within a year, and shares are smoothed with a 3-year moving average.

the location, and the industry.

We also collect data on German FDI from the *Deutsches Kolonial-Handbuch* (German Colonial Handbook). We are able to locate editions covering the period from 1903 to 1913. During this period, German economic activity in China was concentrated primarily in Kiautschou (Kiaochow), Shantung. The sections *Kolonisations-Gesellschaften* and *Personalien* record German firms in China. The data we compile are consistent with Hou (2000)'s estimates of the number of German firms. In principle, we would like to have comparable FDI data for a broader set of countries, particularly Britain. Unfortunately, we have not been able to identify nationwide firm-level data for other countries with a comparable level of detail.

The foreign trade data are constructed from the trade reports of the Chinese Maritime Customs (CMC). The CMC was an international institution responsible for administering foreign trade under the Treaty Port system. One of its main duties was to collect customs revenues, which were used in part to service the indemnities China owed to foreign powers. As a result, the CMC maintained detailed and high-quality trade records. Further details on the Treaty Port system and the Chinese Maritime Customs are provided by Keller and Shiue (2020). We collect the data from the *Analysis of Foreign Trade*, which reports annual total imports at each treaty port. Under the treaty port system, treaty ports served as the exclusive entry points for foreign goods into China. We therefore use imports through treaty ports to estimate each prefecture's exposure to foreign trade.

4 Empirical Framework

4.1 Baseline Estimation

4.1.1 The Effects of Japanese FDI on Journals

We begin by examining the effects of Japanese FDI on journals, which serve as a key vehicle for knowledge diffusion (Mokyr, 2005). We estimate a two-way fixed effects OLS specification,

as shown in Equation (1).

$$\log(\#Journal_{i,t}) = \beta \log(FDI_{i,t-1}) + \gamma_i + \gamma_t + \epsilon_{i,t} \tag{1}$$

The dependent variable is logged journal activity in prefecture i and time period t. Specifically, we consider both the number of new journals established in each period ("journal entry") and the total number of journals in existence in period t ("journal stock"). Both are important measures of knowledge in society: journal stock captures the total number of knowledge vehicles available, while journal entry reflects the public's interest in knowledge. The key explanatory variable, $\log(FDI_{i,t-1})$, captures FDI exposure. We construct this measure using the number of Japanese firms located within distance bands of 0 km, 0-100 km, 100-200 km, and 200-500 km from prefecture i. The prefecture fixed effects, γ_i, control for time-invariant characteristics of each prefecture, such as geographic advantages, natural endowments, and local culture. The year fixed effects, γ_t, control for nationwide time-varying factors.[6]

A potential concern is reverse causality: rather than FDI leading to increased journal activity, it may be that areas with greater journal activity attract more Japanese FDI. To address this concern, we use lagged FDI as our explanatory variable.

We take logarithms of both the dependent and independent variables for two reasons. First, this allows us to interpret the coefficients as elasticities, which are unit-free and facilitate comparison across specifications. Second, the journal variables exhibit right-skewness, and the log transformation helps mitigate the influence of extreme values.

Table 2 reports the OLS results for journal *entry*. Column (1) shows that greater FDI exposure within a prefecture is associated with the entry of more new journals. The coefficient of 0.102 shows that a 10% increase in the number of Japanese firms in a prefecture raised

[6]Because Japanese FDI is not observed annually, we aggregate journal entry over intervals defined by consecutive FDI observation years. Each FDI observation is matched to journal entry occurring after that observation and through the year of the next FDI observation. For example, when Japanese FDI is observed in 1909 and 1912, the 1909 Japanese FDI observation is linked to journal entry from 1910 through 1912. Therefore, t indexes consecutive observation intervals rather than individual calendar years.

journal entry by about 1%, and a doubling of the Japanese presence raised it by roughly 7.3%. To gauge the historical importance of this effect, note that among prefectures that ever received Japanese FDI, the average number of Japanese firms rose from 2.2 in 1903 to 52.9 in 1926, an increase of 2.83 log points. The point estimate implies that this expansion raised annual journal entry by about 0.29 log points (0.102×2.83), or roughly 34%. Over the same period, journal entry in these prefectures grew by 1.92 log points, so the growth of Japanese FDI can account for roughly 15% of the observed growth in journal entry. Column (2) shows that the effects of FDI were geographically limited. The magnitude of the effects declined substantially with distance from FDI and became statistically insignificant outside the prefecture. The elasticity with respect to Japanese firms located within 100 km of the prefecture is only about 1/4 of the within-prefecture elasticity, and the estimates for the more distant bands are essentially zero. Knowledge spillovers from FDI were tightly local.

Column (3) replaces year fixed effects with province-year fixed effects. This specification controls for time-varying changes at the provincial level, such as domestic political conditions and the return of foreign-educated students. The estimated elasticity is, if anything, slightly larger in this more demanding specification, indicating that the baseline result is not driven by province-level shocks.

Columns (4) and (5) indicate that FDI exposure had positive effects on the entry of both natural science and social science journals, suggesting that FDI facilitated the diffusion not only of technical knowledge but also of social knowledge. The two elasticities are of comparable magnitude, indicating that the effect on social knowledge was as strong as the effect on technical knowledge rather than a side effect of it.

Columns (6) and (7) further show that Japanese FDI exposure encouraged the entry of journals aimed both at disseminating existing knowledge and at publishing original innovations. Although the absolute number of journals focused on knowledge diffusion was larger than that of journals focused on innovation, the effects of Japanese FDI on the two types of journals were similar in magnitude. This suggests that Japanese FDI not only facilitated the dissemination of existing knowledge but also stimulated original innovation.

Column (8) shows that manufacturing FDI had the largest and most statistically significant effect, which we interpret as evidence of demonstration effects. The elasticity with respect to manufacturing FDI (0.183) is more than six times that with respect to non-manufacturing FDI (0.028), and only the former is statistically significant. This gap is not an artifact of manufacturing FDI's smaller variation: a one-standard-deviation increase in log manufacturing exposure raises journal entry by about 0.073 log points, roughly three times the 0.023 log points implied by a one-standard-deviation increase in log non-manufacturing exposure. The impact of FDI was stronger when local actors could directly observe how knowledge was put into practice and contributed to production. This mechanism may have applied both to technical knowledge used in manufacturing and to social knowledge, such as managerial practices and market analysis.

Finally, Column (9) controls for the preexisting stock of journals (i.e., the number of journals in operation in the previous year). This specification helps account for local characteristics, such as publishing infrastructure, readership, and intellectual networks, that may have influenced both FDI and subsequent journal entry. Roughly 60% of the baseline effect (0.061 versus 0.102) survives this most demanding control for local intellectual infrastructure.

To address the concern that the estimated effects of FDI may be driven by a particular province, such as Jiangsu, one of the most developed provinces in China at the time, we further conduct a leave-one-province-out exercise, in which we sequentially drop each province and re-estimate the baseline specification. The results are presented in Table A4. The estimates remain robust regardless of which province is excluded. Importantly, the results remain qualitatively unchanged when Jiangsu, the province in which Shanghai is located, is excluded. This suggests that the effects we capture reflect the broader impact of Japanese FDI rather than being driven solely by Shanghai.

We further divide China into three broad regions: North China (Fengtian, Jilin, Heilongjiang, Zhili, Shandong, Shanxi, Shensi, Gansu, and Henan), Central China (Anhui, Jiangsu, Zhejiang, Jiangxi, Hubei, Hunan, and Sichuan), and South China (Fujian, Guangdong, Guangxi, Guizhou, and Yunnan), and re-estimate the baseline specification separately

for each region. Japanese interests differed across these regions. In particular, northern China was of greater military and geopolitical importance to Japan, whereas economic incentives played a relatively more important role in Central and South China. As shown in Table A5, Japanese FDI had a significant effect in all three regions, although the estimated effects are larger in Central and South China. Nevertheless, this regional heterogeneity suggests that endogenous investment selection based on economic opportunities may be a relevant concern, which motivates the event-study design introduced in the next section. At the same time, the significant effect in North China, where Japanese investment was more strongly shaped by strategic and geopolitical considerations that were less dependent on local economic conditions, provides additional evidence that the effects of Japanese FDI are not driven solely by endogenous economic investment decisions.

Table 3 reports the results for journal *stock*. The results remain qualitatively similar.[7] These results together demonstrate the significant effects of Japanese FDI on knowledge diffusion. Japanese FDI both increased local interest in discussing knowledge and expanded the stock of vehicles for knowledge dissemination.

[7]One potential explanation is that many journals survived for only one year.

Table 2: The Effects of Japanese Firms on Journal Entry

Dependent Variables:	log(Entry)			log(Natural)	log(Social)	log(Innovation)	log(Diffusion)	log(Entry)	
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables									
$\log(FDI^{0})$	0.102***	0.105***	0.130***	0.085***	0.110***	0.086***	0.079**		0.061***
	(0.035)	(0.035)	(0.035)	(0.031)	(0.037)	(0.030)	(0.032)		(0.022)
$\log(FDI^{0,100})$		0.028							
		(0.018)							
$\log(FDI^{100,200})$		-0.009							
		(0.010)							
$\log(FDI^{200,500})$		-0.007							
		(0.009)							
$\log(Manufacturing^{0})$								0.183**	
								(0.072)	
$\log(Non_manufacturing^{0})$								0.028	
								(0.044)	
$\log(Stock_{t-1})$									0.374***
									(0.043)
Fixed-effects									
Prefecture	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Province × Year			Yes						
Fit statistics									
Observations	4,718	4,718	4,718	4,718	4,718	4,718	4,718	4,718	4,381
R^2	0.741	0.742	0.779	0.690	0.731	0.600	0.685	0.744	0.778
Within R^2	0.022	0.025	0.034	0.026	0.026	0.036	0.019	0.035	0.152

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 3: The Effects of Japanese Firms on Journal Stock

Dependent Variables:	log(Stock)			Stock	log(Natural)	log(Social)	log(Innovation)	log(Diffusion)	log(Stock)
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables									
$\log(FDI^{0})$	0.109***	0.113***	0.138***	2.797*	0.089**	0.119***	0.093***	0.087**	
	(0.038)	(0.039)	(0.040)	(1.621)	(0.035)	(0.042)	(0.035)	(0.035)	
$\log(FDI^{0,100})$		0.024							
		(0.019)							
$\log(FDI^{100,200})$		-0.009							
		(0.010)							
$\log(FDI^{200,500})$		-0.012							
		(0.010)							
$\log(Manufacturing^{0})$									0.160**
									(0.071)
$\log(Non_manufacturing^{0})$									0.044
									(0.046)
Fixed-effects									
Prefecture	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Province × Year			Yes						
Fit statistics									
Observations	4,718	4,718	4,718	4,718	4,718	4,718	4,718	4,718	4,718
R^2	0.776	0.776	0.814	0.581	0.737	0.762	0.661	0.726	0.778
Within R^2	0.025	0.028	0.039	0.020	0.026	0.030	0.040	0.022	0.034

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

There are two related questions regarding the effects of Japanese FDI on knowledge diffusion.

First, a potential endogeneity concern is that an omitted factor may simultaneously drive both Japanese FDI and knowledge diffusion. In particular, local demand may affect both the decisions of Japanese firms and the number of journals. As a result, the estimated effect of Japanese FDI could partly reflect underlying demand rather than knowledge transmission itself. To address this concern, we use foreign trade exposure as a proxy for local demand and develop a simple framework in Appendix E.2 to clarify the distinct roles of trade and FDI in knowledge diffusion. In the model, foreign trade increases awareness of the gap to the technological frontier by exposing local actors to foreign products and technologies. At the same time, it reduces incentives to acquire new knowledge because access to imported goods lowers the benefits of local learning. By contrast, FDI facilitates knowledge absorption by lowering the costs of accessing and learning foreign technologies. The model therefore predicts that FDI increases knowledge diffusion, foreign trade alone has a negative effect on knowledge acquisition, and the interaction between FDI and foreign trade is positive.

The construction of foreign trade exposure measure is presented in Appendix C. Notice that the trade data is available only after 1904, so we restrict the sample accordingly.

Table 4 presents the results. The first three columns show that trade exposure itself did not have a positive effect on journal entry. If anything, the estimated effect is negative. Columns (4) and (5) show that the interaction between Japanese manufacturing FDI and trade exposure had a significant positive effect, consistent with the prediction of the model. Note that, this means, at the mean level of trade exposure, doubling Japanese manufacturing FDI is associated with a 14 percent increase in journal entry.[8] We interpret this pattern as follows. Trade exposure may have made locals more aware of their distance from the technological frontier by revealing the existence of certain foreign products. However, exposure to products alone did not necessarily enable them to acquire the underlying knowledge,

[8]We focus on manufacturing FDI to avoid conflating the effects of FDI with those of trade, as some FDI was in commercial activities. Moreover, as shown in the previous results, manufacturing FDI had the strongest effect on knowledge diffusion.

because such knowledge was difficult to infer directly from the products themselves. Once locals became aware of these knowledge gaps, however, Japanese FDI became a more effective channel for knowledge diffusion because locals were more willing to acquire and engage with new knowledge.

Table 4: Comparing the Effects of Japanese FDI and Foreign Trade Exposure on Journal Entry

Dependent Variables:	log(Entry)		log(Natural)	log(Entry)	log(Natural)
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
$\log(FDI^0)$	0.116***		0.091***		
	(0.035)		(0.030)		
log(Trade)	-2.070*	-1.542	-0.718		
	(1.129)	(1.216)	(0.852)		
$\log(Manufacturing^0)$				0.194***	0.132***
				(0.068)	(0.050)
Z^{trade}				-0.122***	-0.069**
				(0.040)	(0.030)
$\log(Manufacturing^0) \times Z^{trade}$				0.059**	0.064***
				(0.024)	(0.021)
Fixed-effects					
Prefecture	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	4,381	4,381	4,381	4,381	4,381
R^2	0.747	0.740	0.699	0.753	0.709
Within R^2	0.030	0.005	0.026	0.055	0.059

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Second, one may worry that Japanese FDI was correlated with FDI from other countries, such that our estimates capture the overall effects of foreign investment rather than the specific contribution of Japanese firms. However, it is unlikely that our results merely reflect the effects of non-Japanese FDI. As discussed earlier, the geographic distribution of Japanese investment differed substantially from that of other foreign investors. In particular, Japanese firms expanded into many regions (e.g., Manchuria) that were not major destinations for Western investment, because of Japan's broader strategic and geopolitical ambitions in China, which ultimately culminated in military expansion after 1931. Consequently, variation in Japanese FDI exposure was largely distinct from the spatial patterns of investment by other foreign powers.

To further address this concern, we compare the effects of Japanese and German FDI. Because data on German FDI are available only for the period from 1903 to 1913, we restrict the sample accordingly. Due to the much shorter panel length, we do not include prefecture fixed effects and instead include only province-year fixed effects to preserve sufficient variation. Table 5 presents regression results comparing the effects of Japanese and German FDI.[9] Overall, while we do not deny that FDI from other countries may also have facilitated knowledge transmission to China, we argue that, at a minimum, foreign investment from different countries was not equally effective in transmitting knowledge.

In Column (1), the coefficient on Japanese FDI is 0.252 in this restricted sample, implying that a 10% increase in Japanese FDI increased journal entry by roughly 2.5%. This estimate barely changes when German FDI is added in Column (2), suggesting that the estimated effect of Japanese FDI is not confounded by German investment. By contrast, the point estimate for German FDI is negative and close to zero. Column (3) further compares the effects of Japanese and German manufacturing FDI. Japanese manufacturing FDI continues to have a significant positive effect on journal entry. The coefficient on German manufacturing FDI is also positive, but it is statistically insignificant and close to 0. The count model in Column (4) draws a sharper contrast: the elasticity of journal entry with respect to Japanese

[9]Compared with Japanese FDI, German FDI was highly concentrated in a single prefecture, Kiaochow. We therefore consider PPML and Probit specifications in addition to OLS.

FDI is three times as large as that with respect to German FDI. This difference becomes even more pronounced when we restrict attention to manufacturing FDI in Column (5). The extensive-margin estimates in Columns (6)–(9) yield a similar pattern. The presence of at least one Japanese firm increased the probability that a prefecture experienced any journal entry in a given year by approximately 40 percentage points, whereas we find no statistically significant effect of German FDI. In the next two subsections, we further investigate the mechanisms underlying this difference through lexicon-level analyses.

Table 5: Comparing the Effects of Japanese and German FDI on Journal Entry

Dependent Variables:	log(Entry)			Entry		$\mathbf{1}^{Journal}$			
Model:	(1) OLS	(2) OLS	(3) OLS	(4) Poisson	(5) Poisson	(6) OLS	(7) OLS	(8) Probit	(9) Probit
Variables									
log(Japanese)	0.253***	0.255***		0.987***					
	(0.075)	(0.075)		(0.139)					
log(Germany)		-0.033		0.305					
		(0.038)		(0.326)					
log(Japanese_Manufacturing)			0.462**		1.521***				
			(0.181)		(0.467)				
log(German_Manufacturing)			0.000		0.029				
			(0.023)		(0.266)				
$\mathbf{1}^{Japanese}$						0.402***		0.378***	
						(0.071)		(0.068)	
$\mathbf{1}^{Germany}$						-0.052		-0.032	
						(0.126)		(0.032)	
$\mathbf{1}^{Japanese_Manufacturing}$							0.393***		0.367***
							(0.089)		(0.072)
$\mathbf{1}^{German_Manufacturing}$							0.129		0.085
							(0.213)		(0.125)
Fixed-effects									
LEV1_PY-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics									
Observations	2,359	2,359	2,359	2,359	2,359	2,359	2,359	2,359	2,359
Squared Correlation	0.306	0.306	0.231	0.795	0.524	0.239	0.169	0.182	0.182
Pseudo R^2	0.424	0.425	0.306	0.642	0.538	2.345	1.588	0.241	0.241
BIC	2,318.1	2,323.8	2,565.8	3,325.3	3,960.3	787.53	995.52	2,072.7	2,072.7

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Finally, we also examine whether the effects of Japanese FDI varied with pre-existing local interest in Western knowledge. We use the number of "Wuxu" societies founded before 1900 as a proxy for such interest. The results show that while Japanese FDI had a significant positive effect on journal entry across prefectures, the effect was larger in prefectures with more "Wuxu" societies. Details are presented in Appendix D.

4.1.2 The Effects of Product-specific FDI on Product-specific Knowledge

We then examine the effects of product-specific FDI on product-specific knowledge, providing more direct evidence on knowledge transfer.

To do so, we first link each selected scientific term to the products to which it is related using an LLM. We then test whether exposure to product-specific FDI increases the likelihood that a given term is discussed.

$$\mathbf{1}_{i,t,r}^{\text{Term}} = \beta \log(FDI_{i,t-1,r}) + \gamma_{i,t} + \gamma_r \tag{2}$$

The estimation equation is given in Equation (2). The dependent variable, $\mathbf{1}_{i,t,r}^{\text{Term}}$, is an indicator equal to one if a specific scientific term r appears in journals published in prefecture i in time period t. The key explanatory variable, $\log(FDI_{i,t-1,r})$, measures exposure to FDI in product categories related to term r. We use a binary indicator for whether a term appears, rather than counting the number of occurrences, because authors differ in their writing styles; term frequency would therefore be biased by such stylistic differences.

We restrict the sample to prefecture–year observations after the appearance of at least one journal. In prefectures without any journals, there is no meaningful measure of whether a given scientific term is discussed.

This specification allows us to include prefecture–year fixed effects, $\gamma_{i,t}$, which control for time-varying factors at the prefecture level that may affect the outcome. For example, these fixed effects capture variation in the number of students returning from abroad and changes in a prefecture's access to foreign trade in a given year. Term fixed effects, γ_r, control for differences across scientific terms. For instance, some scientific terms may be

more intuitive or tangible (e.g., chemical materials), while others are more abstract (e.g., theoretical concepts in physics).

Table 6 reports the effects of product-specific FDI on product-specific knowledge. We find that FDI in products related to a given term significantly increases the likelihood that the term appears in journals. Given term appears in a prefecture's journals in only 3.5 percent of term–prefecture–year observations. Column (1) and (2) shows that doubling term-specific FDI exposure raises the probability that the term appears by around 0.3 percentage points, or 9 percent of the baseline rate. We interpret this finding as direct evidence of knowledge transfer. Moreover, Column (5) shows that, conditional on the existence of journals, the effect of FDI was equally strong within the prefecture and up to 100 km away. We interpret this pattern as indicating that once knowledge vehicles, journals, are established, the transmission of knowledge becomes easier over distance. However, the creation of these vehicles relies on highly localized forces.

We further compare the effects of product-specific German and Japanese FDI. The results are presented in Table A6. Overall, the findings are similar to those for the effects of aggregate FDI on journal entry. German FDI did not have a significant effect on product-specific knowledge diffusion.

4.1.3 The Effects of Japanese FDI on the Adoption of Japanese Scientific Languages

Finally, we test whether exposure to Japanese FDI encouraged the adoption of Japanese term variants.

$$\mathbf{1}_{i,t,r}^{Adoption} = \log(FDI_{i,t-1}) + \gamma_i + \gamma_t + \gamma_r \tag{3}$$

The dependent variable, $\mathbf{1}_{i,t,r}^{\text{Adoption}}$, is an indicator equal to one if the Japanese variant of term r—*distinct from the Jiangnan variant*—appears in journals published in prefecture i in time period t. If the Japanese and Jiangnan variants are identical, we do not classify the observation as an instance of "adoption." The key explanatory variable, $\log(FDI_{i,t-1})$,

Table 6: The Effects of Product-Specific FDI on Product-Specific Knowledge

Dependent Variable:	$\mathbf{1}^{Term}$				
Model:	(1)	(2)	(3)	(4)	(5)
	Logit	Logit	OLS	OLS	Logit
Variables					
$\log(Term_FDI^{0})$	0.005**	0.005***	0.026**	0.039***	0.005**
	(0.002)	(0.002)	(0.010)	(0.011)	(0.123)
$\log(Term_FDI^{0,100})$					0.005*
					(0.175)
$\log(Term_FDI^{100,200})$					-0.000
					(0.002)
Fixed-effects					
Prefecture × Year	Yes		Yes		Yes
Term	Yes	Yes	Yes	Yes	Yes
Prefecture		Yes		Yes	
Province × Year		Yes		Yes	
Fit statistics					
Observations	86,875	86,875	86,875	86,875	86,875
Squared Correlation	0.512	0.492	0.316	0.235	0.512
Pseudo R^2	0.625	0.604	-0.686	-0.485	0.625
BIC	19,189.9	15,929.7	-71,684.1	-65,859.4	19,206.7

Notes: This table reports estimates of Equation (3). The dependent variable is an indicator equal to one if term r, regardless of its variant, appears in journals published in prefecture i during period t. $\log(Term_FDI^{0})$ measures prefecture-level exposure to term-specific Japanese FDI, defined as Japanese FDI in the product group(s) associated with the term. Columns (1), (2), and (5) report average marginal effects from Logit models, with standard errors calculated using the delta method. Columns (3) and (4) report OLS estimates from linear probability models. Standard errors clustered by prefecture and term are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

measures exposure to Japanese FDI. We control for all of the prefecture fixed effects γ_i, year fix effect γ_t, and the term fixed effects γ_r.

We restrict the sample to prefecture–year observations after the appearance of the term (in any variant). In prefectures where the term has not been discussed, it is not meaningful to examine whether the Japanese variant of the term was adopted.

Table 7 reports the results on the adoption of Japanese scientific language. Among prefecture–term–year observations in which the term had already appeared, the Japanese variant was in use 26 percent of the time. Based on the average marginal effect in Column (1), doubling Japanese FDI exposure raises the probability of adopting the Japanese variant by 3.1 percentage points, or about 12% of this baseline rate. The OLS regression in column (2) shows a similar result. These effects are persistent: China and Japan continue to share many scientific terms today as a result of this early 20^{th}-century adoption.

The adoption of Japanese variants left a lasting imprint on the Chinese vocabulary. Among the 125 terms in our sample, 56 Japanese variants were eventually adopted and remain in use in contemporary Chinese.

4.2 Event Study

To further strengthen identification, we implement an event-study design that exploits the timing of the first arrival of Japanese FDI across prefectures. We do not assume that overall FDI decisions are exogenous to prefecture-level economic conditions. However, the first arrival of Japanese FDI, the "pioneer" investment, may be less systematically related to prefecture-specific unobservables. In particular, early investors faced substantial uncertainty, so the precise timing of the first arrival of Japanese FDI in each prefecture is partly idiosyncratic.

We therefore use the first arrival of Japanese FDI in a prefecture as the treatment event. Once a prefecture receives its first FDI, it remains treated in all subsequent periods, consistent with the idea that initial entry facilitates subsequent investment. The identifying variation therefore comes from differences in the timing of the first Japanese FDI. We group

Table 7: The Effects of Japanese Firms on the Adoption of Japanese Scientific Languages

Dependent Variable:	Adoption Exist	
Model:	(1)	(2)
	Logit	OLS
Variables		
$\log(FDI^0)$	0.045***	0.032**
	(0.015)	(0.014)
Fixed-effects		
Prefecture	Yes	Yes
Province-Year	Yes	Yes
Term	Yes	Yes
Fit statistics		
Observations	5,929	5,929
Squared Correlation	0.658	0.540
Pseudo R^2	0.634	0.650
BIC	6,847.8	6,826.3

Notes: This table reports estimates of Equation (3). The dependent variable is an indicator equal to one if the Japanese variant of term r—distinct from the Jiangnan variant—appears in journals published in prefecture i in period t; observations where the Japanese and Jiangnan variants coincide are not counted as adoption. $\log(FDI^0)$ measures Japanese FDI exposure within the prefecture. Column (1) reports the average marginal effects from the logit model, with standard errors calculated using the delta method. Column (2) is an OLS (linear probability) estimate. Both specifications include prefecture, province–year, and term fixed effects. The sample is restricted to prefecture–year observations after the term first appears in any variant. Standard errors clustered by prefecture and term are in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels.

event time into three-year intervals because our Japanese FDI data are drawn from surveys conducted at discrete points in time rather than annually, with gaps of up to three years between consecutive survey waves. Using three-year intervals therefore helps avoid individual event years with few or no newly treated prefectures.

The assumption that the exact timing of entry is plausibly exogenous has been widely used in the literature (e.g., Arcidiacono et al., 2020; Davis et al., 2025). Moreover, this assumption is supported by a substantial body of historical evidence. For example, Wilkins (1986) points out that the earliest Japanese textile investments in twentieth-century China were undertaken to *test* production costs, the availability of materials, and market conditions. Some investment attempts ultimately failed to materialize because investors were unfamiliar with the environment. For another example, *The Biography of Taniguchi Fusazō* contains the following record: "Now, as for launching the enterprise in China, the initial plan was to operate it as one factory [Osaka Gōdō Bōseki]. However, between our country and China there are differences in customs and in political conditions, and moreover it was difficult to readily predict how the exchange-rate relationship between the two countries might change in the future [...] so in the end it was decided to run the operation as a separate company adapted to conditions in China." This suggests that early Japanese investment in China faced substantial uncertainty and that whether and when individual investment attempts were ultimately realized was difficult to predict. Such uncertainty supports the assumption that the exact timing of the first FDI arrival in each prefecture was plausibly exogenous.

We estimate a staggered difference-in-differences event-study design following Callaway and Sant'Anna (2021). The unit of observation is a prefecture–period. The sample spans 1880 to 1930, with years grouped into three-year bins. Let G_i denote the first period in which prefecture i is exposed to Japanese FDI within the prefecture:

$$G_i = \min\{t : FDI^0_{i,t} > 0\}.$$

For prefectures that are never exposed to Japanese FDI, we set $G_i = 0$.

The outcome variable $Y_{i,t}$ measures an outcome of interest, such as journal entry.

For each cohort g and period t, we estimate the group-time average treatment effect

$$ATT(g,t) = E\left[Y_{i,t}(g) - Y_{i,t}(0) \mid G_i = g\right],$$

where $Y_{i,t}(g)$ denotes the potential outcome for prefectures whose first arrival of Japanese FDI occurs in period g, and $Y_{i,t}(0)$ denotes the potential outcome in the absence of FDI. The comparison group consists of prefectures that *have not yet* received Japanese FDI by period t.

We then aggregate the group-time treatment effects by event time $e = t - g$:

$$ATT(e) = \sum_{g} w_g(e) ATT(g, g+e),$$

where $w_g(e)$ are cohort-size weights among cohorts observed at event time e. The dynamic specification traces the evolution of journal entry or journal stock before and after the first arrival of Japanese FDI.

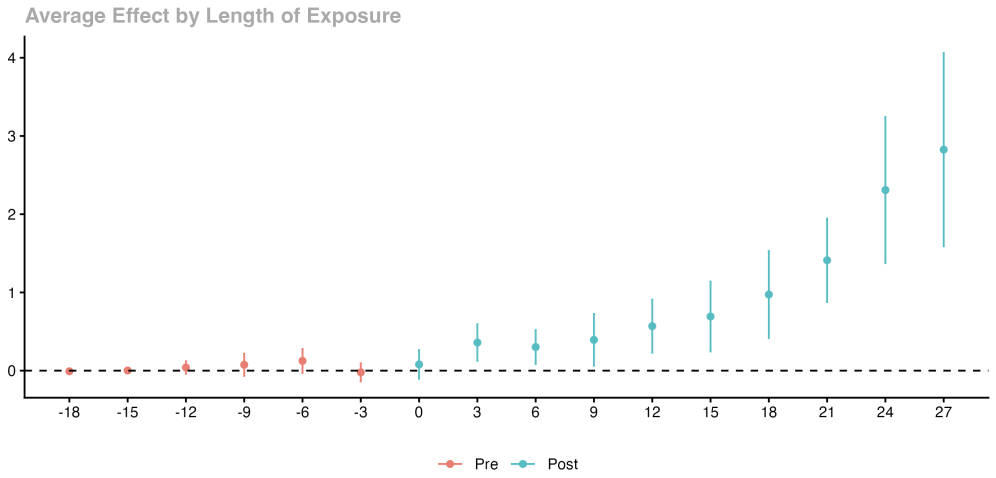
$$\log(Y_{i,t}) = \alpha_i + \lambda_t + \sum_{e \neq -1} \beta_e \mathbf{1}\{t - G_i = e\} + \varepsilon_{i,t}. \tag{4}$$

Figure 5 presents the event-study results for journal entry. There is no significant difference between treated and not-yet-treated prefectures prior to the first arrival of Japanese FDI. However, shortly after the first arrival, the number of new journals increases significantly.

The estimated effects are also economically large. The average treatment effect reaches 0.35 log points in the second three-year period after the first arrival. This implies a ATE of 42% more new journals than in not-yet-treated prefectures.

We further conduct an event study for product-specific FDI and product-specific knowledge. We replace the treatment as the first arrival of FDI in products related to a term and the outcome as the binary indicating whether the term appears in the journal. Figure 6 presents the event-study results. Consistent with previous specifications, we find no evidence of pre-trends. The effects emerge quickly in the period when FDI first arrives. The magnitudes are also substantial, relative to the low baseline frequency of term usage. The

Figure 5: Event Study: Journal Entry



Notes: This figure plots dynamic event-study estimates of the effect of the first arrival of Japanese FDI within a prefecture on log journal entry, following Callaway and Sant'Anna (2021). The unit of observation is a prefecture–period, with years grouped into three-year bins over 1880–1930. Treatment is the first period in which the prefecture receives Japanese FDI; the comparison group consists of not-yet-treated prefectures. The horizontal axis is event time relative to first arrival, with event time -1 the omitted reference period; vertical bands are 95% confidence intervals.

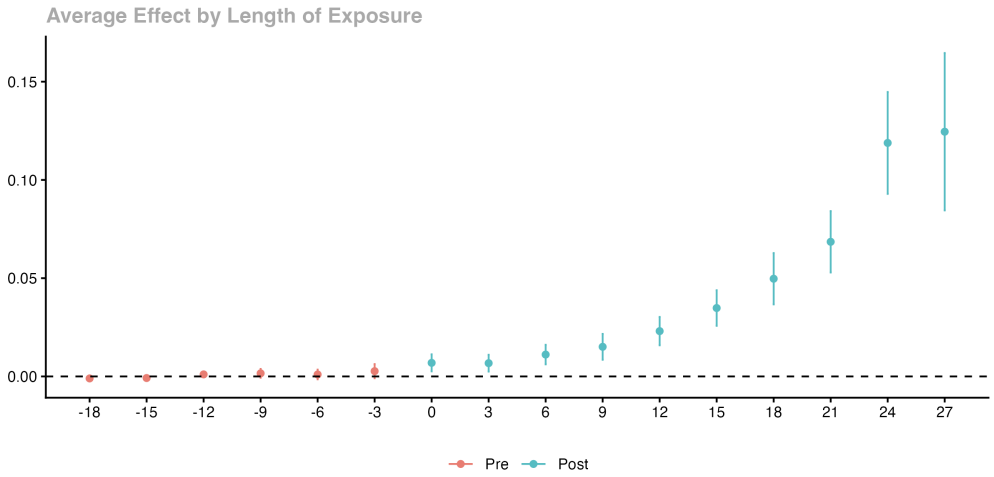
arrival of product-related FDI raises the probability that a term is discussed by about 0.7 percentage points in the period of first arrival, an increase about 3.5 times as large as the pre-treatment base rate of roughly 0.2%.

These findings suggest that there was no difference in knowledge between prefectures that would later receive FDI and those that would not before FDI actually arrived. However, the difference became significant once Japanese FDI arrived, suggesting a causal effect of Japanese FDI on knowledege. The results also indicate that the effects of Japanese FDI were immediate. Once Japanese FDI entered, knowledge transfer began promptly.

4.3 Knowledge's Impact on Economic Activity

Next, we examine the impact of FDI on domestic industrial producers in China. We adopt a similar empirical framework but restrict the sample period to 1904–1927. The sample begins in 1904, following the enactment of the Company Law, which finally allowed private domestic

Figure 6: Event Study: Term-specific FDI



Notes: This figure plots dynamic event-study estimates following Callaway and Sant'Anna (2021), replacing the treatment with the first arrival of FDI in products related to a given scientific term and the outcome with an indicator for whether the term appears in the prefecture's journals. The unit of observation is a prefecture–term–period, with years grouped into three-year bins. The comparison group consists of not-yet-treated prefecture–term pairs. The horizontal axis is event time relative to first arrival, with event time -1 the omitted reference period; vertical bands are 95% confidence intervals.

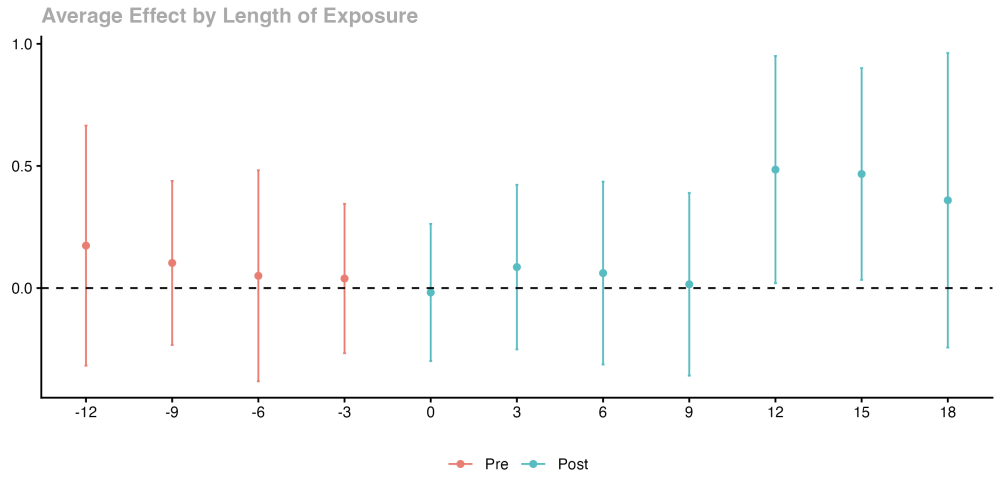
producers to freely enter the market. The sample ends in 1927, the last year covered by our data on domestic producers. Accordingly, prefectures that had already received Japanese FDI before 1904 are excluded from the analysis, because they were already treated before the beginning of the sample period.

One thing to note is that the dependent variable in this analysis is domestic firm entry. The use of this outcome can be justified in several ways. First, firm entry is a common measure of "new" economic activity (e.g., Abebe et al., 2022) and is particularly useful for assessing whether knowledge diffusion contributed to the onset of industrialization. Second, other commonly used measures, such as TFP, are not available for China during this period. Moreover, because China had only opened to FDI in 1895 and permitted private industrial production in 1904, changes in the TFP of existing firms would capture only a limited portion of the economic impact of knowledge diffusion.

Two additional potential concerns are less consequential in this setting. The first concern relates to competition in the labor market. For unskilled workers, such competition is unlikely to have been important given China's abundant supply of unskilled labor during this period. Skilled labor presents a potentially greater concern, as skilled Chinese workers were relatively scarce and Japanese firms could have competed with domestic firms for them. In practice, however, Japanese firms often brought technicians and other skilled personnel from Japan, reducing their reliance on the local skilled labor market. Moreover, to the extent that Japanese firms did employ Chinese workers, interactions between Japanese and Chinese employees constitute a potentially important channel of knowledge diffusion. We examine this channel in the next section.

The second concern is whether Japanese and Chinese firms competed directly in product markets. In the early period, both Chinese and Japanese firms generally served China's large domestic market (Du, 1991; Wilkins, 1986). Later, particularly after WWI, Japanese firms and some Chinese firms located in major treaty port citiessuch as Shanghai also began to serve overseas markets. Overall, however, most consumer goods markets were sufficiently competitive, both domestically and internationally, that strategic interactions between indi-

Figure 7: Event Study: Domestic Industrial Producers



Notes: This figure plots dynamic event-study estimates of the effect of the first arrival of Japanese FDI within a prefecture on the (log of one plus the) number of domestic industrial producers, following Callaway and Sant'Anna (2021). The sample period is 1904–1927, with years grouped into three-year bins; prefectures that received Japanese FDI before 1904 are excluded. The comparison group consists of not-yet-treated prefectures. The horizontal axis is event time relative to first arrival, with event time -1 the omitted reference period; vertical bands are 95% confidence intervals.

vidual Japanese and Chinese firms were unlikely to be a major concern.

Figure 7 presents the results for domestic producers. Compared with knowledge outcomes, the effects of FDI on domestic producers are not immediate. The estimates become large and statistically significant only after 12 years. These findings suggest that the translation of knowledge into actual economic activity takes time. One explanation is that a sufficient accumulation of knowledge is required before it can affect actual economic activity. In addition, domestic producers need time to absorb and apply new knowledge. Taken together, these results indicate that the absence of immediate effects of FDI on domestic producers does not imply a lack of knowledge transfer, but rather reflects the gradual process of learning and adoption.

That firm entry required the accumulation of knowledge is further supported by Figure 8. The figure plots the average cumulative journal entry in each year before and after the entry of the first domestic firm in a prefecture. Cumulative journal entry begins to increase

Figure 8: Knowledge Accumulation Before Firm Entry

noticeably about ten years before the first domestic firm enters, for both natural- and social-science journals. This temporal pattern suggests that the emergence of domestic firms was preceded by a gradual accumulation of locally available knowledge rather than occurring immediately after the onset of knowledge diffusion.

Figure 8 shows that, prior to the entry of the first domestic firm, both social science and natural science journals gradually accumulated. A natural question is which type of knowledge was more important for domestic firm entry. We therefore estimate a discrete-time hazard model of first domestic firm entry. We construct a prefecture-year panel in which prefectures remain in the risk set until the year of their first domestic firm entry, while prefectures without entry remain in the sample throughout the period. The outcome equals one in the year of first firm entry and zero in all preceding years. We relate domestic firm entry hazard to the stock of knowledge accumulated through journal entry prior to each year. Importantly, because domestic firm entry was only allowed after 1904, prefectures with natural science journals in our estimation sample also always had social-science journals. We therefore distinguish between prefectures with only social science journals and those with both social and natural science journals.

Table 8 presents the results. The variable *Social Only* equals one if the prefecture has accumulated at least one social science journal. The variable *Both* equals one if the prefecture has accumulated both social science and natural science journals. Therefore, the

coefficient on *Social Only* captures the difference between prefectures with only social science knowledge and those with neither type of knowledge, while the coefficient on *Both* captures the additional association of natural science knowledge conditional on the presence of social science knowledge. The results show that having social science knowledge is associated with a 5.9 percent point increase in the probability of first domestic firm entry, while the additional presence of natural science knowledge is associated with a further 23.2 percentage point increase. Although the structure of the data does not allow us to examine prefectures with natural science knowledge but no social science knowledge, these results suggest that natural science knowledge was particularly important for the emergence of domestic firms once a basic stock of social science knowledge had already accumulated.

Table 8: Journal Entry and First Domestic Firm Entry

Dependent Variable:	First Domestic Firm Entry
Model:	(1)
Variables	
Social Only	0.059***
	(0.020)
Both	0.232***
	(0.073)
Fixed-effects	
Year	Yes
Fit statistics	
Observations	5,283
R^2	0.051
Within R^2	0.040

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

To understand this gradual process of knowledge accumulation and domestic firm entry, we measure how much of a product's technical knowledge local manufacturers have absorbed

and ask how large this stock must become before domestic firms begin to enter.

Measuring knowledge accumulation. For each product p, let $\mathcal{K}_p$ denote the set of distinct technical terms associated with that product, and let $N_p = |\mathcal{K}_p|$ be the size of that vocabulary; we keep products with $N_p \geq 3$ terms. A term is "adopted" in prefecture i once it has appeared in that prefecture's journals. Let $a_{i,k,t} = 1$ if term k has appeared in prefecture i at or before period t, and 0 otherwise. We then define the *knowledge adoption share*

$$S_{i,p,t} = \frac{1}{N_p} \sum_{k \in \mathcal{K}_p} \mathbf{1}\{\textstyle\sum_{s \leq t} a_{i,k,s} > 0\} \ \in \ [0,1], \tag{5}$$

or the cumulative fraction of product p's technical vocabulary that prefecture i has encountered by period t.

For example, the product category "Chemicals And Allied Products (Including Pharmaceuticals)" depends on 109 technical terms; if by period t a prefecture's journals have used 40 of these 109 terms, its adoption share for lumber is $S_{i,p,t} = 40/109 \approx 0.36$.

As in the previous section, the sample runs from 1904 to 1927 in three-year bins, and the outcome is the number of domestic firms entering in product p and prefecture i.

Defining treatment by a knowledge threshold. We define that a prefecture-product pair becomes "knowledge-treated" the first time its knowledge accumulation share in the product group crosses a threshold τ. Formally, for a given threshold τ the treatment cohort is

$$G_{i,p}(\tau) = \min\{\, t \geq 1904 : S_{i,p,t} \geq \tau \,\}, \tag{6}$$

and $G_{i,p}(\tau) = 0$ for pairs that never reach the threshold within the sample. Pairs that have already crossed τ before 1904 are dropped, since they would be treated before the sample begins.

With $G_{i,p}(\tau)$ in hand, we estimate the same staggered difference-in-differences event study as in Equation (6)'s predecessor, following Callaway and Sant'Anna (2021), using not-yet-treated pairs as the comparison group and event time $e = t - G_{i,p}(\tau)$.

Figure 9 reports the estimates for four knowledge thresholds $\tau \in \{0.1, 0.2, 0.4, 0.6\}$. None of the four specifications shows a pre-trend, i.e., before the prefecture crosses the knowledge threshold, firm entry in treated and not-yet-treated pairs is statistically indistinguishable.

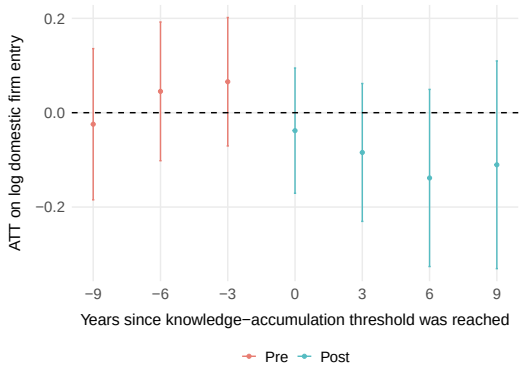
The post-treatment response depends sharply on how much knowledge has been accumulated. At the low thresholds, namely 0.1 and 0.2, crossing the threshold has no detectable effect on firm entry. However, at the high thresholds, namely 0.4 and 0.6, the effect of knowledge accumulation on firm entry starts to emerge. In particular, when the knowledge accumulation reaches 0.4, significant effects on domestic firm entry in that product group become to emerge in 6 years. When the knowledge accumulation reaches 0.6, there began to be immediate effects on domestic firm entry. At the 0.6 threshold, the effect is already 0.36 log points in the crossing period and climbs to 0.68–0.90 log points (roughly 100–150%) within the following six years.

Figure 10 reports the estimated average treatment effect three years after a prefecture–industry pair first reaches each knowledge-adoption threshold. At relatively low thresholds, the estimated effects are small and statistically insignificant, suggesting that limited knowledge accumulation is not yet sufficient to generate observable economic activity. The estimates become larger and clearly positive once the adoption share reaches a relatively high level, around 0.6. This pattern is consistent with the idea that knowledge must accumulate to a sufficiently high level before it can be translated into firm entry. At still higher thresholds, however, the estimated effect three years after threshold crossing becomes smaller again. One possible interpretation is that, for units that eventually reach very high levels of knowledge accumulation, the economic response may begin before the final threshold is crossed. Consequently, for higher thresholds, $t = 3$ may capture a later stage of the response, when the effect has already begun to diminish.

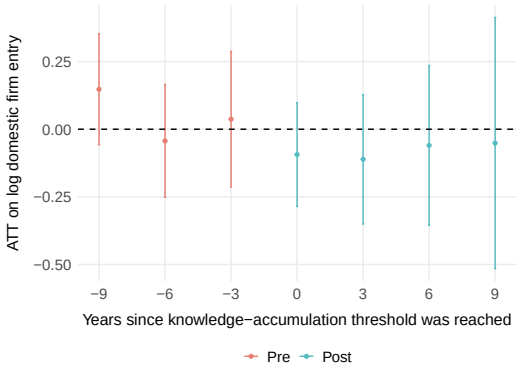
Finally, we complement the event-study analysis with a nested-threshold specification that examines how domestic firm entry varies across successive levels of knowledge accumulation. The estimating equation is given by:

$$\log\left(\text{Firm Entry}_{i,p,t}\right) = \sum_{q \in \mathcal{Q}} \beta_q \mathbf{1}\left\{\text{Accumulation Share}_{i,p,t} \geq q\right\} + \alpha_{i,p} + \gamma_{p,t} + \varepsilon_{i,p,t}. \qquad (7)$$

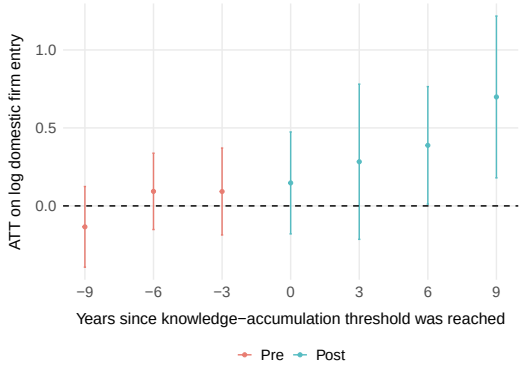
Figure 9: Event Study: Knowledge Threshold and Domestic Firm Entry



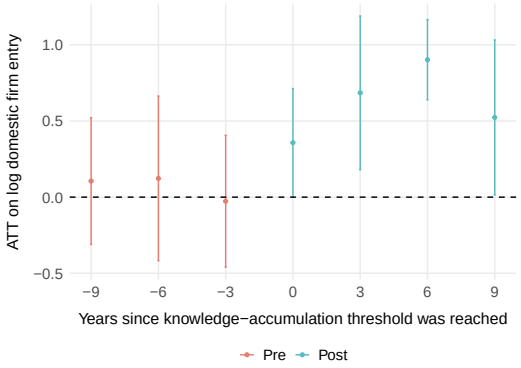
(a) Threshold $\tau = 0.1$



(b) Threshold $\tau = 0.2$



(c) Threshold $\tau = 0.4$



(d) Threshold $\tau = 0.6$

Notes: Each panel plots dynamic event-study estimates from a staggered difference-in-differences design (Callaway and Sant'Anna, 2021). The unit of observation is a prefecture–product pair; the outcome is the log of one plus domestic firm entry. Treatment is the first period in which the prefecture's knowledge adoption share $S_{i,p,t}$ for the product (Equation 5) crosses the threshold τ, defined in Equation (6). The four panels use thresholds of $\tau = 0.1$ (Panel A), $\tau = 0.2$ (Panel B), $\tau = 0.4$ (Panel C), and $\tau = 0.6$ (Panel D), i.e. the prefecture must have accumulated 10%, 20%, 40%, and 60% of the product's technical vocabulary, respectively. The horizontal axis is event time in years relative to threshold crossing; vertical bands are 95% simultaneous confidence intervals. Comparison units are prefecture–product pairs not yet treated by the relevant period; pairs crossing the threshold before 1904 are excluded.

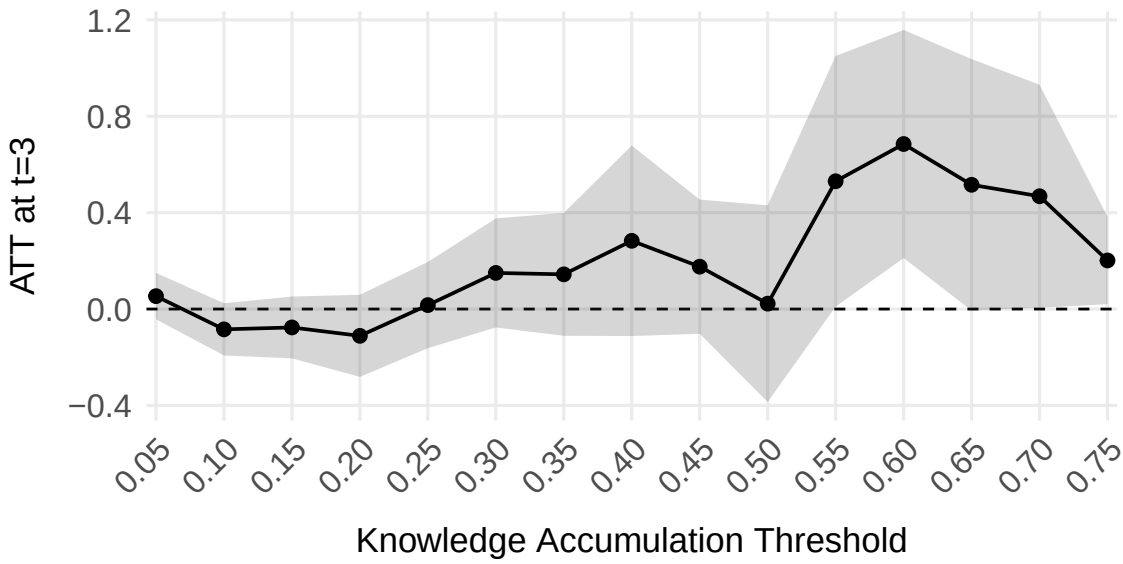


Figure 10: Treatment Effects on Firm Entry Three Years after Knowledge-Threshold Crossing

The dependent variable is the number of domestic firms entering in Prefecture i, Industry p, and Period t. The term $\alpha_{i,p}$ denotes prefecture–industry fixed effects, while $\gamma_{p,t}$ denotes industry-by-period fixed effects. The set

$$\mathcal{Q} = \{0.05, 0.10, 0.15, \ldots, 0.75\}$$

denotes the grid of knowledge-accumulation thresholds.

Because the threshold indicators are nested, the coefficients should be interpreted incrementally. Each coefficient β_q captures the difference in firm entry between the knowledge interval beginning at threshold q and the immediately preceding interval. Accordingly, the difference in firm entry associated with a given level of knowledge accumulation relative to the reference category is obtained by summing the coefficients on all thresholds reached up to that level. Thus, individual coefficients describe changes between adjacent knowledge ranges, whereas their cumulative sum describes the difference relative to the reference category with an accumulation share below 0.05.

For any observed accumulation share a, define

$$\bar{q}(a) = \max\{q \in \mathcal{Q} : q \leq a\},$$

that is, the highest threshold in $\mathcal{Q}$ that does not exceed a.

For example, an accumulation share of 0.47 falls in the interval $[0.45, 0.50)$. Under the nested-threshold specification, its estimated difference in current-period domestic firm entry relative to the reference category, *Accumulation Share* < 0.05, is

$$\beta_{0.05} + \beta_{0.10} + \cdots + \beta_{0.45}.$$

The coefficient $\beta_{0.45}$, in turn, captures the incremental difference in current-period firm entry between the intervals $[0.45, 0.50)$ and $[0.40, 0.45)$.

Importantly, a negative coefficient at a higher threshold does not imply that additional knowledge reduces the stock of existing firms. Because the outcome measures new firm entry in the current period, a negative coefficient instead indicates that new entry is lower than in the immediately preceding knowledge interval. Such a pattern can arise if a substantial portion of the entry response has already occurred at lower levels of knowledge accumulation. Therefore, the sequence of coefficients traces how the intensity of new firm entry changes as knowledge accumulates, rather than how the existing stock of firms changes.

Figure 11 reports the cumulative effects on domestic firm entry associated with reaching each successive knowledge accumulation threshold. The estimated effect becomes significantly positive once the accumulation share reaches 0.6, consistent with our previous finding that an accumulation share of 0.6 represents an important threshold at which accumulated knowledge begins to translate into actual economic activity. This pattern further suggests that the relationship between knowledge accumulation and new firm entry is nonlinear, with particular stages of the accumulation process associated with stronger entry responses.

Taken together, these results sharpen the interpretation of the earlier event-study evidence on the effects of Japanese FDI on domestic producers. Knowledge does not translate into economic growth term by term. Rather, it must accumulate beyond a sufficiently high level before it begins to generate substantial firm entry. At the same time, this process

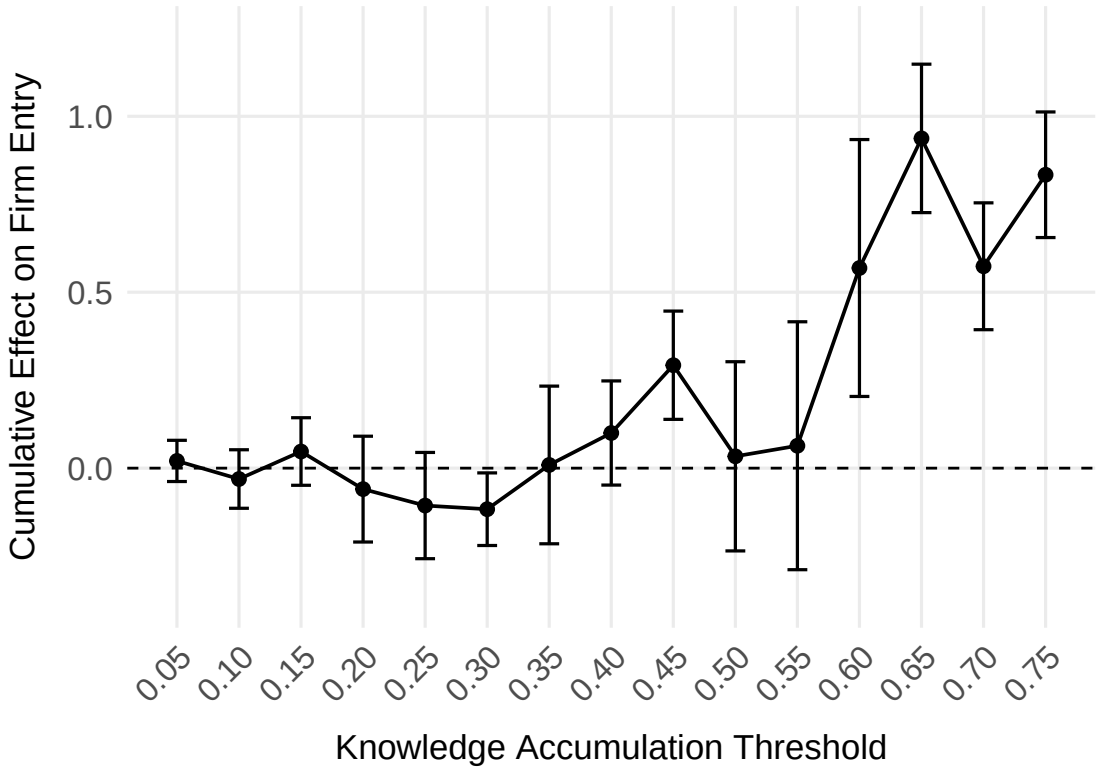


Figure 11: Cumulative Effects of Knowledge Accumulation on Firm Entry

appears to be nonlinear. Thus, although FDI may initiate knowledge transfer upon arrival, its effects on actual economic activity may emerge only gradually and over a substantially longer horizon.

5 Potential Mechanisms

The empirical findings have established the transmission of knowledge from Japanese FDI to China and the conversion of that knowledge into actual economic production. One remaining question concerns the potential mechanisms through which knowledge was transferred from FDI to local Chinese. Knowledge transmission could occur through multiple channels, many of which are difficult to quantify. Nevertheless, we discuss two possible channels using both quantitative and qualitative evidence.

Factory Visits. A broad channel through which Japanese factories could facilitate knowledge diffusion was factory visits. Newspapers at the time contain numerous reports of scholars, officials, and students being organized to visit factories for educational and observational purposes. For example, the *Shishi Xinbao* (时事新报) reported on May 5, 1924 that students in the mechanical, chemical, and textile departments of the Shanxi Industrial School were organized by the school to visit factories within the province for observation and learning. Similarly, the *Shengjing Shibao* (盛京时报) reported on April 16, 1924 that a primary school in Fengtian organized students to visit nearby factories with the explicit aim of fostering their interest in industrial enterprise. Such visits provided students with opportunities to observe production processes, machinery, and factory organization firsthand, thereby facilitating the diffusion of technical and managerial knowledge.

Labor Contact. A more direct channel of knowledge transmission was contact between Chinese and Japanese workers. The Japanese surveys record employment information for a subset of Japanese firms. In particular, for some firms, they report the number of employees by nationality. Although these employment data are available only for a limited number of years and firms, they provide a useful picture of the general employment structure. Table 9 presents the summary statistics. Overall, we observe employment information for around

Table 9: Employment Summary Statistics

Variable	N	Mean	SD	Min	P25	Median	P75	Max
Total Employment	3871	44.1	420.8	1	4.0	7.0	13.0	13400
Japanese Employment	3166	5.6	26.6	0	1.0	2.0	5.0	1200
Chinese Employment	3166	40.4	420.3	0	2.0	4.0	10.0	13000
Japanese Employment Share	3166	0.4	0.3	0	0.1	0.3	0.6	1
Chinese Employment Share	3166	0.6	0.3	0	0.4	0.7	0.9	1

3,000 firm-year observations.

Two patterns emerge from Table 9. First, consistent with the discussion above, Japanese FDI was characterized by a large number of relatively small and geographically dispersed firms rather than a small number of very large firms. Most Japanese firms employed fewer than 10 workers, although there were also several very large establishments, typically textile factories. Second, Japanese firms commonly employed both Chinese and Japanese workers.[10] Among observations for which disaggregated employment data are available, 75.8% employed both Chinese and Japanese workers. This employment structure created substantial opportunities for Chinese and Japanese workers to interact in the workplace, thereby facilitating the learning and adoption of Japanese knowledge.

Qualitative evidence also suggests that Japanese factories placed considerable emphasis on worker training. For example, a June 13, 1926 issue of the *Shangbao* (商报) reported on a journalist visit to a Japanese-owned cotton mill and specifically noted facilities such as a "workers' club" (工人俱乐部) and a "worker training school" (工人养成学校). The report also noted that the factory was equipped with entirely new machinery ("机械全新"). Such arrangements created opportunities for Chinese workers to acquire skills and production knowledge through direct training, day-to-day interactions, and hands-on exposure to advanced machinery.

These channels are also consistent with several aspects of our findings. First, they pro-

[10] A small number of firms also employed Korean workers or workers of other nationalities. Therefore, Chinese employment plus Japanese employment does not necessarily equal total employment.

vide additional evidence for why manufacturing FDI was particularly effective in transferring knowledge. Manufacturing establishments exposed local workers and visitors to actual production practices, making learning through direct contact and observation more feasible. Second, these channels help explain why the effects of FDI were geographically limited. Direct interactions with Japanese workers necessarily occurred locally. Factory visits could, in principle, take place over longer distances, but doing so was more costly than visiting nearby factories.

6 Conclusion

This paper provides direct evidence on how FDI from a more advanced economy reshaped the knowledge base of a developing economy, using the unique historical context of China's first opening to foreign investment in the early 20^{th} century. We decompose the economic effects of FDI into two stages: the transfer of foreign knowledge into the local economy, and the translation of that knowledge into domestic economic activity. In the first stage, exposure to Japanese FDI lowered the access costs of knowledge, increasing both the entry and the stock of local journals, raising the discussion of product-specific scientific knowledge, and promoting the adoption of Japanese scientific terminology that remains embedded in the Chinese language today. In the second stage, we find that these knowledge gains translated into domestic firm entry only with substantial delay, and only after a prefecture had accumulated a sufficiently large share of a product's technical vocabulary.

Two broader lessons emerge. First, not all FDI is equally effective at transmitting knowledge: source-country characteristics, and linguistic and cultural proximity in particular, shape how readily foreign knowledge can be accessed and adopted. Japanese FDI, embedded in production and carried by managers, engineers, and a shared written language, transferred knowledge more effectively than the more geographically concentrated and linguistically distant investment of the Western countries, and more effectively than foreign trade alone. Second, knowledge spillovers do not mechanically or immediately raise domestic productivity. Because knowledge must first be accumulated, the economic returns to

FDI can appear weak in the short run even when substantial knowledge transfer is already underway. This helps reconcile the widespread policy enthusiasm for attracting FDI with the mixed empirical record on its productivity effects in developing countries.

While our setting is historical and specific, the findings, such as linguistic proximity and threshold effects in the accumulation of knowledge, speak directly to contemporary debates on technology transfer and industrial policy. They suggest that the payoff to foreign investment depends not only on how much investment a country attracts, but also on how transferable the accompanying knowledge is and on the local capacity to absorb and apply it over time.

References

Abebe, G., McMillan, M., and Serafinelli, M. (2022). Foreign direct investment and knowledge diffusion in poor locations. *Journal of Development Economics*, 158:102926.

Ahn, J., Kim, C., Li, N., and Manera, A. (2026). Knowledge diffusion through fdi: Worldwide firm-level evidence. *Journal of International Economics*, page 104205.

Aitken, B. J. and Harrison, A. E. (1999). Do domestic firms benefit from direct foreign investment? evidence from venezuela. *American economic review*, 89(3):605–618.

Amiti, M. and Konings, J. (2007). Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *American economic review*, 97(5):1611–1638.

Arcidiacono, P., Ellickson, P. B., Mela, C. F., and Singleton, J. D. (2020). The competitive effects of entry: Evidence from supercenter expansion. *American Economic Journal: Applied Economics*, 12(3):175–206.

Branstetter, L. (2006). Is foreign direct investment a channel of knowledge spillovers? evidence from japan's fdi in the united states. *Journal of International economics*, 68(2):325–344.

Callaway, B. and Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of econometrics*, 225(2):200–230.

Comin, D. and Hobijn, B. (2011). Technology diffusion and postwar growth. *NBER macroeconomics annual*, 25(1):209–246.

David, P. A. (1985). Clio and the economics of qwerty. *The American economic review*, 75(2):332–337.

Davis, L. W., McRae, S., and Seira, E. (2025). Competitive effects of entry in gasoline markets. *The Journal of Industrial Economics*, 73(4):589–607.

Djankov, S. and Hoekman, B. (2000). Foreign investment and productivity growth in czech enterprises. *The World Bank Economic Review*, 14(1):49–64.

Du, X. (1991). *Minzu Ziben Zhuyi Yu Jiuzhongguo Zhengfu: 1840-1937*. Shanghai : Shanghai She Hui Ke Xue Yuan Chu Ban She. National Capitalism and the Governments of Old China.

Eaton, J. and Kortum, S. (1999). International technology diffusion: Theory and measurement. *International Economic Review*, 40(3):537–570.

Ethier, W. J. and Markusen, J. R. (1996). Multinational firms, technology diffusion and trade. *Journal of International Economics*, 41(1-2):1–28.

Fan, T. (2011). *Jindai Zhongguo Kexue Shetuan Yanjiu [A Study of Scientific Societies in Modern China]*. People's Press, Beijing.

Fu, X. (2012). Foreign direct investment and managerial knowledge spillovers through the diffusion of management practices. *Journal of Management Studies*, 49(5):970–999.

Galofré-Vilà, G. (2023). The diffusion of knowledge during the british industrial revolution. *Social Science History*, 47(2):167–188.

Goetzmann, W. N. and Koll, E. (2005). The history of corporate ownership in china: State patronage, company legislation, and the issue of control. In *A history of corporate governance around the world: Family business groups to professional managers*, pages 149–184. University of Chicago Press.

Goldberg, P. K., Khandelwal, A. K., Pavcnik, N., and Topalova, P. (2010). Imported intermediate inputs and domestic product growth: Evidence from india. *The Quarterly journal of economics*, 125(4):1727–1767.

Haddad, M. and Harrison, A. (1993). Are there positive spillovers from direct foreign investment?: Evidence from panel data for morocco. *Journal of development economics*, 42(1):51–74.

Helpman, E. (2006). *The mystery of economic growth*. Academic Foundation.

Hou, C.-m. (2000). *Foreign investment and economic development in China, 1840-1937*, volume 8. Taylor & Francis.

Jones, C. I. (2003). Human capital, ideas and economic growth. In *Finance, research, education and growth*, pages 51–74. Springer.

Juhász, R., Sakabe, S., and Weinstein, D. (2024). Codification, technology absorption, and the globalization of the industrial revolution. Technical report, National Bureau of Economic Research.

Keller, W. and Shiue, C. H. (2020). China's foreign trade and investment, 1800-1950. Technical report, National bureau of economic research.

Konings, J. (2001). The effects of foreign direct investment on domestic firms: Evidence from firm-level panel data in emerging economies. *Economics of transition*, 9(3):619–633.

Kronick, D. A. (1978). Authorship and authority in the scientific periodicals of the seventeenth and eighteenth centuries. *The Library Quarterly*, 48(3):255–275.

Mokyr, J. (2005). The intellectual origins of modern economic growth. *The Journal of Economic History*, 65(2):285–351.

Mokyr, J. (2016). The european enlightenment and the origins of modern economic growth. In *Culture of Growth*. Princeton University Press.

Partha, D. and David, P. A. (1994). Toward a new economics of science. *Research policy*, 23(5):487–521.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvements: Evidence from chilean plants. *The Review of economic studies*, 69(1):245–276.

Puffert, D. J. (2002). Path dependence in spatial networks: the standardization of railway track gauge. *Explorations in Economic History*, 39(3):282–314.

Remer, C. F. (1933). *Foreign Investments in China*. Macmillan, New York.

Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, 98(5, Part 2):S71–S102.

Scott, P. (2001). Path dependence and britain's "coal wagon problem". *Explorations in Economic History*, 38(3):366–385.

Wilkins, M. (1986). Japanese multinational enterprise before 1914. *Business History Review*, 60(2):199–231.

A Examples of Journals

- **江西省农会丛刊** (*Jiangxi Provincial Agricultural Association Bulletin*)
  - Start Year: 1920
  - Location: 南昌(Nanchang), 江西(Jiangxi)
  - Category: Natural Sciences & Social Sciences.
  - Knowledge orientation: Diffusion & Innovation.
  - Summary: 1920年3月创刊于江西南昌，收录至1921年3月第3期。馆藏1920年第2期和1921年第3期共两期。**由江西省农会编辑处编辑，江西省农会发行。半年刊，属于农业相关刊物。主要撰稿人有张范村、乐洪勋、陶平、需念祖、吴信修、吴恺等，主要栏目有公牍、调查、纪事等。** 该刊以"**辅助农业行政机关，以图农业改良和发展为使命**"，**主要登载内容为江西农业试验，农业与森林产品调整，林木灾害防治，农人传略，中外农事消息，各地公函及有关训令等**。其中纪事一栏刊载《纪事：国内消息：海州渔业技术传习所之创设》、《纪事：本省消息：烟草市价之陡然腾贵》等文章，**刊载各地及江西一省渔业、烟草业、棉业、朝鲜养蚕业等相关的国内外重要消息，报道各地各业的成绩、进展，方便读者了解国内外各地农事情况与技术，对于促进江西一地农业发展有一定积极作用。该刊辅助农业行政机关，以图农业改良与发展为使命，刊登江西农事试验，农业与森农林产品调整，林木灾害防治，农人传略，中外农事消息，各地公函及有关训令。**刊载有杨士京的《农人传（续江西省农会丛刊第二期）》文章等，介绍农业相关人物，农业明星的介绍，促进农业进展推广。张范村的文章《日生两卵之养鸡术》及陶平的文章《人造丝之制造法及工厂组织法》等，**介绍生两卵的养鸡方法、人造丝的制造方法、防范病虫害的方法、养猪的方法、学校造林法等诸多方法，对于推广先进的科技方法，提高农业生产效率，促进农业发展提供渠道和方法，方便读者掌握了解先进的技术方法。**另外，文章《公牍：实业厅令一（七月三十日）：令改缮修改会章三份送厅核转备案文》、《公牍：本会呈文三（七月十五日）：遵农商部令填报本会调查表文》等公牍性文章，**刊载报道江西省农会简章、农会对省长的呈请、农业部的调查表等内容，对于读者了解当时政令**

情况及当时农业相关的状况开启一扇窗口。该刊对于记述介绍当时先进的农业相关生产方法、章程、命令等起到一定促进作用，为今天研究江西一地农业发展状况、政府对农业的参与等提供一定研究资料。

– Translated Summary: The Jiangxi Provincial Agricultural Association Bulletin was founded in March 1920 in Nanchang, Jiangxi, and was collected through its third issue in March 1921. The library holds two issues: the second issue from 1920 and the third issue from 1921. **It was edited by the Editorial Office of the Jiangxi Provincial Agricultural Association and issued by the Jiangxi Provincial Agricultural Association. Published semiannually, it was an agriculture-related periodical. Its main contributors included Zhang Fancun, Le Hongxun, Tao Ping, Xu Nianzu, Wu Xinxiu, Wu Kai, and others. Its main columns included official documents, surveys, and chronicles.** The journal took as its mission **"to assist agricultural administrative agencies in pursuing agricultural improvement and development." Its main contents included agricultural experiments in Jiangxi, adjustments in agricultural and forestry products, prevention and control of damage to forest trees, biographies of agricultural figures, Chinese and foreign agricultural news, official correspondence from various localities, and relevant administrative orders.**

In the "Chronicles" section, it published articles such as "Chronicles: Domestic News: The Establishment of the Haizhou Fishery Technology Training Institute" and "Chronicles: Provincial News: The Sudden Rise in Tobacco Market Prices." **These articles reported important domestic and foreign news related to fisheries, tobacco, cotton, sericulture in Korea, and other agricultural sectors both within Jiangxi and elsewhere. By reporting achievements and progress across different regions and sectors, the journal helped readers understand agricultural conditions and techniques in China and abroad, and played a positive role in promoting agricultural**

development in Jiangxi.

The journal assisted agricultural administrative agencies and aimed to promote agricultural improvement and development. It published materials on agricultural experiments in Jiangxi, adjustments in agricultural and forestry products, prevention and control of forest-tree damage, biographies of agricultural figures, Chinese and foreign agricultural news, local official correspondence, and relevant administrative orders. It also published articles such as Yang Shijing's "Biographies of Farmers: Continued from the Second Issue of the Jiangxi Provincial Agricultural Association Bulletin," which **introduced figures related to agriculture and highlighted outstanding agricultural practitioners, thereby helping to promote agricultural progress.** Articles such as Zhang Fancun's "A Method for Raising Hens That Lay Two Eggs a Day" and Tao Ping's "The Manufacturing Method and Factory Organization of Artificial Silk" **introduced a wide range of practical methods, including techniques for raising hens that lay two eggs a day, manufacturing artificial silk, preventing and controlling pests and diseases, raising pigs, and establishing school forests. These articles provided channels and methods for disseminating advanced scientific and technological techniques, improving agricultural productivity, and promoting agricultural development, while also helping readers learn about and master advanced technical methods.**

In addition, official-document articles such as "Official Documents: Order No. 1 from the Department of Industry, July 30: Ordering the Revised Association Regulations in Triplicate to Be Submitted to the Department for Review and Filing" and "Official Documents: Petition No. 3 from the Association, July 15: Submitting the Association Survey Form in Compliance with the Order of the Ministry of Agriculture and Commerce" **reported materials such as the regulations of the Jiangxi Provincial Agricultural Association, the Association's**

petitions to the provincial governor, and survey forms from the Ministry of Agriculture. These materials opened a window for readers to understand the administrative orders and agricultural conditions of the time.

Overall, the journal played a positive role in recording and introducing advanced agricultural production methods, regulations, and administrative orders of the period. It also provides valuable research materials today for studying agricultural development in Jiangxi and the government's involvement in agriculture.

- **安徽实业杂志** (*The Anhui Industrial Magazine*)
  - Start Year: 1913
  - Location: 安庆(Anqing), 安徽（Anhui)
  - Category: Natural Sciences & Social Sciences
  - Knowledge orientation: Innovation dominant
  - Summary: 1913年1月创刊，停刊于1917年5月第7期；续刊于1917年5月第1期，改由安徽实业杂志编辑所编辑，出版至1920年2月第32期；第1卷第1期出版至1920年7月，停刊于1925年10月第6卷第3期；第1期出版于1926年1月，停刊于1926年11月第11期。**由安徽实业司署在安徽安庆编辑并发行**。月刊。地方实业刊物。**以学习实业新知、探究利弊，注重改良，发展殖产业为宗旨。主要刊登本省有关实业学理的探讨、各地发明创造与调查报告。**分图画、论说、公文、法规、统计、专件、译丛、白话、纪事与丛录十二项。栏目有**画图、论著、法令、公牍、学术、调查报告、记闻、译林、杂纂、专件、统计等。撰稿人有谢琨、程艺山、汪志泉、徐思齐、史浩然、程振钧等。** 刊载文章如《整顿安徽茶务议案》、《公商务咨官价采买禁革陋规酌留改归商界公用体察情形酌核办理文》、《安徽交通调查表》（宣称至广德路线）、《中国产棉考》、《实报出版披露》、《东流县历年水害大略情形》、《科学的选择工人法》、《参观朝鲜皮革工场实习笔记》等。
  - Translated Summary: Founded in January 1913, the journal ceased publication with Issue 7 in May 1917. It resumed publication in May 1917 with Issue 1,

under the editorship of the Editorial Office of Anhui Industrial Magazine, and continued until Issue 32 in February 1920. Volume 1, Issue 1 was published through July 1920, and the journal ceased publication with Volume 6, Issue 3 in October 1925. Another Issue 1 appeared in January 1926, and publication ended with Issue 11 in November 1926. **It was edited and published by the Anhui Industrial Administration Office in Anqing, Anhui**. It was a monthly local industrial journal. **Its mission was to promote the study of new industrial knowledge, investigate advantages and disadvantages, emphasize improvement, and develop productive industries. It mainly published discussions of industrial theories related to Anhui Province, inventions and innovations from various places, and survey reports.** The journal was divided into twelve sections: illustrations, essays, official documents, regulations, statistics, special reports, translations, vernacular writings, records of events, and collected notes. **Its columns included illustrations, essays, laws and decrees, official correspondence, scholarship, survey reports, news and records, translations, miscellaneous writings, special reports, and statistics. Contributors included Xie Kun, Cheng Yishan, Wang Zhiquan, Xu Siqi, Shi Haoran, Cheng Zhenjun, and others.** Articles published in the journal included "Proposal for Rectifying Anhui Tea Affairs," "Official Communication from the Public and Commercial Affairs Department on Investigating and Handling the Purchase of Goods at Official Prices, Abolishing Malpractices, and Reserving Funds for Public Use by the Commercial Sector," "Anhui Transportation Survey Table" (covering the route from Xuancheng to Guangde), "A Study of Cotton Production in China," "Disclosure on the Publication of Shibao," "General Conditions of Flood Damage in Dongliu County over the Years," "Scientific Methods for Selecting Workers," and "Practical Notes from a Visit to Leather Factories in Korea."

- **科学通俗谈** (*Popular Science Talks*)

- Start Year: 1920
- Location: 福州(Fuzhou), 福建(Fujian)
- Category: Natural Sciences & Social Sciences
- Knowledge orientation: Diffusion dominated
- Summary: 1920年2月创刊于福建省福州市，半月刊，每月的五日、二十四日固定刊行一号。**由科学通俗谈杂志社负责编辑出版发行，社址位于福州市北门正一行宫十二号寿白医院内**，属于科普类刊物，具体停刊原因以及时间不详，目前馆藏仅存1920年第一期。**该刊物以引起一般人的知识到科学的轨道上去为主要的创刊宗旨，其特点在于用浅显易懂、接近于白话的语言，为民众阐释生活中各种现象和日常事务的科学原理。创刊之时，国民的思想已经开始出现了变化，尤其在思想界，科学常识引起了更多人的关注，而福州当地却并没有这项刊物的出现以满足当地民众日益增长的文化需求，因而这一刊物就此诞生。**因此，**该刊物在内容上主要刊登飞机、军械乃至口腔卫生等各方面科学小知识及一些日常事物的科学原理等。**该刊物中所刊载的文章并没有进行明显的栏目划分，就其刊载的文章内容上来看可将其分为几个部分。**其一，生活小常识类。这部分中刊载了大量关于日常生活的常识介绍，对于人们日常生活中遇到的稀松寻常的现象都用通俗易懂的语言将其中蕴含的科学原理进行阐释。代表文章有《试金子的真假》、《火柴》；其二，则是对科学通俗化这一话题的讨论，通过多篇载文的发表，进一步强调额本刊的最初理念，即用最通俗的方式，让更多的普通民众了解和学习科学知识，以提高国民文化修养和水平。代表载文有《为什么作科学通俗谈》、《我对于科学通俗的感想》等。**该刊物根据生活中最常见的现象进行最真实科学真理的阐述，**并涉及到物理、化学、生物等多种学科知识**，对于提升民众科学素养有很大帮助，而对于我们研究民国时期思想界的思想变动等方面提供了不少研究素材和研究资料。
- Translated Summary: Founded in February 1920 in Fuzhou, Fujian Province, the journal was a semimonthly publication, issued regularly on the 5th and 24th of each month. It was edited, published, and **distributed by the Magazine**

Office of Popular Talks on Science, located inside Shoubai Hospital, No. 12 Zhengyi Xinggong, North Gate, Fuzhou. It was a popular science periodical. The specific reason and date of its discontinuation are unknown; only the first issue from 1920 is currently preserved in library holdings.

The journal's main founding purpose was to guide general knowledge onto the path of science. Its distinguishing feature lay in its use of plain, accessible, and nearly vernacular language to explain to the public the scientific principles behind various phenomena and everyday matters. At the time of its founding, changes had already begun to appear in national thought. In intellectual circles in particular, scientific knowledge was attracting increasing attention, yet no such periodical had appeared locally in Fuzhou to meet the growing cultural needs of the local population. It was against this background that the journal was created. Accordingly, the journal mainly published **short pieces of scientific knowledge** on topics such as airplanes, military equipment, oral hygiene, and **the scientific principles underlying everyday objects and phenomena**.

The articles published in the journal were not clearly divided into fixed columns. Based on their content, however, they may be grouped into several categories. **The first category consisted of practical knowledge related to everyday life.** This section included many introductions to common knowledge about daily life, explaining the scientific principles behind ordinary phenomena in clear and accessible language. Representative articles include **"Testing Whether Gold Is Genuine"** and **"Matches." The second category consisted of discussions of the popularization of science.** Through the publication of multiple articles on this topic, the journal further emphasized its original ideal: **to enable more ordinary people to understand and learn scientific knowledge in the most accessible way possible, thereby improving the cultural cultivation and level of the nation.** Representative articles include "Why We Write

Popular Talks on Science" and "My Thoughts on the Popularization of Science." By explaining the most authentic scientific truths behind the most common phenomena in everyday life, the journal covered knowledge from multiple disciplines, including physics, chemistry, and biology. It was highly useful for improving the public's scientific literacy, and it also provides valuable research materials for studying changes in intellectual thought during the Republican period.

- **毛革杂志** (*The Journal of Leather and Fur*)
  - Start Year: 1920
  - Location: Beijing
  - Category: Natural Sciences
  - Knowledge orientation: Innovation & Diffusion
  - Summary: 皮革工业刊物。本刊主要介绍畜牧常识、牲畜品种改良、防病、制革工艺，报道世界各地畜牧及毛纺织业概况、商情等。主要内容分论著、调查、译述、杂录、纪事等栏目。载文有"改良羊种说略"、"商品学上之羊毛及羊毛鉴定法"、"皮革制造法"等。
  - Translated Summary: It was a leather industry periodical. The journal mainly introduced general knowledge of animal husbandry, livestock breed improvement, disease prevention, and leather-making techniques, while also reporting on the general conditions and market information of animal husbandry and the wool textile industry around the world. Its main contents were divided into columns such as essays and studies, investigations, translations and summaries, miscellaneous records, and chronicles. Articles published in the journal included "A Brief Discussion of Improving Sheep Breeds," "Wool and Methods of Wool Appraisal in Commodity Studies," and "Methods of Leather Manufacturing."

B Comparing Variants

We collect three dictionaries compiled by the Jiangnan Arsenal, covering chemistry, medicine, and engineering. Together, these dictionaries contain more than $14,000$ words and phrases. They are remarkably comprehensive, including even highly specialized and infrequently used phrases, such as "Admiralty rules for horse power." This breadth reflects the substantial effort that the Jiangnan Arsenal devoted to translation. However, such highly specific phrases are less informative for understanding the broader development of scientific terminology. In this section, we therefore focus on single words in these dictionaries to provide a clearer picture of how Chinese scientific terminology evolved.

In total, there are 3,063 single-word terms: 1,196 from chemistry, 462 from engineering, and 1,405 from medicine. Table A1 compares the terminology used in the Jiangnan Arsenal dictionaries with that of contemporary Chinese. The second row shows that fewer than 10% of the terms in the Jiangnan dictionaries remain in use in contemporary Chinese.

The comparison also reveals two important patterns. First, terms in the Jiangnan dictionaries were much more likely to be transliterated (i.e., translated phonetically), whereas transliteration is considerably less common in contemporary Chinese scientific terminology. Second, terms in the Jiangnan dictionaries were, on average, longer in terms of the number of Chinese characters than their contemporary counterparts. These changes reflect both the adoption of Japanese terminology and the creation and refinement of terminology by Chinese scholars during the early Republican period.

Semantic translation and conciseness are generally regarded as two desirable features of scientific translation, although a systematic judgment of translation quality between the Jiangnan dictionaries and contemporary Chinese is beyond the scope of this paper. Importantly, translation quality is unlikely to confound our empirical analysis, because our identification relies on comparisons across prefectures and all specifications control for term fixed effects. Nevertheless, this comparison suggests that the evolution of Chinese scientific terminology led, at least from a linguistic perspective, toward more concise and semantically transparent forms.

Table A1: Scientific Terms in Jiangnan Arsenal Dictionaries

Statistic	Chemistry	Engineer	Medical
Number	1196	462	1405
Jiangnan Same as Contemporary Chinese	0.054	0.087	0.062
Jiangnan Share Transliterated	0.975	0.857	0.976
Jiangnan Average Length	5.027	3.253	5.283
Contemporary Chinese Share Transliterated	0.457	0.340	0.377
Contemporary Chinese Average Length	2.757	2.156	2.731

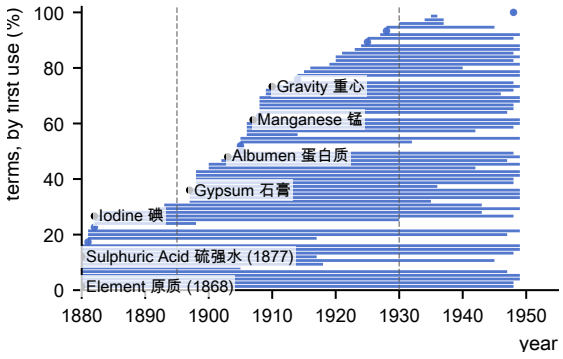
Table A2 uses simple regressions to examine which characteristics of Jiangnan Arsenal terminology are associated with its survival in contemporary Chinese. The results show that shorter translations are more likely to remain in use, whereas transliterated terms are less likely to survive. Figure A1 further presents the usage spans of selected scientific terms, revealing a clear pattern in which terminology from the Jiangnan Arsenal dictionaries was gradually replaced by Japanese terms or newly coined Chinese terminology.

Table A2: Jiangnan Arsenal Terminology in Contemporary Chinese

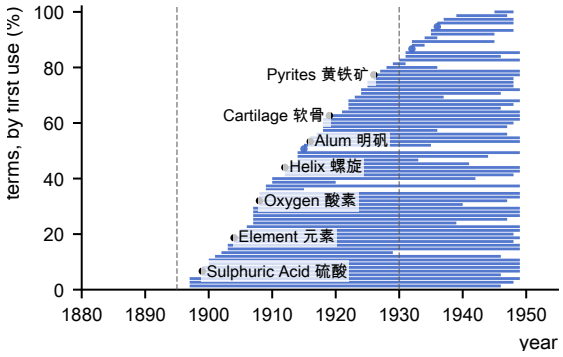
Dependent Variable:	$\mathbf{1}_{Jiangnan=Contemporary}$	
Model:	(1)	(2)
	Probit	OLS
Variables		
log(Jiangnan_Length)	-0.075***	-0.169***
	(0.004)	(0.007)
Jiangnan_Transliteration	-0.069***	-0.186***
	(0.018)	(0.020)
Fit statistics		
Observations	3,063	3,063
Squared Correlation	0.285	0.229
Pseudo R^2	0.433	74.740
BIC	837.82	-763.72

IID standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

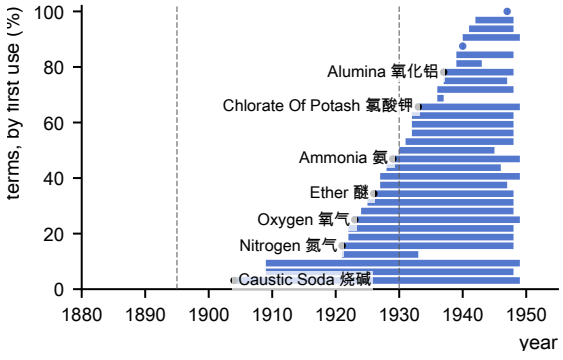
Figure A1: Usage Spans of Scientific Terms in Chinese Journals, by Translation Origin



(a) Jiangnan (traditional Chinese) variants ($n = 75$)



(b) Japanese variants ($n = 75$)



(c) Contemporary Chinese variants ($n = 32$)

Notes: Each panel plots, for one translation origin, the span from the first to the last appearance of each scientific-term variant in Chinese journals. Terms are ordered by year of first use. A selection of frequently used terms is labelled with the English term and its Chinese variant; the black dot marks the first appearance, and for terms first appearing before 1880 the true first year is given in parentheses. Dashed vertical lines mark 1895 and 1930.

C Foreign Trade Exposure

One limitation of the foreign trade data, however, is that they do not record how imports were distributed from treaty ports to individual prefectures.[11] To construct a prefecture-level measure, we therefore distribute trade exposure across prefectures according to geographic distance.

Specifically, we construct prefecture-level exposure to foreign trade using a distance-weighted average of imports through treaty ports. For each prefecture i and treaty port p, we calculate the great-circle distance d_{ip} using their geographic coordinates. We then assign each port an inverse-distance weight,

$$\widetilde{w}_{ip} = \frac{1}{\log(d_{ip})},$$

and normalize these weights across all treaty ports:

$$w_{ip} = \frac{\widetilde{w}_{ip}}{\sum_{p'} \widetilde{w}_{ip'}}.$$

Prefecture i's exposure to foreign trade in year t is then defined as

$$\text{ImportExposure}_{it} = \sum_{p} w_{ip} \text{Imports}_{pt},$$

where Imports_{pt} denotes the total value of imports through treaty port p in year t.

The resulting measure does not necessarily coincide with the actual value of imports received by each prefecture. Nevertheless, in a large country with relatively underdeveloped modern transportation infrastructure, as was the case in early twentieth-century China, geographic distance was likely a major component of the trade costs governing the inland distribution of imported goods. Moreover, relying on geographic distance helps mitigate concerns that the trade activity may itself be endogenous to local economic development.

[11] The *Inland Transit* section records trade flows between treaty ports and (interior) provinces, but these data are not available at the prefecture level.

D Wuxu Societies

The baseline estimates capture the average effect of Japanese FDI across prefectures. In this section, we examine whether the effects of Japanese FDI depended on the presence of pre-existing local scientific communities, measured by the number of "Wuxu societies" (戊戌学会) founded during the Wuxu Reform movement of the late 1890s. These societies were established by reform-minded intellectuals seeking to promote reform, disseminate Western learning, and expand access to modern knowledge. Most were founded before 1900 and were short-lived. For example, the Qiang Xue Hui (强学会) lasted only three to four months, while the Bao Guo Hui (保国会) lasted only two months. Thus, this measure is better interpreted as capturing pre-existing local interest in scientific and academic pursuits rather than organized academic activities or publication output during our sample period.

We digitize a list of 71 Wuxu societies founded between 1895 and 1898 from Fan (2011). We record each society's name, location, and founding date.

We then add an interaction between FDI exposure and the Wuxu societies to Equation (1)

$$\log(\#Journal_{i,t}) = \beta_1 \log(FDI_{i,t-1}) + \beta_2 \log(FDI_{i,t-1}) \times Society_i + \gamma_i + \gamma_t + \epsilon_{i,t} \qquad (1)$$

where $Society_i$ is either the log number of societies founded in prefecture $i+1$ or an indicator for having at least one society. The Wuxu society measure is time-invariant, so its own effect is absorbed by the prefecture fixed effects.

Table A3 presents the results. Column (1) repeats the baseline estimate from Column (1) of Table 2. Column (2) adds the interaction with the log society count. The interaction term is 0.209, with high precision. Note that, in prefectures without a society, the elasticity of journal entry with regard to Japanese FDI is 0.0424. Column (3) and (4) show a similar pattern. Thus, the effect of Japanese FDI on journal entry was stronger in prefectures that already had greater interest in Western science.

This is consistent with our interpretation that FDI lowered the access costs of foreign knowledge. If a community of interested readers was already in place, lower access costs translated into journal activity. If such a community did not exist, then the lowered access

costs generated little response.

Table A3: Journal Entry: Japanese FDI Interacted with Pre-1898 Wuxu Societies

Dependent Variable:	log(Entry)			
Model:	(1)	(2)	(3)	(4)
Variables				
$\log(FDI^0)$	0.102***	0.042*	0.046*	0.068***
	(0.035)	(0.024)	(0.024)	(0.025)
$\log(FDI^0) \times \log(Societies)$		0.209***		0.178***
		(0.021)		(0.021)
$\log(FDI^0) \times \mathbf{1}^{Society}$			0.357***	
			(0.071)	
Fixed-effects				
Prefecture	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	
Province × Year				Yes
Fit statistics				
Observations	4,718	4,718	4,718	4,718
R^2	0.741	0.755	0.751	0.788
Within R^2	0.022	0.074	0.062	0.073

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: *Societies* is the number of Wuxu societies founded in the prefecture between 1895 and 1898, and $\mathbf{1}^{Society}$ indicates a prefecture with at least one such society. Both measures are time-invariant, so their main effects are absorbed by the prefecture fixed effects. FDI^0 is the one-year-lagged number of Japanese firms located within the prefecture. Standard errors are clustered at the prefecture level.

E Model

We close with a simple model of knowledge accumulation that rationalizes our empirical findings. Normalize the foreign knowledge frontier to 1 and let $S_t \in [0,1]$ denote the local knowledge stock.[12] Each period, the prefecture chooses how much new knowledge to accumulate:

$$\Delta S = S_{t+1} - S_t. \tag{2}$$

Let F_t denote the amount of FDI in the prefecture.

Throughout, we speak of "the prefecture" choosing how much knowledge to accumulate. This is shorthand for a decentralized process, because in our data the people who produce codified knowledge, the translators, editors, and journal authors, are not the entrepreneurs who later establish factories. We therefore interpret the decision problem below as the equilibrium of a local market for codified knowledge. Publishers and translators supply codified knowledge, and their production cost falls when foreign firms are present, whose personnel, terminology, and manuals they can draw on. Entrepreneurs, technicians, and students demand codified knowledge, and their willingness to pay reflects its value in local production. The two sides are linked by the returns that flow back to knowledge producers: sales and subscription revenue, future employment as advisors or engineers in the very firms their translations make possible, and the reputation that accrues to the first person to introduce a technology to the locality. The downstream benefit of knowledge is thus baked into the writer's payoff, even though the writer never operates a factory himself.[13] Under this reading, the first-order condition below is a market-clearing condition: codified knowledge accumulation proceeds until the marginal value of new knowledge to its users equals the marginal cost of producing it.

The benefit of new knowledge depends on the existing local stock: acquiring ΔS yields a

[12] We drop the prefecture subscript i because prefectures make their decisions independently of one another.

[13] If knowledge producers appropriate only a share $\lambda \in (0,1]$ of the downstream value — because printed knowledge circulates beyond paying subscribers — the first-order condition below becomes $\lambda\, b(S_t) = \frac{c(F_t)}{1-S_t}\Delta S$. Codified knowledge is then inefficiently low, but every comparative static in this section is unchanged; we therefore set $\lambda = 1$.

payoff $b(S_t)\,\Delta S$, where $b(S_t) > 0$ and $b'(S_t) > 0$. That is, an additional unit of knowledge is more valuable where the existing stock is already large, because pieces of technical knowledge are complements: a single term or technique is productive only in combination with the related knowledge required to apply it. This assumption is motivated directly by our findings in Section 4.3, where domestic firm entry responds to knowledge accumulation only after a sufficiently large share of a product's technical vocabulary has been absorbed.

Learning is costly. Acquiring ΔS costs

$$\frac{c(F_t)}{2(1-S_t)}\,(\Delta S)^2, \qquad c(F_t) > 0,\ c'(F_t) < 0. \tag{3}$$

This cost function has three features. First, $c'(F_t) < 0$: the more FDI a prefecture receives, the cheaper it is to learn, because foreign firms bring the personnel, terminology, and demonstrations through which frontier knowledge can be absorbed. Second, the cost is scaled by $1/(1-S_t)$: the farther a prefecture is from the frontier, the more unlearned knowledge remains, and the cheaper it is to pick up an additional unit — a standard catch-up force. Third, the cost is quadratic in ΔS, so the marginal cost of learning rises with how much the prefecture attempts to absorb within a single period.

The prefecture solves

$$\max_{\Delta S}\ \ b(S_t)\,\Delta S\ -\ \frac{c(F_t)}{2(1-S_t)}\,(\Delta S)^2. \tag{4}$$

The choice set is $\Delta S \in [0,\, 1-S_t]$: the prefecture cannot unlearn, and the stock cannot exceed the frontier. To ensure the upper constraint does not bind, we impose $b(1) \le c(\bar{F})$, where $\bar{F}$ is the highest FDI level a prefecture could achieve.

The objective is strictly concave in ΔS, so the first-order condition characterizes the optimum:

$$b(S_t)\ =\ \frac{c(F_t)}{1-S_t}\,\Delta S.$$

Rearranging,

$$\Delta S^*\ =\ \frac{b(S_t)}{c(F_t)}\,(1-S_t). \tag{5}$$

Discussion. Equation (5) delivers our baseline result. Holding the local knowledge stock constant, an increase in F_t lowers $c(F_t)$ and therefore raises ΔS^*: prefectures that receive more FDI accumulate knowledge faster, which corresponds to our baseline estimates in Section 4.1.

The effect of the existing knowledge stock, by contrast, is ambiguous. Differentiating Equation (5) with respect to S_t,

$$\frac{\partial \Delta S^*}{\partial S_t} \;=\; \frac{b'(S_t)\,(1 - S_t) \;-\; b(S_t)}{c(F_t)}, \tag{6}$$

which can take either sign. Two forces pull in opposite directions. The first term reflects complementarity: because $b'(S_t) > 0$, a larger stock raises the return to learning, pushing accumulation up. The second term reflects the shrinking gap: as S_t approaches the frontier, little unlearned knowledge remains and the marginal cost of learning rises, pushing accumulation down. Knowledge accumulation therefore need not accelerate as the stock grows; whether it does depends on which force dominates.[14]

E.1 Extension 1: The Effect of Language Proximity

Suppose now that there are two types of FDI, Japanese and German, denoted F_t^J and F_t^G, and let ΔS^J and ΔS^G denote the knowledge acquired through each channel, with $\Delta S = \Delta S^J + \Delta S^G$. Linguistic and cultural proximity makes learning through the Japanese channel cheaper: because Japanese technical vocabulary shares Chinese characters, absorbing knowledge from a Japanese firm requires less translation effort than absorbing it from a German one. We capture this by assuming

$$c^G(F) \;=\; \theta\, c^J(F), \qquad \theta > 1, \tag{7}$$

where θ measures language distance: at any level of FDI, learning through the German channel is θ times as costly.

[14]Note also that $\Delta S^* \to 0$ as $S_t \to 1$, so the knowledge stock never overshoots the frontier. Throughout we assume $b(S_t) \le c(F_t)$, which guarantees the interior solution satisfies $S_{t+1} \le 1$.

The optimization problem becomes

$$\max_{\Delta S^J,\, \Delta S^G} \; b(S_t)\left(\Delta S^J + \Delta S^G\right) \; - \; \frac{c^J(F_t^J)}{2(1-S_t)}\,(\Delta S^J)^2 \; - \; \frac{c^G(F_t^G)}{2(1-S_t)}\,(\Delta S^G)^2. \tag{8}$$

The two first-order conditions are separable and yield

$$\Delta S^{J*} \;=\; \frac{b(S_t)}{c^J(F_t^J)}\,(1-S_t), \qquad \Delta S^{G*} \;=\; \frac{b(S_t)}{\theta\, c^J(F_t^G)}\,(1-S_t). \tag{9}$$

Two predictions follow. First, both types of FDI raise knowledge accumulation: ΔS^{G*} is increasing in F_t^G just as ΔS^{J*} is increasing in F_t^J. Second, the Japanese channel is systematically stronger. At equal levels of FDI ($F_t^J = F_t^G = F$), Equation (9) implies

$$\Delta S^{G*} \;=\; \frac{1}{\theta}\,\Delta S^{J*}, \qquad \frac{\partial \Delta S^{G*}}{\partial F_t^G} \;=\; \frac{1}{\theta}\,\frac{\partial \Delta S^{J*}}{\partial F_t^J}\;:$$

both the level and the marginal effect of German FDI are a fraction $1/\theta$ of their Japanese counterparts. This matches our empirical comparison of the two source countries: German FDI enters with a positive coefficient, but its effect is smaller than that of Japanese FDI and statistically indistinguishable from zero in most specifications.

E.2 Extension 2: Trade vs. FDI

Now consider foreign trade, and let T_t denote the prefecture's trade exposure. Trade resembles FDI on the cost side but differs sharply on the benefit side.

On the cost side, trade lowers the cost of learning: imported goods can be observed, purchased, and taken apart, and exposure to foreign products reveals what there is to learn. Trade also complements FDI in reducing learning costs: once local actors have seen the foreign products, the engineers and managers brought by foreign firms have concrete knowledge to transmit. On the benefit side, however — and unlike FDI — trade erodes the return to local knowledge: imported goods compete with local production, so when foreign products are readily available, the value of mastering the knowledge needed to produce them locally falls. Formally, we write the benefit as $b(S_t, T_t)$ and the cost as $c(F_t, T_t)$, with

$$b_T < 0, \qquad c_F < 0, \qquad c_T < 0, \qquad c_{FT} < 0,$$

where subscripts denote partial derivatives and $c_{FT} < 0$ captures the complementarity between the two channels.

The optimal accumulation takes the same form as before,

$$\Delta S^* \;=\; \frac{b(S_t, T_t)}{c(F_t, T_t)}\,(1 - S_t), \tag{10}$$

and yields three predictions.

1. **FDI unambiguously raises knowledge accumulation:**

$$\frac{\partial \Delta S^*}{\partial F_t} \;=\; -\,\frac{b\,c_F}{c^2}\,(1 - S_t) \;>\; 0.$$

FDI lowers the cost of learning without affecting the benefit, so its effect is positive without qualification.

2. **The effect of trade alone is ambiguous, and negative when market competition dominates:**

$$\frac{\partial \Delta S^*}{\partial T_t} \;=\; \frac{b_T\,c - b\,c_T}{c^2}\,(1 - S_t) \;<\; 0 \quad \text{if and only if} \quad \frac{|b_T|}{b} \;>\; \frac{|c_T|}{c}.$$

Trade cuts both the cost and the benefit of learning, so its net effect depends on which proportional change is larger. Our estimates indicate that trade alone had, if anything, a negative effect on knowledge diffusion, implying that the market-competition effect outweighed the observational learning that trade provides. This is the key contrast with FDI: what distinguishes the two channels is not that trade carries no knowledge, but that it simultaneously erodes the incentive to learn.

3. **Trade and FDI are complements:**

$$\frac{\partial^2 \Delta S^*}{\partial F_t\,\partial T_t} \;=\; -\,\frac{1 - S_t}{c^2}\left(b_T\,c_F + b\,c_{FT} - \frac{2\,b\,c_F\,c_T}{c}\right) \;>\; 0 \quad \text{if and only if} \quad \frac{|c_{FT}|}{|c_F|} + \frac{2\,|c_T|}{c} \;>\; \frac{|b_T|}{b}.$$

Two forces push the interaction positive. The first is the direct complementarity $c_{FT} < 0$: trade exposure gives FDI's personnel concrete knowledge to transmit. The second is a level effect: by lowering the cost level c, trade amplifies the marginal impact of FDI's cost reduction. The interaction is positive whenever these cost-side effects, measured in proportional terms, outweigh trade's erosion of the benefit.

Taken together, the empirical pattern in Section 4.1 — FDI positive, trade alone negative, and their interaction positive — obtains precisely when

$$\frac{|c_T|}{c} \;<\; \frac{|b_T|}{b} \;<\; \frac{|c_{FT}|}{|c_F|} + \frac{2\,|c_T|}{c},$$

that is, when trade erodes the benefit of local knowledge faster than it directly reduces the cost of learning, but its complementarity with FDI is strong enough to make the two channels reinforce each other. In our interpretation, foreign trade mainly increased awareness of foreign products and the gap to the technological frontier, while FDI reduced the cost of acquiring and applying the relevant knowledge; only where the two coincided did trade contribute to knowledge diffusion.

F Additional Regression Results

Dropped_Province	Coefficient	SE	t_stat	p_value
Anhui	0.10	0.04	2.93	0.00
Fengtian	0.14	0.04	3.22	0.00
Fujian	0.10	0.04	2.93	0.00
Gansu	0.10	0.03	2.93	0.00
Guangdong	0.09	0.03	2.61	0.01
Guangxi	0.10	0.03	2.97	0.00
Guizhou	0.10	0.03	2.93	0.00
Heilongjiang	0.11	0.04	2.94	0.00
Henan	0.10	0.03	2.95	0.00
Hubei	0.10	0.04	2.75	0.01
Hunan	0.10	0.03	2.82	0.01
Jiangsu	0.09	0.03	2.73	0.01
Jiangxi	0.10	0.04	2.93	0.00
Jilin	0.13	0.04	3.46	0.00
Shandong	0.11	0.04	2.65	0.01
Shanxi	0.10	0.03	2.91	0.00
Shensi	0.10	0.03	2.95	0.00
Sichuan	0.10	0.03	2.92	0.00
Yunnan	0.10	0.03	2.84	0.00
Zhejiang	0.10	0.03	3.02	0.00
Zhili	0.07	0.03	2.65	0.01

Table A4: Leave-One-Province-Out: Japanese FDI on Journal Entry

Notes: Each row reports the coefficient on $\log(\text{FDI}^0)$ from a separate estimation of the baseline specification in Equation (1), corresponding to Column (1) of Table 2, after excluding all prefectures in the indicated province. The dependent variable is the log number of new journals established in a prefecture-year, and FDI^0 is the one-year-lagged number of Japanese firms located within the prefecture. All regressions include prefecture and year fixed effects. Standard errors are clustered at the prefecture level. For comparison, the full-sample estimate is 0.102 (Table 2, Column (1)).

Table A5: The Effects of Japanese FDI on Journal Entry by Region

Dependent Variable:	log(Entry)					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
	North	Central	South	North	Central	South
Variables						
log(FDI^0)	0.062*	0.201***	0.335***			
	(0.036)	(0.067)	(0.068)			
log(Manufacturing^0)				0.108**	0.623***	0.562***
				(0.048)	(0.124)	(0.199)
Fixed-effects						
Prefecture	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	2,072	1,498	1,148	2,072	1,498	1,148
R^2	0.689	0.791	0.676	0.690	0.804	0.674
Within R^2	0.019	0.034	0.097	0.020	0.098	0.091

Clustered (Prefecture) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A6: Comparing Japanese and German Product-Specific FDI on Product-specific Knowledge

Dependent Variable:	$\mathbf{1}^{Term}$			
Model:	(1)	(2)	(3)	(4)
	Logit	Logit	OLS	OLS
Variables				
log(Term_Japanese_FDI)	0.011***	0.011**	0.026**	0.025**
	(0.004)	(0.004)	(0.012)	(0.011)
log(Term_German_FDI)		0.004		0.046
		(0.008)		(0.029)
Fixed-effects				
Province × Year	Yes	Yes	Yes	Yes
Term	Yes	Yes	Yes	Yes
Fit statistics				
Observations	31,000	31,000	31,000	31,000
Squared Correlation	0.317	0.317	0.135	0.136
Pseudo R^2	0.522	0.522	-0.097	-0.098
BIC	4,701.2	4,710.7	-48,418.7	-48,451.7

Clustered (Prefecture & Term) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*