# FDI Spillovers in History: Interwar Japanese "Zaikabo" investment in China's cotton spinning industry


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**Abstract**

We estimate productivity spillovers from Japanese cotton-spinning firms in China (known as Zaikabo) to local Chinese cotton-spinning mills based on plant-level data for 1925 to 1938. In order to capture the important role of distance in facilitating such spillovers we geo-localised the plants. Our results provide clear evidence for positive spillovers from Zaikabo to local Chinese mills, which go hand-in-hand with an upgrade in production technology towards greater use of capital. Spillovers are very localised, being strongest within a radius of up to 10 km around the Zaikabo and particularly strong for mills in Shanghai. Exploiting information on the workforce composition of the Japanese affiliates, we find suggestive evidence of a skilled-labour channel: spillovers tend to be larger from Zaikabo employing higher shares of skilled labour. We also find some evidence in line with the idea that these gains are larger for Chinese mills with higher initial productivity, consistent with a role for absorptive capacity. Our paper is the first to document FDI productivity spillovers in a historical context and to characterise the channels through which they operate.



**JEL Codes**: F23, N65

**Keywords**: FDI spillovers, Zaikabo, cotton mills, China

## 1 Introduction

Attracting foreign direct investment (FDI) is frequently seen as an important means to foster overall economic development or the growth of particular industries in host countries. This is reflected in policies trying to boost inward investment (UNCTAD, 2018). Despite extensive research in the last decades on potential positive spillover effects from multinationals,[1] the jury is still out on whether such effects exist, and what the exact mechanisms are. A convincing search for such impacts is complicated by the complexity of modern-day industry. Different industries use different technologies, and organise their production chains in various ways. Looking across several industries (which most empirical studies of spillovers do) therefore makes it challenging to tease out what the exact mechanisms are through which spillovers from FDI may happen. In this paper we re-examine the existence of productivity spillovers from horizontal FDI for the historic setting of Japanese cotton spinning companies' affiliates in China – which are commonly referred to as Zaikabo - in the interwar period.

We follow the well-established literature in modern contexts that tries to identify empirically "productivity spillovers" from foreign to domestic firms (e.g., Jiang et al., 2024; Lu et al., 2017; Girma et al., 2015 look specifically at China). In our setting we look at spillovers from the more advanced Japanese affiliates to local Chinese cotton spinning mills. To this end we geo-localized and digitized information on all Japanese cotton spinning companies' affiliates in China (including Manchuria) as well as other local Chinese firms during the period 1925 to 1938. Importantly, apart from output and employment, the data contains detailed information on the quantity and type of capital stock employed, allowing us to proxy the nature of technology utilized by the Japanese Zaikabo. Moreover, we observe measures of worker skills in Japanese affiliates and initial productivity of local Chinese mills, which enable us to look at potential mechanisms and the role of absorptive capacity.

Being able to pinpoint the exact location of both the Japanese Zaikabo and their Chinese counterparts importantly allows us to capture the role of distance in facilitating any productivity spillovers. This represents an important novelty of our study, as the role of distance is generally neglected even in modern spillover studies on FDI. Rather, the focus of the spillover literature has been primarily on spillovers within an industry, or across vertically

[1] Recent examples are Jiang et al. (2024), Abebe et al. (2022), and Fons-Rosen et al. (2018), with earlier work including Aitken and Harrison (1999), Girma et al. (2001) and Görg and Strobl (2002). Görg and Strobl (2001) and Keller (2021) provide extensive surveys.

connected industries, with a few studies also considering spillovers within geographic units – usually defined as fairly large administrative regions (e.g., Girma et al. 2015; Barrios et al., 2011; Aitken and Harrison, 1999). Our fine-grained data with geolocalized information on both locations of Japanese FDI as well as local Chinese mills are much more granular, so that we can dig much deeper into the role of distance, using distance-weighted spillover variables as are commonly employed in the literature on knowledge spillovers (e.g. Jaffe and Trajtenberg, 1996; Figueriredo et al., 2015).

Apart from the focus on geographical distance, our data and context allow us to alleviate a number of other limitations inherent in papers on FDI spillovers using modern data. Firstly, our sample covers nearly 15 years between World War I and the Second Sino-Japanese War, i.e., arguably a period where costs for FDI may be considered to have been quite high. WWI had disrupted production activities in Europe and thereby also impeded global operations of firms. In particular, there were virtually no Japanese investments into the US or Europe at that time.[2] Additionally, telegram wire cables, which were necessary to timely communicate with foreign affiliates, were connected from Japan only to Shanghai and Vladivostok. Moreover, Shanghai at the time was an international market (urbanized, with a concentration of information and advanced culture) and liberal and was managed by developed countries (most notably France) rather than China. There were also several other incentives for Japanese multinationals to locate in the International Concession zone in Shanghai, such as tax concessions and low-priced land leases.

For these reasons, the main FDI destination for Japan during our sample period was Shanghai, and subsequently other parts of China. Thus, in stark contrast to operations in today's global economy, where investors have to choose among a multitude of possible investment locations and therefore respond to a variety of location factors (making modelling these challenging), in our setting Japanese firms had a strong incentive to mainly locate in China, and in particular Shanghai. In other words, the choice between concurrent competing alternative locations, and thus location choice being endogenous is less of a worry in our case than in many other settings in the literature. Moreover, the choice of Japanese cotton-spinning companies to open affiliates in China was primarily driven by the cost of borrowing and labour costs in Japan,

[2] Tanno (2016) shows that during 1914 to 1936, direct investments to China (including Manchuria) accounted for 80-90% of all foreign investments by Japan, while the remainder went to the Philippines, Southern Pacific islands, and South East Asia (e.g. Malaya and Dutch Indies).

and an increase of tariff rates in China (Nakamura, 1971; Takamura, 1982). Thus, this choice can be considered plausibly exogenous to cotton yarn production by Chinese firms.

Modern studies typically use micro data for the whole economy or the manufacturing sector, although modern industrial activity is characterised by substantial heterogeneity – most notably in terms of technology used - not only across industries but also within industries across firms (e.g., Abebe et al., 2022; Fons-Rosen et al., 2018; Lu et al., 2017). This makes it difficult to gauge the potential spillover effects that might accrue to a particular firm in a particular industry due to a particular technology. In our paper we focus on one industry only, namely the cotton-spinning industry, which at the time of analysis was fairly homogenous, with relatively straightforward technologies used for production. As such we are better able to capture the superior technology used by Japanese Zaikabo that may have benefitted local Chinese firms through productivity spillovers, rather than other aspects that might be correlated with the value of the capital stock.

Causal identification of our analysis is based on the variation in productivity within Chinese cotton spinning mills over time, alongside fluctuations in the activity levels of Japanese Zaikabo. In particular, Japanese operations experienced a sharp decline following the economic crisis of 1930, followed by a relatively rapid recovery. This time-varying exposure to Japanese Zaikabo activity is plausibly exogenous from the perspective of local Chinese mills (as we argue further below in Section 4), allowing us to isolate the causal effect of FDI from potentially endogenous location choices by Japanese Zaikabo.

The Chinese cotton spinning industry is a highly interesting case to look at. China is today one of the major textile exporters world-wide. For example, in 2022, China accounted for more than 40 percent of the value added in global textile exports according to the WTO.[3] While the foundations for this success reach back to the 19th-century opening of the treaty ports and the market integration it set in motion (Keller, Li and Shiue, 2011, 2013), the period between the two World Wars was arguably an important era, in which productivity spillovers from Japanese affiliates may have contributed to the modernisation of local Chinese mills. As Liu (2020) argues, while cotton spinning industry was among the first industrialised sectors in China, it was fairly unproductive, this only changing with the introduction of new technology in the form of industrialised spindles in the 1920s. A number of studies have explored possible

[3] Source: https://www.wto.org/english/res_e/statis_e/miwi_e/gvc_sectoral_profiles_textiles_clothing24_e.pdf

explanations for this take-off in the industry in China, the most recent being Liu (2020). However, what has been neglected thus far is the role of foreign investment. In this regard Zeitz (2013) shows that during the inter-war period Zaikabo located in China were by far the most productive in the country, enjoying productivity advantages of about 70 per cent over both local Chinese and affiliates of British firms. Moreover, the capital stock of Japanese firms increased from about 21 to 42 per cent during 1918 to 1936, while that of British firms declined from 35 to 6 per cent over the same period.

Our results indicate that spillovers from Japanese Zaikabo had a statistically significant and economically meaningful impact on productivity of nearby Chinese cotton-yarn producers. Accounting for distance is crucial in this regard, as spillover effects decline sharply with distance—becoming insignificant beyond approximately 10 kilometres. Exploiting further the geographic dimension of our data, we find that the average effect is primarily driven by firms in Shanghai. This makes sense as this was the centre for the Cotton spinning industry at the time.[4] As a possible mechanism of how firms boost productivity, we also observe an increase in capital stock, as reflected in the number of spindles employed by Chinese cotton spinning mills.

We also exploit information on the workforce composition of the Japanese affiliates to further identify possible channels through which spillovers operate. Our results indicate a pronounced skilled-labour channel. The productivity gains are driven almost entirely by proximity to Zaikabo with a higher share of skilled workers (proxied by the male share of production workers and by the share of white collar workers), whereas standardised spinning operations generate no measurable spillovers. This is consistent with the notion that it is transferable technical and managerial know-how, rather than routine production tasks that diffuses across firms (Caves, 1974).

Although we cannot directly observe more about underlying mechanisms, our findings, and particularly the highly localized nature of the effects together with the importance of skills, suggest that job-hopping within a shared labour market between Zaikabo and local Chinese



[4] Since then, of course, the industry has moved on to other regions in China, in particular after the cultural revolution (which turned existing producers in Shanghai into state-owned enterprises) and then the decision in the early 1990s to transition Shanghai from industry to services (https://bridgingthegaps.leeds.ac.uk/shanghai-textile-industry-chinas-mother-industry/).

mills may have played a role in facilitating knowledge transfer (in line with the case studies by Ashizawa, 2014, 2011).

Regarding the Japanese mills themselves, we find that larger Zaikabo, both in terms of local plant size and the overall size of the parent firm, generate stronger spillovers. Zaikabo headquartered in China rather than in Japan, and thus more embedded in the local economy, also tend to generate larger spillovers. Finally, we find suggestive evidence that local Chinese mills with higher initial total factor productivity benefit more from spillovers, in line with the classic absorptive-capacity hypothesis of Cohen and Levinthal (1990). However, our sample, is too small to establish this heterogeneity with statistical confidence.

Our paper contributes to a closely related strand of work that studies the long-run spatial consequences of trade openness in China after the Opium War. Keller, Li and Shiue (2011, 2013) and Keller and Shiue (2025) document geographically expansive effects of treaty-port opening on Chinese trade, growth and market integration, propagating far inland along trade and transport networks. Our findings are complementary: those studies identify a broad market-access channel that diffuses over long distances through trade and price integration, whereas we isolate a firm-to-firm technology-transfer channel that the knowledge-spillover literature shows to be highly localized. Because tacit production know-how travels poorly over distance while trade effects travel well, we find spillovers concentrated within 10km of a Japanese Zaikabo, while trade-based studies document a much wider reach. A further distinction is that those studies concern the colonial and institutional policies of the powers governing the treaty ports, whereas the Zaikabo were established by purely private commercial investors with no role in Shanghai's governance nor the Japanese colonial strategies (as discussed below in section 2 and in Takamura, 1982; Ishii, 2012). Hence, our estimates identify spillovers from plant-level FDI rather than from colonial policy.

Some papers investigated Japanese recent FDI in China in terms of location but without directly investigating spillovers, as, e.g., Belderbos and Carree (2002) and Kim et al. (2010).[5] However, none of these studies directly consider the role of distance between local and

[5] Belderbos and Carree (2002) investigated the location of the Japanese affiliates in China in terms of firm heterogeneity and found that small size firms tend to locate closer to Japan but have less benefits from local Chinese market. Kim et al. (2010) investigated the exit of the Japanese subsidiaries in China from 1979 to 2001 and found that exit rates are affected by parent firms' operation experience in the industries and geographical distance from other Japanese subsidiaries.

multinational firms in determining productivity spillovers, despite the crucial importance of distance in facilitating technological spillovers being well established in the literature (Jaffe and Trajtenberg, 1996; Keller and Yeaple, 2013). Arguably, and in line with our results, geographic proximity of foreign and domestic firms is likely to have been even more important in terms of facilitating spillovers in historical settings with less developed transport and communication infrastructure. But what the literature has not considered is whether local Chinese firms were able to learn from these foreign firms, in particular from the Japanese. To fill this gap in the literature, we investigate whether and how the presence of these highly productive Japanese firms in China may have contributed to the growth of the Chinese cotton spinning industry through so-called "productivity spillovers".

Finally, it should be noted that Foreign Direct Investment has of course a long history, arguably starting with the East India Company in 1601 (Clegg, 2017).[6] However, given the unavailability of comprehensive and accessible historical data on FDI, especially at the firm or industry level, essentially all of the existing studies examining its role for local economic development are limited to using a more narrative approach based on case studies or highly aggregate statistics.[7] Our study is to the best of our knowledge the first to consider very detailed and comprehensive plant level historic data, enabling us to quantify any spillovers from foreign direct investments.

The remainder of the paper is organized as follows. We describe the relevant background of the cotton spinning industry, including the role of Japanese firms, in China for our setting. The data used in our analysis is described in Section 3. Our methodological approach is outlined in Section 4. Results are discussed in Section 5, mechanism and heterogeneity of the effects are explored in Section 6. In the final section we provide some concluding remarks.

[6] See Wilkins (2001) for an insightful overview.

[7] For instance, Lopes and Simões (2020) provide many examples of foreign company involvement in Portugal from 1700 until the 2000s, also considering those companies' implications for local development. Lanciotti and Lluch (2020) use a somewhat similar approach to discuss investments by American and British firms in Argentina in the late 19th and early 20th century, focusing on recruitment and management aspects, including transfer of know-how to the domestic economy. Fernández-de-Pinedo et al. (2020) is a very detailed case study of the operations of a French multinational firm (Derosne and Cail) in the 19th century, exploring the consequences for knowledge transfer to the host countries. Mason (1987) also discusses the involvement of foreign companies in Japan, as well as the implications for its economic development. The earliest paper in the more formal econometric "spillovers literature" that we are aware of is Caves (1974) using data for Australia for 1966. All other studies use data from the 1970s onwards (Görg and Strobl, 2001).

## 2 Historical Background

*2.1 The Development of the Japanese Cotton Spinning Industry Post-Autarky*

After having been an autarky for around 250 years, Japan finally opened several ports to trade in 1858 as a result of the US–Japan Treaty. Consequently, silk and textiles quickly became major export products (see Yamazawa and Yamamoto, 1974; Okubo, 2007).[8] Trade continued to increase, with the process accelerating during the Meiji Restoration (1870s-1880s), where the core industries were silk reeling, and weaving, as well as cotton spinning and fabric manufacturing. In terms of cotton spinning, after Osaka Spinning, Co. was founded in 1882, several large-scale companies followed and successfully produced high-quality cotton yarns by introducing advanced foreign technology and machines (Nakamura, 1971). By the early part of the 20th century, the textile sector had become the primary manufacturing sector in Japan (Saxonhouse, 1974; Nishikawa and Abe, 1990; Takamura, 1971; Ishii, 1972), by 1920 42% of all manufacturing output was in textiles (Census of Manufacture, 1920). As was the case in other countries, an important feature of textiles firms was that they were very labour intensive (Hunter, Ch.4-5, 2003; Nakamura and Molteni, 1994).

*2.2 Japanese Cotton Spinning FDI in China (1902-1937)*

Emergence of Zaikabo

After the Russo-Japan War (1904 to 1905), Japan emerged as one of the major players in international politics, substantially extending its geographical power base. One such expansion consisted of establishing some authority in Northeast China (later called "Manchuria"). The Northeast China area was economically taken over by a Japanese national policy company, the South Manchuria Railway. Meanwhile, in Shanghai, some private companies started FDI. For example, Naigaimen Co., headquartered in Osaka, constructed a large production plant in Shanghai in 1911, which is considered the first large-scale private-company-based Japanese FDI (Takamura, 1971, 1982).

After World War I, Zaikabo investment drastically increased, and three important factors for increasing such FDI to China have been highlighted (Nakamura, 1971; Takamura, 1982; Mori, 2005; Ishii, 2012; Abe et al., 2017). The first one is tariff jumping as a result of the rise of tariff

[8] The opening of trade also drastically changed the domestic market; see Bernhofen and Brown (2005) for details.

rates in China. China did not have autonomy over tariff policy and had been requesting a rise in tariff rates, this was allowed by Western countries in August 1919. The subsequent hike in tariff rates was followed by two further revisions. As a result, Japanese exports of cotton yarns to China decreased by 60-70%, constituting a 50% fall of total Japanese cotton yarns exports (Nakamura, 1971: p282). To avoid the tariffs, many Japanese companies located cotton spinning mills in China. The second factor for increasing FDI was the cost advantage of operating in China, in particular concerning wages. For example, wages in Zaikabo were from between half to two-thirds of what was paid in Japan domestic mills (ibid., p. 284). The third big driver of Japanese FDI in China was that Japanese cotton spinning factories had large excess money for investment from substantial profits accumulated during WWI due to temporarily but drastically increasing exports, compensating for the decline of European exports to Asia (ibid., pp.282-287).

An important aspect of Japanese FDI presence in China was a "competition-and-dependence" relationship with Chinese local firms. More precisely, as a result of Europe and India decreasing production of cotton yarns, Chinese firms substantially increased their output and hence began constituting a serious threat to Japanese companies. As a reaction, Zaikabo shifted production to high-quality yarns for differentiation purposes in the 1920s (Kuwahara, 2011). Moreover, to further eschew competition, some Zaikabo started collaborating with the Chinese local mills in importing cotton as well as through jointly undertaking projects to improve the quality of cotton (Abe, 2011). Hence, while Zaikabo and Chinese local mills did compete, they were also dependent on each other (Imai, 2010). This constitutes an important potential channel for technology spillovers from Japanese Zaikabo.



Prosperity and Turbulence

By 1924, Zaikabo accounted for 32.4% of cotton yarn and 30.4% of cotton fabric production in China, which is a significant increase from the 8.4% post-World War I figure (Takamura, 1982: p129-130). From the end of WWI to the early 1920s, all 10 major Japanese cotton spinning mills started operations in China. By contrast, ownership of mills by US or European owners became negligibly small (ibid., p. 118-120). Zaikabo were geographically highly concentrated in Shanghai.

The prosperity of Zaikabo in Shanghai was swayed by the political situation in China. The "21 Demands" proposed in 1915 by Japan steadily stirred up Chinese nationalism. The rise of antiimperialism in China led to labor protests and boycotts, often orchestrated by the Communist Party. Furthermore, inflation in the boom after WWI caused workers to go on strikes for higher wages, of which 33 strikes occurred in cotton mill factories during the 1918 to 1922 period. Out of these 33, 17 strikes happened in Zaikabo, while 2 were in companies under UK ownership and 14 in Chinese local factories (Takamura, 1982: p.139). In 1923, the movement for recovering Port Arthur and Dalian led to a further anti-Japan sentiment. In 1925, riots erupted, such as the "May Thirtieth Movement," stemming from a frustration with the poor working conditions. On May 15th, a riot by Chinese workers erupted in a factory of Naigaimen, Co., and one young Chinese Communist worker was shot dead. Then, riots spread to other Zaikabo mills. Finally, on 30th May, the Communist Party instigated a large-scale protest by thousands of workers and students in Shanghai City, resulting in 4 being shot dead, 20 injured, and many arrested, further inciting strikes all over China (ibid., pp.145-146). Importantly, according to Ishii (2012: pp180-183), the main cause of riots was not attributable to the Zaikabo but rather arose from an increased sense of Chinese nationalism due to Japan's "21 Demands" in 1915 as well as criticism of Japan's increased interest in the Manchuria area.[9]

Despite these events, Zaikabo's profitability remained relatively unaffected, arguably in part because they faced excess supply issues, and the unrest presented an opportunity to reduce this excess (Takamura, 1982: p. 148). Additionally, plants outside of Shanghai experienced little damage, allowing them to increase production. To address these challenges and coordinate efforts among Zaikabo mills while suppressing riots and strikes, the "Zaikabo Spinners' Association" was formed in June 1925. The association aimed to coordinate interests, exchange information, provide mutual assistance in case of riots, and exert political influence against the anti-Japanese movement (ibid, p.148).

<ins>Deterioration of the Sino-Japanese Relationship and withering Zaikabo</ins>

On September 18th, 1931, the Mukden (also referred to as Manchurian) Incident occurred. This was a Japanese military action, where an explosion destroyed the South Manchuria Railways. The Japanese military accused Chinese dissidents of the act and used it as a pretext



[9] Nakamura (1971: p330) similarly points out that the riots were just one political incident and not directly caused by Zaikabo's wage and management system. More specifically, he argues that a Zaikabo was considered as a purely private company's FDI buying raw materials, such as cotton, from the Chinese local market, hiring Chinese workers, and selling textiles on the local market, and hence not thought of as vanguard of Japanese imperialism (ibid, p.331).

for the military invasion of Northeast China. The Mukden Incident is a crucial moment of the deterioration of the Sino-Japanese relationship (e.g. Koike, 2003; Ishii, 2012), with the result that Japanese troops occupied the Northeastern part of China. Subsequently, a new country, Manchuria, was founded in 1932 and put under Japanese political control. This triggered a boycott of Japanese goods and intensified the anti-Japanese movement across China (Bo et al., 2024).

Shanghai was particularly affected by this movement, involving Chinese capitalists, workers, and the general public. To quell the movement, Japanese military troops were dispatched to Shanghai, and the international settlement area was placed under martial law. This eventually escalated into the Battle of Shanghai in January 1932, which lasted for three months. As a consequence, from January 28th to April 25th, 1932, Zaikabo operations came to a halt. The Japanese military withdrew in May 1932 following a cease-fire agreement. In response to the boycott and anti-Japanese sentiments, Zaikabo gradually relocated production from Shanghai to North China and Manchuria. Tianjin and Tsingtao thus became important locations for Zaikabo operations, with Tsingtao already being under Japanese control due to territorial changes after World War I (Takamura, 1982: pp. 217-218) Tsingtao was originally occupied by Germany and then seized by Japan in 1914 to be used as a strategic military and naval base. Unlike in Shanghai, there were few Chinese firms while the Japanese military government in Tsingtao actively facilitated FDI from Japan by offering land, raw materials and machinery at affordable prices.

The Second Sino-Japanese War began with the Marco Polo Bridge Incident on July 7th, 1937, and escalated into military conflicts, particularly in Shanghai, in August 1937. This conflict led to the suspension of Zaikabo operations from August 13th onwards. Japanese employees' families were sent back to Japan, and Japanese workers collaborated with Japanese military forces. Many Zaikabo mills in Shanghai were damaged or destroyed during military attacks. In particular, a significant portion of Zaikabo mills located in the International Settlement area faced extensive damage. Shanghai suffered the greatest destruction with all Zaikabo mills being completely obliterated in December 1937.

*2.3 History of Shanghai and its prosperity as an International City*

The reason why Shanghai served as a location for foreign business and trade activity, and ultimately the main location for Japanese cotton spinning mills, can be traced back to the

Treaty of Nanking in 1842, which was the first of a number of unequal treaties imposed on China by Great Britain as a results of the First Opium War (1839-1842).[10] As a result, Shanghai was opened to European countries and the US for trade and commerce, as well as creating the Shanghai International Settlement and the French International Settlement in Shanghai city. Additionally, in 1854 the Shanghai Municipal Council was established as an autonomous administrative body in the international settlements. Subsequently, many branch offices and factories were established by European and US trading, banking, financial, commercial, and manufacturing companies in the area, while at the same time, many modern buildings and transportation systems were constructed under European-style urban planning. Lastly, after the first Sino-Japanese war in 1894, the Treaty of Shimonoseki in 1895 added Japan as another foreign power in Shanghai and a member of the Shanghai Municipal Council. This resulted in a number of Japanese districts in Shanghai, attracting Japanese businesses, and the construction of residences, hospitals, schools, and commercial shops. By the 1920s, Shanghai had become a modern city and a centre of finance and commerce in Asia.

*2.4 Background on productivity spillovers from Zaikabo*

Did the Japanese Zaikabo bring any benefits to local Chinese cotton mills? According to theories of the multinational enterprise (such as Markusen 1995), multinationals have a technology advantage vis-à-vis domestic firms, which can then "spill over" to local firms (e.g., Görg and Strobl, 2001). Hence, an important condition for productivity spillovers from Zaikabo to Chinese local mills to occur is that the former had substantial productivity advantages over the latter. In this regard, as shown in Takamura (1982: p181), while Zaikabo's productivity was lower compared to Japan (48-52% of Japanese domestic production), it still outperformed local Chinese mills, which operated at only 55-70% of Zaikabo's productivity levels. As pointed out by Takamura (1982: pp.181–184), there are a number of reasons for this. Firstly, Zaikabo benefited from using modern and more advanced machinery, while Chinese local mills used machines that were often outdated by decades.[11] Second, Zaikabo had more efficient management systems. They implemented a direct control employment system, akin to the standard Japanese management system, which ensured better management and coordination



[10] See e.g. Takahashi and Furumaya (1995) about the history of Shanghai City.

[11] In Chinese local mills, extremely old spinning machines, used for 26 to 47 years, accounted for 30%, while those used for 16 to 25 years made up 14%. While over 90% of Zaikabos used machines with electric motors, among the 45 Chinese factories, 29 used electric motors, 12 used steam engines, and 4 used both. (Takamura, 1982: p.182)

of employees, often involving a piece rate wage system tied to class-based wages.[12] In contrast, Chinese local mills relied on the "Houshin Sei" employment system, which involved contractors hiring workers from rural areas, leading to inefficiencies, poor machine management, and an overall lack of effective supervision. Third, Japanese networks provided Zaikabo with access to lower-cost capital from Japanese banks and cotton at reasonable prices from Japanese trading companies, whereas Chinese local mills often had limited access to capital and had to rely on higher-cost material inputs. Fourth, Chinese local mills faced greater taxation than Zaikabo. For instance, in the Shanghai International Settlement, Zaikabo were levied only land tax and small contributions to the Japanese Residents Union, but otherwise no taxation. Thus, they enjoyed more favourable taxation conditions than the Chinese local mills due to their extraterritoriality.

Given that Zaikabo had a productivity advantage compared to local firms, one may expect the potential for spillovers to be present. Indeed, there is evidence that Zaikabo aggressively transferred technologies and know-how from headquarters and plants in mainland Japan to their affiliates in Shanghai. According to Kuwahara (2011, 2007), Naigaimen Co., sent many Japanese workers to their Chinese affiliate factories to boost productivity. 54 Japanese workers were sent to Shanghai in 1917 and this increased to 365 workers in 1924 (Kuwahara, 2011: p.15). In terms of training, Chinese local workers were required to learn the Japanese language and know-how on cotton machines usage, spending one hour per working day or two days per week.

Local worker's 'job hopping' has also been shown to be a channel for spillovers. Ashizawa (2014, 2011), investigating job carrier, job training, and skills of Chinese employees using worker level data in Naigaimen, Co.[13], finds that before getting jobs in Naigaimen, many Chinese local workers had already some experience in neighbouring local Chinese cotton spinning factories in Shanghai. After acquiring some skills, they often obtained positions in Naigaimen in search of higher wages. Naigaimen used a system for on the job training and had a wage system based on bonuses and promotions to provide incentives to increase effort.



[12] One should note that while this was efficient, it did occasionally lead to racial tensions.
[13] The micro-data in Naigaimen, Co. covers Chinese local workers' background, job carriers and experiences, salaries, and detail task and position inside Naigaimen factory.

However, job tenure was very short: around 70% left within a few years (Ashizawa, 2014).[14] They often subsequently obtained jobs in Chinese local mills, which appreciated the working experience in Zaikabos.[15] Thus, Shanghai was characterized by a dense labour market for skilled cotton spinning workers involving frequent job-hopping between Zaikabo and Chinese local mills.

## 3 Data sources

In order to examine more comprehensively whether Chinese cotton mills benefited from the presence of Zaikabo in their geographic vicinity, we have collected unique data at the plant level relating to the activities of Zaikabo and Chinese local mills. The data come from the *Handbook of Textile Industries* ("Boushoku Yoran") which is published annually by Boshoku Zasshi-sha, and *Statistics on Japanese Spinning Industry*, ("Bouseki Jijo Sankosho") published by Dai-Nihon Bouseki Rengokai (Japan Association of Cotton Spinning). We have assembled the data for the period 1925 to 1938. Both data cover all Japanese cotton spinning companies and their plants in Japan, their Zaikabo affiliates in China (including Manchuria) as well as other local mills in China.

We are able to obtain information on firms' addresses (headquarters and all plants), their total output in terms of cotton yarn value, the number of spindles and looms, capital assets, number of employees as well as the year of foundation of the plant. This is available for Zaikabo and Chinese local mills.

In order to geo-locate firms, we use information on the firms' addresses to gather detailed information on longitude and latitude. We then determine the coordinates of plant location in Shanghai from historical maps on the Shanghai Concession, "Plan of Shanghai" published by the War Office, Geographical Section (1937), "Saishin Shanghai Chizu (New Shanghai Map)" published by Osaka Asahi Newspaper (1932). These maps include all street names as well as locations of companies and plants, hotels, banks, apartments, shops, transportation infrastructure and public places (e.g. hospitals and schools). We can also identify the location of the Japanese residential place, "Little Tokyo". Since most streets are the same as current

[14] Male technicians tended to have longer tenure (many are more than 5 years). Main reasons are lay-off, double registration with other companies, and personal reasons. In terms of employment Naigaimen, Co. had the stance that "those who come are welcome and those who left are not regretted" (Ashizawa, 2011).

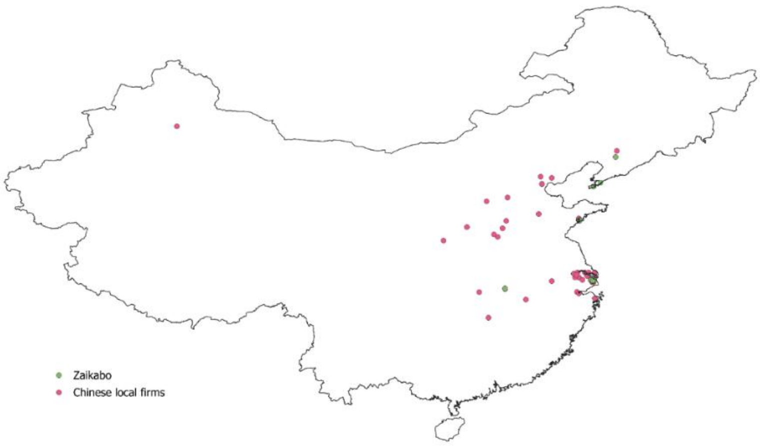
[15] Zhuang (2003) illustrated how Chinese local firm owners managed to boost productivity by visiting Zaikabo factories to learn their production systems and recruiting Chinese male technicians.

ones, we use GIS to measure coordinates. We can thus identify the exact location of each cotton mill in Shanghai.

To do the same for firms located outside of Shanghai, we use the information on firm location, which is available at the town level. We then use the name of the town and determine the centre of the town by GIS. Figure 1, Panel A illustrates the locations of Zaikabo in green and the location of Chinese local mills in red. This shows a concentration of firms in the Eastern part and, in particular, in Shanghai. Panel B zooms in on Shanghai.

**Figure 1: Locations of Zaikabo and Chinese Local Firms**

Panel A: Location across China




Panel B: Location in Shanghai

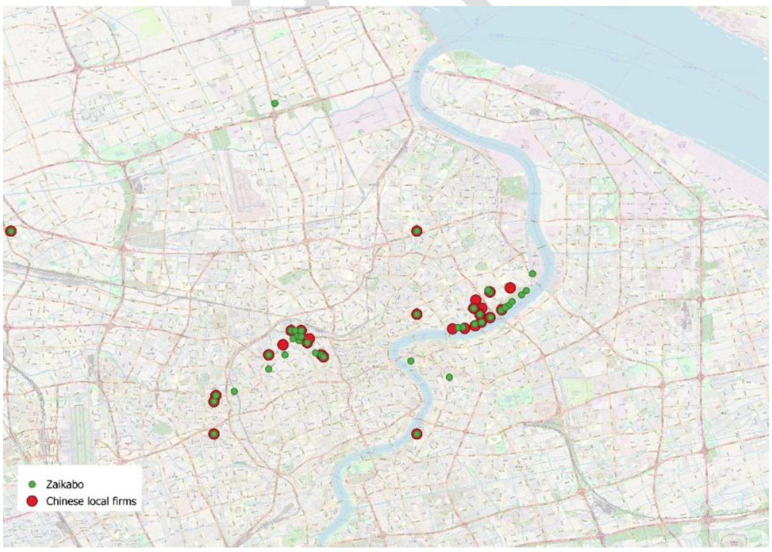


Table 1 shows descriptive statistics for Chinese local mills (Panel A) and Zaikabo (Panel B) in our data.[16] There is substantial variation in plant size as Chinese local mills employ between 270 and 13,189-workers. Similarly, the number of spindles employed per plant and the output volume vary substantially across plants.

**Table 1: Summary Statistics**

a) Chinese local mills

| | Mean | Std. dev. | Min. | Max. | Observations |
|---|---|---|---|---|---|
| Output (in yards) | 26,395.52 | 33,345.89 | 730 | 601,000 | 403 |
| Spindles | 46,640.88 | 38,131.98 | 5,120 | 407,480 | 403 |
| Capital assets (yen) | 2,571,215.89 | 2,646,099.55 | 114,400 | 12,000,000 | 356 |
| Number of workers | 2,611.41 | 2,058.11 | 270 | 13,189 | 403 |

The sample is restricted to plant-year observations with positive output. The estimation sample includes only firms with positive output and positive number of spindles, resulting in 403 observations. This includes 50 Chinese local mills in an unbalanced panel.

b) Zaikabo

| | Mean | Std. dev. | Min. | Max. | Observations |
|---|---|---|---|---|---|
| Spindles | 56,580.00 | 38,815.78 | 3,360 | 338,000 | 351 |
| Capital assets (yen) | 21,149,890.39 | 29,396,878.13 | 2,400,000 | 160,000,001 | 304 |
| Founding year of plant | 1,907 | 15.74 | 1,887 | 1,929 | 351 |
| HQ in JPN | 0.47 | 0.50 | 0 | 1 | 351 |

Note: The estimation sample is restricted to plant-year observations with a positive number of spindles. The time span is 1925-1938. The founding year is not Zaikabo's but the plant's.

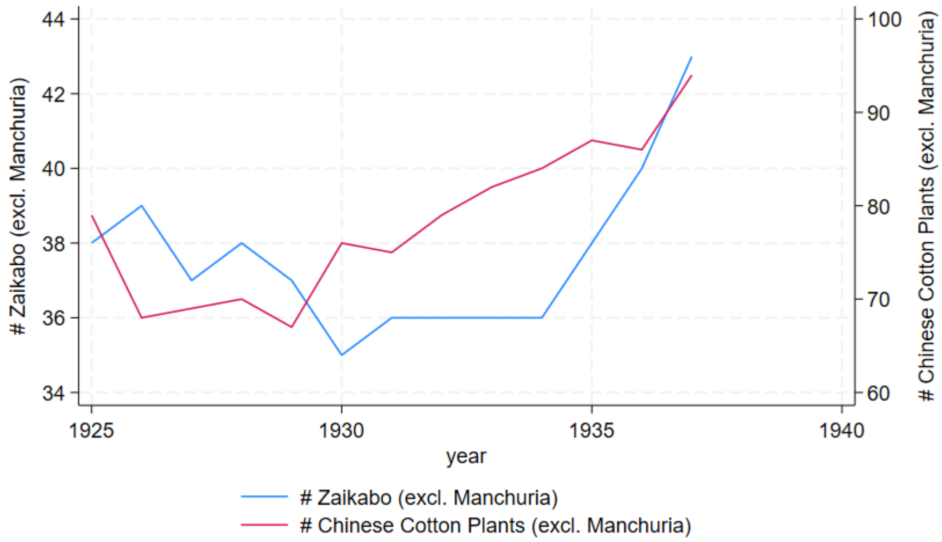
Considering Zaikabo in Panel B, note that, the founding year is the year of starting operation of the plant rather than its firm. The oldest Zaikabo's plant dates back to 1887 (a plant taken over from a Chinese local firm). As mentioned above (section 2), the first greenfield Zaikabo was founded in 1911 (Naigaimen, Co.), and most of the Zaikabo plants were taken over from various local Chinese and foreign-owned mills (Takamura, 1982: pp.75-78, pp.116-123).[17] Zaikabo often acquired cotton mills of exited firms or dormant/abandoned mills. The acquisition rather than green field FDI could save costs and time, which gave a large advantage to the Japanese firms in the Chinese market (Zhang, 2011: p.133).



[16] Appendix B discusses measurement of key variables, and in particular unit conventions applied.

[17] For example, Shanghai Bouseki and Toka Boseki took over the bankrupt Chinese local firms and Nikka Boushoku, Co. took over a British firm.

**Figure 2: Trends in Active Zaikabo and Chinese Local Firms Over Time**




Note: We define an active plant as one that has positive output in the respective year, according to our data.

Figure 2 illustrates the evolution of the number of active plants of Zaikabo and local Chinese firms in our data. We define a Chinese cotton spinning mill as active in year *t* if it reports positive yarn output in that year, and a Zaikabo plant as active if it reports a positive number of spindles. As is evident, Zaikabo were affected by the economic crisis in 1930, decreasing from 37 in 1929 to 35, but then recovered again to reach 43 by the year 1937. Over the same period, local Chinese mills experienced a steady increase in their numbers. This likely reflects several economic reforms (tariff, currency, and banking) by the Nationalist Government of China. These national reforms targeted only Chinese-owned firms, while Zaikabo were supported by Japanese trading companies and banks in finance, transportation, and purchasing raw materials (cotton) (Takamura, 1982). In our data, the number of active local Chinese mills increased from 67 to 94 between 1929 and 1937.

## 4 Econometric Methodology

### *4.1 Econometric Specification*

To investigate whether Japanese Zaikabo impacted the performance of Chinese cotton-yarn producers, we estimate sets of augmented production functions (as in, e.g., Aitken and Harrison, 1999; Lu et al., 2017; Abebe et al., 2022). Output is measured as the total value of yarn produced. Plant-level inputs are the level of employment and the number of spindles used in the production process. We then analyse whether, conditional on these observable input factors, the presence of Zaikabo in the vicinity of the Chinese mills has any measurable impact on their output.

We estimate the following production function:

$$y_{it} = \beta_1 s_{it} + \beta_2 l_{it} + \beta_3 \, pres\_zaikabo_{it-1} + d_i + d_t + \varepsilon_{it} \qquad (1)$$

where $y$ is log output (in terms of yarn produced) by local Chinese plant $i$ in year $t$, $s$ is the log number of spindles (as a proxy for capital stock), $l$ is log employment, and $d_i$ and $d_t$ are full sets of firm and year dummies, respectively.[18] *Pres_zaikabo* measures the lagged presence of Zaikabo in the vicinity of plant $i$, which is defined below. In this specification, the coefficient of interest $\beta_3$ measures, conditional on other variables in the model, the impact of changes in the presence of Japanese cotton-yarn producers on the total factor productivity of Chinese plants. This is what we refer to as the "spillover effect".

In order to get an idea of a possible mechanisms through which firms change productivity, we also look at the impact of the presence of Zaikabo on capital employed by Chinese plants. Specifically, we use the number of spindles as an outcome variable to do so. The spillover estimate in this case indicates whether Chinese plants have adapted their stock of spindles, which may suggest changes in production technology.

The presence of Zaikabo, *Pres_zaikabo*, is measured using our detailed geographic data.[19] Specifically, we geo-reference all local Chinese plants and all Zaikabo $j \in J$ and compute the Euclidean distance for each pair $dist_{ij.}$ We follow the literature on knowledge spillovers (e.g. Jaffe and Trajtenberg, 1996; Figueriredo et al., 2015) and construct a spillover term which is given by

[18] We note that the number of looms counted as spindle equivalent in our analysis follows the approach suggested by Kiyokawa (1974).

[19] The standard approach to measuring FDI spillovers is generally based on a variable that measures the presence of foreign firms as the share of employment (or output) in foreign multinationals relative to total employment in plant i's industry or in vertically related industries. To allow for a geographic dimension, this may be calculated for a geographic cluster, usually an administrative region or municipality (e.g., Girma et al., 2015, Aitken and Harrison, 1999). This is, of course, a fairly rough way of considering how the distance between local and foreign plants matters for spillovers through knowledge transfers. Given our detailed geographic data, we are able to follow a much more fine-grained approach.

$$pres\_zaikabo_{it} = \sum_{j=1}^{J} \frac{1}{(dist_{ij})^{\alpha}} \quad (2)$$

where $\alpha$ is set to unity in the benchmark specification and all Zaikabo are considered for each Chinese plant. In other words, we allow for each Zaikabo to have a potential spillover effect on all Chinese plants, but this effect diminishes with distance.

Note that *pres_zaikabo* is plant *i* specific, as the distance between *i* and *j* varies across plants. This is an advantage over the spillover variables generally used in modern studies (as share of employment in foreign firms), which are industry-region, but not firm specific. For our spillover variable, time variation comes through new Zaikabos entering and existing Zaikabos becoming inactive. We only consider active Zaikabo for our purposes.

To look at more detail into the spatial characteristics of FDI spillovers, we also, in an extension to our baseline model, calculate spillover effects across different distance ranges. We then run alternative specifications with varying distance bands where we compute the spillover term for Zaikabo within the range *l* to *u* as $pres\_zaikabo_{it}^{l,u} = \sum_{j=1}^{J} \frac{1}{(dist_{ij})^{\alpha}} \ for\ l \leq dist < u$. Specifically, in what we report below we defines distance bands as between 0 and 5km, 5-10km, 10-25km, and above 25km. This reflects the finding in the literature that spillovers are generally geographically localised (e.g. Jaffe and Trajtenberg, 1996; Driffield and Girma, 2003; Figueriredo et al., 2015).

As these measures thus far are only based on number of Zaikabo, without giving regard to the size of the plant, we also define Zaikabo presence weighted by the size of the respective Zaikabo. This is measured in terms of the share of spindles of the respective Zaikabo in total production capacity in China, referred to as $pres\_zaikabo\_weighted_{it}$ . More specifically, we generate the variable as

$$pres\_zaikabo\_weighted_{it}^{l,u} = \sum_{j=1}^{J} \frac{Spindles_j}{(dist_{ij})} \ for\ l \leq dist < u \quad (3)$$

As alternative we also consider Zaikabo presence weighted by the total number of spindles owned by the Japanese company to which the Zaikabo belongs. In other words, we then sum over all China-based as well as non-China based plants of the company. This variables is referred to as $pres\_zaikabo\_weighted\_parent_{it}$.

Note that, in order to facilitate interpretation, we estimate elasticities at the mean for the spillover terms so as to have comparable coefficients.

*4.2 Causal Identification*

The key concern in terms of interpreting the estimated coefficient on *pres_zaikabo* (and *pres_zaikabo_weighted*) from Equation (1) causally is that the location decisions, including those leading to maintaining, expanding, contracting, or closing plants, may respond to Chinese firm productivity or market conditions. There are a number of aspects of our historical setting that make this concern less likely to be important.[20]

*4.2.1 Location of Zaikabo Plants*

The spatial distribution of Zaikabo plants was highly constrained within the International Concession, as Japanese firms faced institutional and geographical restrictions when establishing operations in Shanghai. More specifically, in Shanghai industrial locations of Zaikabo plants were shaped by concession boundaries, access to waterways, the availability of existing industrial facilities, and personal connections (Kuwahara, 1990; Tomizawa,2011). Thus, rather than selecting locations based on local productivity or demand conditions, Japanese firms often entered through the acquisition of vacant lands or expansion of pre-existing plants. More importantly, as pointed out in Section 2, the entry of Japan into the Shanghai International Settlement was much later than that of European countries and the US, which had already dominated territories for business and manufacturing production in Shanghai. Furthermore, cotton mills were required to locate in riverside areas to transport raw materials and final products. As shown in Figure 1, cotton mills formed two clusters, Yangshupu district on the Huangpu river (East one in Figure 1) and Putuo district on the Suzhou Creek (West one). Therefore, the Zaikabo had almost no room for location choice (Yayama, 1924), which reduces the selection bias in terms of geography inside Shanghai.

[20] In addition to the two issues discussed in detail in this section, another concern may be selection of Chinese firms' entry into and exit from the panel. We cannot model this selection directly, but the firm fixed effects absorb time-invariant differences between entering, exiting and surviving firms, so the spillover is identified from within-firm changes in Zaikabo exposure. The gradual, macro-driven evolution of the sample (Figure 2) and the concentration of the effect among Chinese firms with higher initial productivity (that we show below in Table 4) further suggest that any residual survivorship bias would dampen rather than inflate our estimates.

*4.2.2 Temporal Variation in Zaikabo Activity*

The temporal variation of Zaikabo activity was primarily driven by shocks originating in Japan rather than by local conditions in China. More precisely, as noted above, starting new plants in China required considerable financial outlay. The creation of Zaikabo was thus mainly financed by Japanese banks and trading companies, which offered lower interest rates than the Chinese financial market. In contrast, many Chinese local firms faced financial difficulties due to small capital assets and high interest rates of local Chinese banks (Takamura, 1982, pp.185-190). As such, cotton FDI by Japanese firms was directly driven by the Japanese credit market and business cycle.

We illustrate this by depicting the number of Zaikabo (excluding Manchuria) alongside the Japanese deposit growth rate in the bottom panel of Figure 3.[21] As can be seen, the two series appear to be move relatively similarly, and the correlation coefficient is 0.76 and significant at the one percent level. The downturns of deposit growth in 1927 and 1930 were due to the Financial Crisis and the Showa Great Depression, respectively, and, as is apparent from the graph, these also correlate with the shutdown of some Zaikabo plants. However, due to the expansionary fiscal policy through increased military spending after the Mukden Incident of 1931, the Japanese economy recovered quickly. In response, Zaikabos upgraded the quality of cotton yarns by introducing high-draft spinning and adopted automatic looms to increase cotton yarns and eventually increased in numbers again (Takamura, 1982).

Another factor that is likely to have driven Japanese cotton-yarn producers to establish plants in China are the wage costs in Japan. One should note in this regard that wage rates in China were stagnant and much lower than in Japan (around 50%). More importantly, the Law of Factories, which prohibited midnight work and limited working hours to 8.5 hours, applied to cotton spinning industries in Japan in 1929.[22] Wage rates consequently hiked in Japan. In contrast, China had no labour regulations. For instance, in Shanghai city working hours were 11 hours for Zaikabo and 12 hours for Chinese local firms on average. These labour market



[21] Deposit is defined as total amount of deposit in ordinary banks and saving banks for each year. Since GDP is not available for pre-war Japan, we use deposits instead as a proxy for the tightness of the credit market. Bank deposit data is taken from Goto (1970, pp.86-89, pp.172-175)

[22] While the Law of Factories, prohibiting child labour and long working hours of young female workers, did come into force in 1916, it was not applicable to the textile sectors until a revision of the law was promulgated in 1923. Moreover, the earthquake in Tokyo in 1923 postponed the enforcement of the revised law, so that it only came into force in July 1929.

differences provided large incentives to Japanese cotton-yarn producers to open new factories in China (Takamura, 1982, pp.173-184).

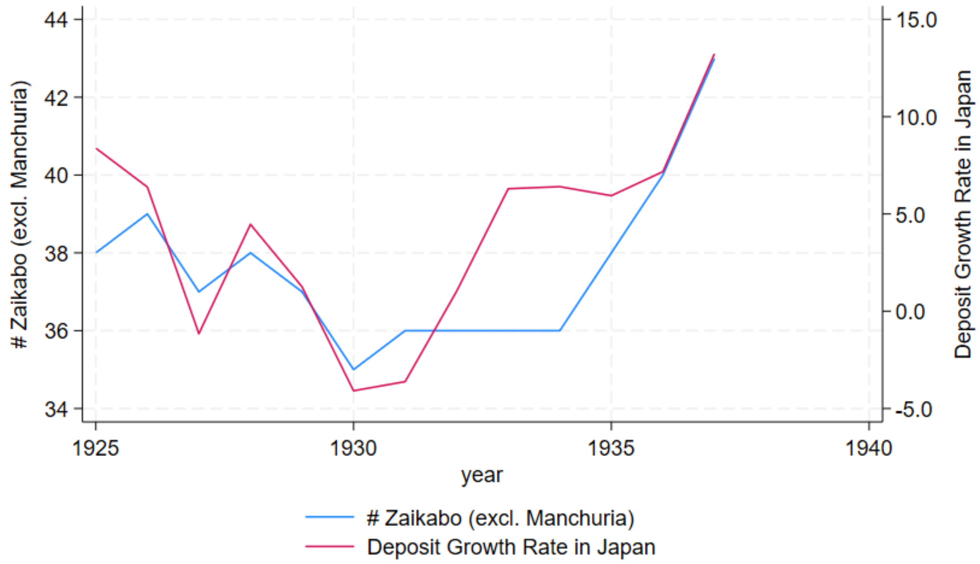
To further investigate this we graph the hourly cotton spinning worker wage growth rate in Japan together with the number of Zaikabo in the bottom panel of Figure 3.[23] Again its fluctuations seem to coincide with the number of Zaikabo plants. This is further substantiated by the positive correlation of 0.74 between the two series, significant at the ten per cent level.

Finally, if we regress the number of Zaikabo on the deposit and cotton worker wage growth rate, both turn out to be significant with positive coefficients of 0.21 and 0.13, respectively, and an R-squared of 0.68. This suggests that while Zaikabo respond more to the cost of borrowing in Japanese credit market than the labour costs in Japan, both together can explain a large part of why Zaikabo plants open and close.

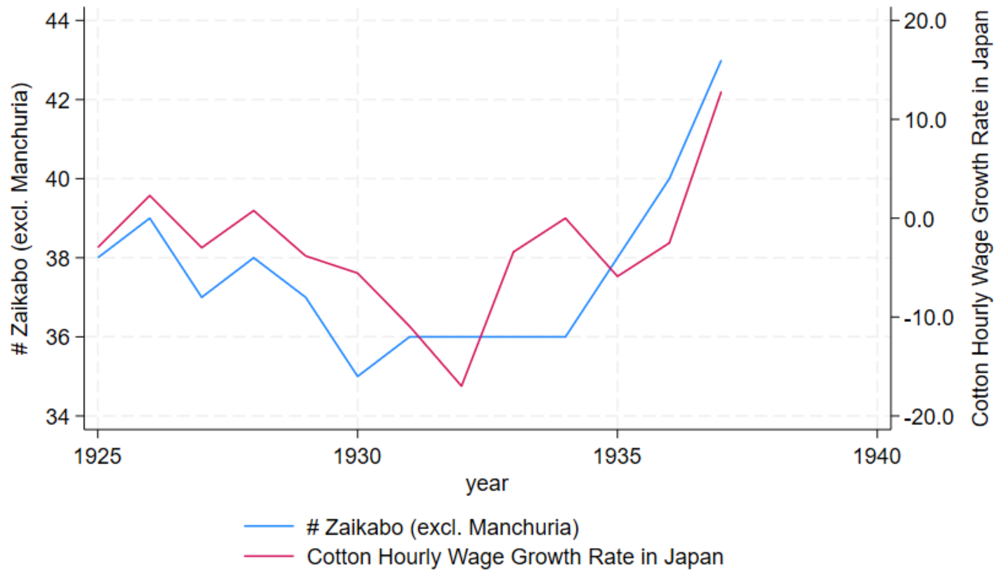
[23] Data on average wage rate of cotton spinning industries in Japan are taken from Ohkawa et al. (1979). Using the average female worker's daily wage rate and average per-day working hours in cotton spinning industries, we derive the hourly wage rates.

**Figure 3: Zaikabo Plants and the Credit and Cotton Labour Market in Japan**

**(a)**




**(b)**




## 5 Estimation Results

Table 2 presents the results of estimating equation (1) described above. The specification in column (1) estimates the Cobb-Douglas parameters for the two input coefficients. The parameters obtained have reasonable magnitudes, indicating a relatively high share of labour input, which is consistent with the characteristics of the cotton spinning industry. Overall, this simple production function approach explains more than 70 percent of the variation in output.

Column (2) employs the distance-weighted measure of spillovers, *pres_zaikabo*, as defined in equation (2). The results indicate a statistically significant and positive coefficient for the distance-weighted spillover indicator. In other words, the findings suggest that cotton-yarn producers can increase their productivity when Zaikabo activity in their vicinity rises. The spillover variable is expressed as an elasticity (normalised by its sample mean), so the coefficient gives the elasticity of Chinese mill's output with respect to proximity-weighted Zaikabo presence, evaluated at the sample mean. In column (2) this elasticity is 0.35, indicating that the estimated effect is not only statistically significant but also economically meaningful.

In columns (3) and (4) we use alternative spillover measures. Specifically, column (3) uses a size-weighted measure, *pres_zaikabo_weighted*, as defined in equation (3), which accounts for differing firm sizes (proxied by the number of spindles).

It thus allows for the fact that we might expect a greater spillover potential from larger Zaikabos.  Reassuringly, the results found using this size-weighted measure are very similar to the ones in column (2), in terms of sign, statistical significance, and magnitude of the estimated effect. Indeed, the coefficient estimate in column (3) compared to column (2) may suggest that the size of Zaikabo plays a role, as the estimates become somewhat more precise with the size-weighted measure of spillovers. It seems a reasonable assumption that larger plants generate more potential for spillovers. If spillovers happen through the movement of workers from Zaikabo to Chinese local plants (as alluded to above, section 2), then larger plants, with a larger number of workers, may generate more spillovers than smaller plants.

In column (4), we replace the size weights of individual Zaikabo plants with a measure based on the size of their parent firm, specifically the capital assets across all plants owned by the respective parent firm of the Zaikabo. Once again, we find strong evidence for spillovers, with the magnitude of the effects increasing slightly.

***Table 2: FDI spillover effects***

| | *(1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* |
|---|---|---|---|---|---|---|
| ***Dependent Variable*** | | ***Log Output*** | | | ***TFP*** | ***Log spindles*** |
| ***pres_zaikabo*** | | 0.345** | | | | |
| | | (0.140) | | | | |
| | | [0.156] | | | | |
| ***pres_zaikabo_weighted*** | | | 0.608*** | | 0.577*** | 0.205 |
| | | | (0.196) | | (0.196) | (0.151) |
| | | | [0.187] | | [0.190] | [0.062] |
| ***pres_zaikabo_weighted_parent*** | | | | 0.259*** | | |
| | | | | (0.082) | | |
| | | | | [0.079] | | |
| ***log spindles*** | *0.185** | 0.174* | 0.168* | 0.166* | | |
| | *(0.094)* | (0.093) | (0.090) | (0.092) | | |
| | *[0.105]* | [0.102] | [0.104] | [0.100] | | |
| ***log workers*** | *0.562**** | 0.573*** | 0.557*** | 0.571*** | | |
| | *(0.097)* | *(0.096)* | (0.092) | (0.094) | | |
| | *[0.119]* | [0.115] | [0.109] | [0.112] | | |
| ***Observations*** | *403* | *403* | *403* | *403* | *403* | *403* |
| ***R-squared*** | *0.766* | 0.768 | 0.773 | 0.771 | 0.357 | 0.866 |

*Robust standard errors in parentheses. Conley HAC standard errors in square brackets. *** p<0.01, ** p<0.05, * p<0.1 (based on robust standard errors). All columns include plant fixed effects and time fixed effects. Elasticities at the sample mean are reported for the spillover terms: pres_zaikabo (inverse-distance-weighted sum of active Zaikabo), pres_zaikabo_weighted (inverse-distance-weighted sum of active Zaikabo weighted by the Zaikabo's share of industry-wide spindle capacity), and pres_zaikabo_weighted_parent (inverse-distance-weighted sum of active Zaikabo weighted by the total capital assets owned by the respective parent firm).*

One should note that using the parent firm's overall size as the weight, however, implicitly assumes that technology diffuses perfectly within the multinational. Following Keller and Yeaple (2013), who show that within-firm knowledge transfer is itself costly and declines with distance, we also experimented with exploiting the fact that we observe which plant belongs to which parent and decomposed the spillover into the local plant's own capacity and that of the parent's other, more distant plants. The results are reported in the Appendix Table A1. The effect loads on the local plant: larger parents generate stronger spillovers through larger local affiliates rather than through their remote capacity, consistent with the localized channel documented below. The coefficients are, however, somewhat imprecisely estimated, likely reflecting that the multi-plant Zaikabo sample is small and the two spillover measures are collinear. Hence, we treat this as merely suggestive and in subsequent analyses, adopt the size weights, accounting for the respective Zaikabo plant's size (column 3 in Table 2) as our preferred measure for spillovers.

In column (5) we shift the dependent variable from log output to log total factor productivity (TFP), computed as the residual from a simple Cobb-Douglas production function as described in Section 4. The advantage of this specification is that it isolates the effect of Zaikabo presence on the productivity of Chinese mills by netting out the direct contribution of measured inputs (spindles and workers) from output. The spillover term is the size-weighted measure, consistent with column (3). The estimated elasticity of about 0.58 indicates that Chinese mills' TFP rises with proximity-weighted Zaikabo presence, statistically significant at the 1 percent level. The magnitude is very close to the column (3) estimate on log output, confirming that the spillover effect operates on productivity itself rather than reflecting a mechanical correlation between Zaikabo presence and observed inputs.[24]

Finally, in column (6) we look at one potential mechanism through which the productivity improvement that local mills experience may come about, namely whether Chinese local plants increase their capital stock. To do so we use as outcome variable the log number of spindle-equivalents in Chinese firms. We do not control for labour. The estimated elasticity is 0.205: Chinese local mills exposed to nearby Zaikabo expand their capital stock. The response is positive and sizeable but only marginally statistically significant. By contrast, when we instead use employment as the outcome we find no significant response of the number of workers to Zaikabo exposure (not reported here to save space). Taken together, exposed mills raise their capital stock while employment is broadly unchanged, i.e. they shift towards more capital-intensive production, consistent with technology upgrading.

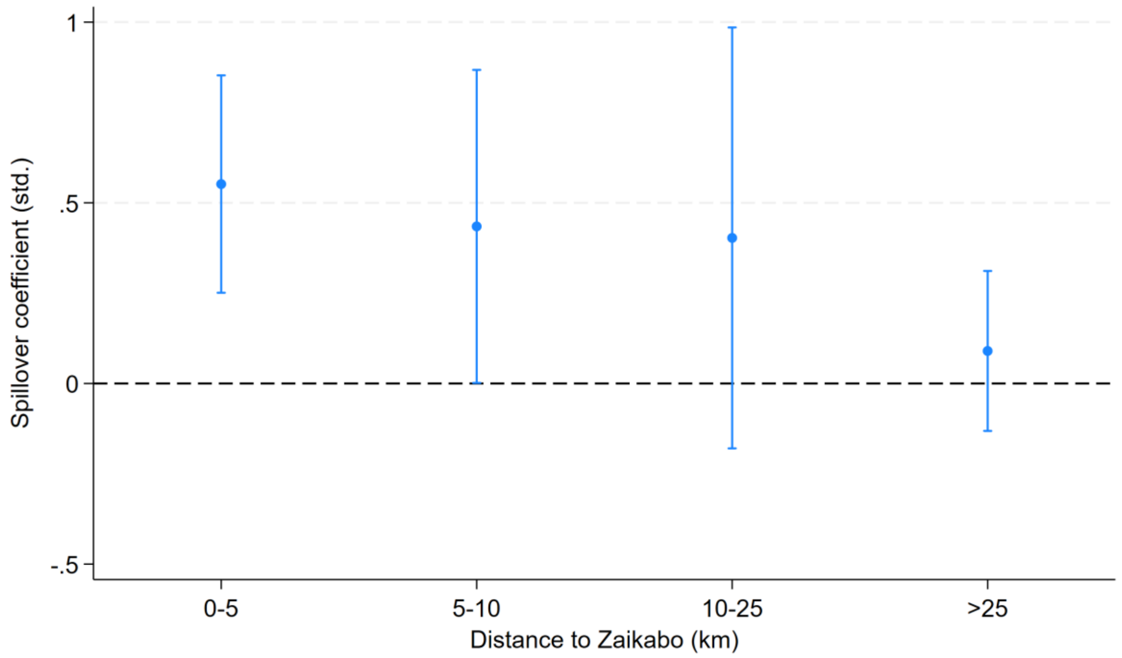
The literature suggests that it is reasonable to assume that spillovers are strongest if the foreign firm (Zaikabo in our context) is in the immediate geographic vicinity and that they peter out over longer distances (e.g. Jaffe and Trajtenberg, 1996; Driffield and Girma, 2003).

[24] We additionally verified that the spillover coefficient on log TFP is robust to alternative production-function specifications (within-firm Cobb-Douglas, translog, and Solow residuals under imposed labour shares of 0.5, 0.6, and 0.7). The elasticity remains close to this value and statistically significant at the 1% level in all specification (see Appendix Table A3).

This may be particularly relevant in the historic context we consider here, as information was arguably far less mobile and transferable than it is in today's age of modern communication technologies. In order to allow for the role of distance, we now calculate spillover measures for four distance bands: the first being within 0 to 5km from the local firm, the second 5 to 10km, the third 10 to 25km and the last over 25km.

We use the size-weighted spillover variables as in Table 2, column (3) for the estimation of these alternative models. The coefficients on the spillover variables from these four specifications are reported in Figure 4 (full estimation results are available upon request). The results clearly show that distance indeed matters: we only find statistically significant positive spillover effects from Zaikabo located within 0 to about 10km away from the Chinese local mills. The coefficient magnitudes monotonically decrease with increasing the distance bands.

**Figure 4. Distance decay of the spillover effects**




Note: Bars indicate 90% confidence intervals (Conley standard errors); Elasticities at the sample mean from a single regression with all four bands, plant and year fixed effects, and the input controls

## 6 Mechanism and Heterogeneity

We now turn to potential mechanisms and heterogeneity in the spillover effects. The first issue we consider is skill intensity. The higher the share of skilled workers in the Zaikabo, the larger the potential for spillovers. To probe this channel, we exploit information on the gender and occupational composition of the Japanese affiliates' workforce. In the inter-war Chinese cotton spinning industry, female workers dominated spinning, which was highly standardised and offered limited scope for transferring tacit technical knowledge, while male workers were concentrated in weaving, mechanical, and supervisory roles where production know-how was more readily transferable across firms (Hunter, 2003; Ashizawa, 2014).

Using plant-level workforce data for 1929-1938, we construct two complementary proxies for a Zaikabo's skill intensity: the male share of production workers (as an indicator of a within-production-floor skill mix) and the intensity of administrative workers relative to all workers (as a proxy for white-collar skilled workers). For each proxy we classify Zaikabo above the cross-plant median as high-skill and the rest as low-skill, and decompose the share-weighted spillover from equation (5) into the high- and low-skill components (columns (2)-(3) of Table 3). Under both proxies the estimated spillover is larger for the high-skill Zaikabo than for the low-skill Zaikabo, directionally consistent with a skilled-labour interpretation of the channel and with the historical evidence that knowledge transfer in the inter-war Chinese cotton spinning industry was mediated by male technical staff. We consider this evidence as suggestive of a skilled-labour channel, consistent with Caves's (1974) emphasis on transferable technical know-how.[25]



[25] Unfortunately, we cannot observe whether these skilled workers actually move from Zaikabo to local mills – i.e., the job hopping channel alluded to above. However, in an attempt to get some suggestive evidence, we distinguished whether Zaikabo were located where they had a local tram line connection to the Chinese mill or not. We find that spillovers only happen if the Zaikabo does not share a tram connection. This suggests that spillovers are driven by workers rather than tram networks. Workers are important and crucial factors but most lived in the dormitory close to factories. Tram networks thus did not play a role. Results are not reported here to save space.

***Table 3: Skill-intensity mechanism — FDI spillover effects by Zaikabo workforce composition***

| | *(1)* | *(2)* | *(3)* |
|---|---|---|---|
| ***Dep. Var.: Log Output*** | ***Baseline*** | ***Prod-worker male share*** | ***Admin intensity*** |
| ***pres_zaikabo_weighted (all Zaikabo)*** | 0.608*** | | |
| | (0.196) | | |
| | [0.187] | | |
| ***pres_zaikabo_weighted (high prod-male share)*** | | 0.290*** | |
| | | (0.085) | |
| | | [0.076] | |
| ***pres_zaikabo_weighted (low prod-male share)*** | | 0.187 | |
| | | (0.147) | |
| | | [0.157] | |
| ***pres_zaikabo_weighted (high admin intensity)*** | | | 0.277*** |
| | | | (0.080) |
| | | | [0.110] |
| ***pres_zaikabo_weighted (low admin intensity)*** | | | 0.107 |
| | | | (0.101) |
| | | | [0.080] |
| ***log spindles*** | 0.168* | 0.176* | 0.181* |
| | (0.090) | (0.092) | (0.093) |
| | [0.104] | [0.108] | [0.109] |
| ***log workers*** | 0.557*** | 0.536*** | 0.533*** |
| | (0.092) | (0.094) | *(0.095)* |
| | [0.109] | *[0.109]* | [0.110] |
| ***Observations*** | *403* | *403* | *403* |
| ***R-squared*** | 0.773 | 0. 773 | 0. 773 |

*Robust standard errors in parentheses. Conley HAC standard errors in square brackets. *** p<0.01, ** p<0.05, * p<0.1 (based on robust standard errors). All columns include plant fixed effects and time fixed effects. Elasticities at the sample mean are reported for the spillover terms. Column (1) reports the baseline share-weighted spillover from all Zaikabo (reproducing Table 2 column 3). Columns (2)-(3) decompose the spillover into a high-skill and a low-skill component using two alternative proxies for a Zaikabo's skill intensity, each split at the cross-plant median: column (2) the male share of production workers, maleworker / (maleworker + femaleworker); column (3) administrative intensity, staff / (staff + worker). Each proxy uses the plant-average over the years for which data are available. Zaikabo without data on a given proxy enter neither*

A complementary question related to mechanisms is whether all Chinese local mills benefit equally from Zaikabo proximity, or whether the absorption of foreign knowledge requires a minimum level of in-house productive capacity (as argued in the classic work on absorptive capacity by Cohen and Levinthal, 1990). To investigate this, we use each Chinese mill's initial TFP as a fixed plant-level proxy for absorptive capacity. In other words, we assume that initially more productive Chinese mills are better able to assimilate spillovers from Zaikabo. We then interact this initial TFP with the size-weighted spillover term.

As initial TFP is time-invariant within plant, its linear main effect is absorbed by the plant fixed effect and only its interaction with the spillover is identified. We report a median split into high- and low-initial-TFP plants (column 2) and a linear interaction between the spillover and initial TFP (column 3) in Table 4. The estimates are consistent with a non-linear absorptive-capacity interpretation: in column (2), the spillover is positive throughout, but it is statistically significant only for the above-median, higher-productivity firms, while the coefficient for below-median firms is positive yet indistinguishable from zero. In column (3), the linear interaction term is not statistically significant and close to zero.[26]

We are, however, cautious not to over-interpret this: a Wald test does not reject equality of the above- and below-median coefficients. With only around fifty Chinese mills, our data likely lack the precision to distinguish these coefficients statistically. We therefore read the evidence as suggestive of, rather than decisive for, stronger spillovers to plants with greater absorptive capacity: the productivity gains accrue at least in part to the more capable local plants, even if we cannot rule out that they are broad-based across the productivity distribution.



26 The same qualitative pattern appears in a non-parametric quartile decomposition, where the top quartile is the only group with an individually significant coefficient (see Figure A1 in the Appendix).

***Table 4: Absorptive-capacity mechanism — FDI spillover effects by Chinese firm's initial productivity***

| ***Dep. Var.: Log Output*** | *(1)* ***Baseline*** | *(2)* ***High vs low (median)*** | *(3)* ***Linear interaction*** |
|---|---|---|---|
| ***pres_zaikabo_weighted*** | 0.608*** | | 0.607** |
| | (0.196) | | (0.260) |
| | [0.187] | | [0.230] |
| ***pres_zaikabo_weighted × high initial TFP*** | | 0.615*** | |
| | | (0.210) | |
| | | [0.204] | |
| ***pres_zaikabo_weighted × low initial TFP*** | | 0.527 | |
| | | (0.442) | |
| | | [0.187] | |
| ***pres_zaikabo_weighted × initial TFP*** | | | 0.002 |
| | | | (0.256) |
| | | | [0.133] |
| ***log spindles*** | 0.168* | 0.167* | 0.168* |
| | (0.090) | (0.091) | (0.091) |
| | [0.104] | [0.103] | [0.104] |
| ***log workers*** | 0.557*** | 0.557*** | 0.557*** |
| | (0.092) | (0.092) | (0.092) |
| | [0.109] | [0.109] | [0.108] |
| ***Observations*** | *403* | *403* | *403* |
| ***R-squared*** | 0.773 | 0.773 | 0.773 |

*Robust standard errors in parentheses. Conley HAC standard errors in square brackets. *** p<0.01, ** p<0.05, * p<0.1 (based on robust standard errors). All columns include plant fixed effects and time fixed effects. Elasticities at the sample mean are reported for the spillover terms. Initial TFP is each Chinese mill's total factor productivity in its earliest observed year with positive output and is time-invariant within plant; its linear main effect is therefore absorbed by the plant fixed effect and only its interaction with the spillover is identified. Column (1) reports the baseline share-weighted spillover (reproducing Table 2 column 3). Column (2) interacts the spillover with a high/low indicator based on the cross-firm median of initial TFP. Column (3) interacts the spillover with the standardised level of initial TFP. A specification additionally including the square of initial TFP yields a quadratic interaction that is statistically insignificant (not reported), we therefore report the linear interaction.*

Our estimates can also be read through the lens of the decomposition of productivity spillovers into a technology-transfer component and a market-share rivalry component proposed by Bloom et al. (2013). The standard concern in the FDI-spillover literature is that the empirical spillover coefficient captures the algebraic sum of positive knowledge externalities and negative demand-displacement effects, so the average effect is a lower bound on the magnitude of the technology channel. We had hoped to separate these two components using the heterogeneity of the effect by the recipient firm's absorptive capacity, on the premise that rivalry would dominate for the least capable firms and learning for the most capable. As reported above, the heterogeneity by initial productivity is only suggestive in the sense that the spillover is individually significant only for higher-productivity recipients, so we cannot cleanly identify the two components separately. Our estimate should therefore be interpreted as the net effect of learning and rivalry, which is positive; to the extent that market-share rivalry is present and works against local firms, the gross technology-spillover effect is even larger than the reported coefficient, so our estimate is conservative.[27]

We now turn to look at a number of further issues related to heterogeneity of the spillover effects depending on characteristics of the Chinese mills. These estimations are reported in Table 5, where we always estimated the baseline specification as presented in column 3 of Table 2 and added an interaction term for the corresponding heterogeneity. Table 5 then reports only the main effect of the coefficient on Zaikabo presence for the reference and the comparison group.

As we saw in the map produced in Figure 1, Chinese local plants as well as Zaikabo, are heavily concentrated in the city of Shanghai. We therefore check whether this city is driving our results, by allowing the spillover effect to be different for Chinese local plants located in Shanghai and those in the rest of the country. This is done by interacting the spillover variable with an indicator equal to one if the local plant is in Shanghai. As the results in the first line in Table 5 show, only Chinese plants located in Shanghai benefit from spillovers. In contrast, we do not find significant spillover effects for plants located in Tsingtao (second line). Notably, the FDI-support policies ran opposite to the results: in Tsingtao the Japanese authorities actively facilitated investment (favourable terms on land, raw materials and machinery), whereas in Shanghai the Zaikabo were purely private entrants operating under European-set rules. That we nevertheless find spillovers in Shanghai and not in Tsingtao reinforces our interpretation, the effect is driven by proximity, a thick shared labour market, and the presence of a substantial base of local recipient firms, while policies supporting FDI as such have less impact.

[27] Our output measure (yards of yarn) does not capture quality upgrading toward higher-count yarn, which attenuates the estimated spillover toward zero, so our estimates are a lower bound. Yarn count is unavailable for the Chinese firms, but splitting the spillover by the source Zaikabo's twisted-yarn share (a proxy for yarn complexity) mirrors the skill-intensity pattern of Table 4, consistent with the transmission of quality-relevant knowledge (see Appendix Table A4).

**Table 5: Heterogeneity of spillover effects depending on Chinese firms**

| | (1) | (2) |
|---|---|---|
| VARIABLES | I=0 (No) | I=1 (Yes) |
| Presence in Shanghai | 1.781 | 0.608*** |
| | (23.488) | (0.196) |
| Presence in Tsingtao | 0.347** | 5.768 |
| | (0.141) | (15.342) |
| Distance to JPN residential area<mean | 0.447** | 1.052*** |
| | (0.207) | (0.269) |
| Firm size > Mean (measured by capital assets) | 0.795*** | 0.869*** |
| | (0.210) | (0.227) |
| Multiplant firm | 0.607*** | 0.610*** |
| | (0.197) | (0.198) |
| Foreign-owned firm | 0.441** | 1.087*** |
| | (0.206) | (0.275) |
| firm age >=mean firm age | 0.271 | 1.246*** |
| | (0.170) | (0.307) |
| Post 1931 | 0.545** | 0.524** |
| | (0.223) | (0.239) |

*Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (based on robust standard errors). Elasticities at the sample mean for the interaction terms are reported. All specifications use the size-weighted spillover term pres_zaikabo_weighted (except the Tsingtao row, which uses the unweighted pres_zaikabo, as in the original specification) and include the same controls (log workers, log spindles) and plant and year fixed effects as column (3) of Table 2.*

We dig a little deeper into the locational aspects by looking at the proximity of the mill location to the Japanese residential area ("Little Tokyo") in Shanghai city. One might argue that Little Tokyo provided additional opportunities for knowledge transfer through informal face-to-face communication in meeting places in this residential area. To account for this, we measure the plant's distance from the central place of Little Tokyo. We then split the sample based on the mean of this measure. The results are in line with our hypothesis: while the positive impact remains significant for both groups, the effect is clearly more pronounced for the mills in the proximity of Little Tokyo. [28]

Further heterogeneities that we looked at are related to other characteristics of the local Chinese mills: size, whether they are a plant of a larger multi-plant company, whether they have some level of foreign ownership (other than Japanese), and the founding year of the firm. Plant size, measured by the capital assets of Chinese mills, appears to be relevant insofar as the point estimates are larger for above-average-sized plants. However, the estimates are also statistically significant for smaller mills, and the confidence intervals of the spillover effects overlap across both size groups.

We find similar spillover effects for single-plant and multi-plant Chinese firms, so the effect is not concentrated in either group. With regard to the age of the local Chinese mills, the spillover is larger and more precisely estimated for older firms: the coefficient is 1.25 (significant at the 1 percent level) for firms above the mean age, against 0.27 (insignificant) for younger plants. A significant effect also pertains to the ownership type of local plants: plants with some non-Japanese foreign-ownership participation see more pronounced spillover effects (an elasticity of 1.09, against 0.44 for wholly domestic firms). The spillover nonetheless remains positive and significant at the 5 percent level even for the wholly domestic firms, so the gains were not limited to firms with some foreign ownership.

As noted in Section 2, relations between Japan and China deteriorated rapidly in the 1930s, particularly after the 1931 Mukden Incident. In such a hostile political environment, one might expect interactions between firms and their workers to be limited, thereby restricting potential spillovers. To examine whether this is reflected in our data, we interact our spillover variable with a dummy variable that equals one for years after 1931 and zero otherwise. The results, reported in the Post-1931 column of Table 5, show that the spillover remains positive, statistically significant and similar in magnitude both before and after 1931. We therefore find no evidence that the productivity spillover diminished following the Mukden Incident: despite the sharp deterioration in the political environment, proximity to Zaikabo continued to raise Chinese mills' output at essentially the same rate. This is consistent with a transmission

[28] Since Little Tokyo was only located in Shanghai, we also estimate this specification for firms only located in Shanghai. Results, which are not reported here to save space, indicate again that proximity to Little Tokyo matters for spillovers. Within Shanghai the elasticity is 0.91 (significant at the 1 percent level) for plants below the mean distance to the Japanese residential district, against 0.25 (statistically insignificant) for plants above it.

channel operating largely through the movement of skilled workers and the imitation of production techniques within a shared local labour market, informal interactions that were relatively insulated from the formal firm-to-firm relations most exposed to the political tensions of the period (Takamura, 1982; Ashizawa, 2014; Tomizawa 2011).

We also examine the implications for spillovers of heterogeneities among Zaikabo. There was substantial heterogeneity in ownership, management system, products, organization, and timing of investment in China (Takamura, 1982). Therefore, not all types of Zaikabo might have the same potential for spillovers.

We first consider whether the Zaikabo reports its headquarters to be in China or in Japan. Some mills (e.g. Naigaimen) headquartered in Japan and established branch offices and plants in China, others established affiliated companies headquartered in China with parent firms in Japan, while some (e.g. Shanghai Bouseki) were headquartered in China and established branch offices in Japan. The potential for spillovers may be higher if the HQ is not located in Japan, as this may indicate that firms are more deeply invested in China, are more internationally oriented and thus generate stronger spillovers. To look at this, we calculate two spillover variables, one based on Zaikabo with HQ in Japan and the other without. We then include both variables in the productivity estimation and report both coefficients in Table 6. Our findings suggest that spillover effects are most pronounced for Zaikabo headquartered outside Japan, in line with our expectations.

Furthermore, we investigate whether the spillover potential differs depending on the size and the age of the *Zaikabo*. We would expect a higher potential for large and old plants to generate spillovers. Larger plants have a higher absolute number of employees, which can potentially move to local plants and transfer knowledge, thus facilitating job-hopping as discussed in Section 2. Also, large and older plants may have a more established knowledge about the industry and the competitive environment, knowledge that can be usefully transferred to local plants. To check this aspect of heterogeneity, we first distinguish plants by employment size into whether they are larger than the lowest percentile of the size distribution or not. We also use an alternative measure defined using the median. Plants are also classified by age using the median age.

Results, shown in Table 6, indicate that larger Zaikabo generate stronger spillovers: mills above the first quartile of the size distribution have a substantially larger coefficient than those below, while across the median the two groups are more similar. The age pattern runs the other way: older Zaikabo generate smaller spillovers than younger ones. This suggests that it is the scale of a Zaikabo and the size of the skilled workforce and modern capacity that go with it rather than its age that governs its spillover potential; if anything, older plants, which are more likely to embody outdated technology, contribute somewhat less.

**Table 6: Heterogeneity of spillover effects depending on Zaikabo**

| | (1) | (2) |
|---|---|---|
| VARIABLES | I=0 (No) | I=1 (Yes) |
| Headquarter in Japan | 0.459*** | 0.183 |
| | (0.101) | (0.119) |
| Firm size > 1. Quartile | 0.115*** | 0.360** |
| | (0.033) | (0.154) |
| Firm size > Median | 0.287*** | 0.319*** |
| | (0.087) | (0.117) |
| Age > Median | 0.537** | 0.322** |
| | (0.214) | (0.136) |

*Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (based on robust standard errors). Elasticities at the sample mean for the interaction terms are reported. All specifications include the same control variable as the main specification in column 3 of Table 2.*

## 7 Conclusions

In this paper, we use comprehensive historic plant-level data to estimate productivity spillovers from Japanese cotton spinning companies' affiliates in China (*Zaikabo*) to local producers in China. We have access to very detailed information on all Zaikabo as well as local cotton spinning firms during the period 1925 until 1938, a period of tumultuous relationships between Japan and China. We geo-localized and digitized this information in order to allow us to pinpoint the exact location of the mills. This enables us to also capture the role of distance in facilitating productivity spillovers.

Our results provide clear evidence for positive spillovers from the Japanese Zaikabo to local Chinese mills. The latter are able to improve their overall productivity, and this goes hand-in-hand with a shift towards greater use of capital: mills exposed to Zaikabo expand their stock of spindles, with no corresponding increase in employment. Our paper is thus the first to provide evidence for such spillovers in a historical context. We also find that spillovers are very localised, being strongest within a radius of up to 10km around the Zaikabo and then petering out with further distance. These extremely localised spillover results may also explain why much of the literature generally fails to find strong evidence for spillovers in the same industry: these studies are not able to zoom in on the geographic dimension in the same detail as we are able to.

At another cut at the geographic dimension of our data, we find that evidence for spillovers is particularly strong for firms in Shanghai. This reflects the importance of Shanghai as the centre for Cotton yarn production at the time.

Overall, our paper shows that FDI spillovers matter also in a historic context. From today's perspective, our paper, by focusing on a very distinct sector with a fairly homogeneous product, provides a novel identification of spillovers, as we can abstract from industry heterogeneity and to a large extent also endogenous plant location, that plague many modern studies using data for the whole manufacturing sector. We are therefore able to clearly pinpoint the source of spillovers and the geographical dimension to it. Our historical approach hence shows that horizontal spillovers can be important.

Our findings suggest that the productivity benefits of FDI depend not only on the presence of foreign affiliates but also on the conditions that facilitate technology diffusion. Geographic proximity and absorptive capacity of local firms play a key role in shaping the extent of spillovers. These findings imply that policies designed to maximize the gains from FDI should promote stronger interactions between foreign affiliates and local firms rather than focusing only on attracting foreign investment.

## Appendix

### Table A1: Local plant vs. remote parent-firm capacity

| | (1) | (2) |
|---|---|---|
| | Log Output | |
| | Baseline | Local + Remote |
| *pres_zaikabo_weighted (local plant)* | 0.608*** | 0.738*** |
| | (0.196) | (0.245) |
| | [0.187] | [0.176] |
| *pres_zaikabo_weighted (parent's remote plants)* | | -0.085 |
| | | (0.107) |
| | | 0.085 |
| log spindles | 0.168* | 0.170* |
| | (0.090) | (0.091) |
| | [0.104] | 0.105 |
| log workers | 0.557*** | 0.550*** |
| | (0.092) | (0.093) |
| | [0.109] | 0.109 |
| Observations | 403 | 403 |
| R-squared | 0.773 | 0.773 |

Robust standard errors in parentheses; Conley HAC standard errors in square brackets. *** p<0.01, ** p<0.05, * p<0.1 (based on robust standard errors). All columns include plant and year fixed effects and log workers and log spindles as controls; spillover coefficients are elasticities at the sample mean. Column (1) is the baseline size-weighted spillover (pres_zaikabo_weighted, as in Table 2, column 3), where each nearby Zaikabo is weighted by its own spindle capacity. Column (2) decomposes this into the capacity of the local plant nearest the Chinese plant and the capacity of the same parent firm's other, more distant plants, entered simultaneously.

**Table A2. Chinese and Zaikabo plants across the sample period**

| | | | | | |
|---|---|---|---|---|---|
| **Panel A. Chinese plants — yarn output (yards)** | | | | | |
| **Year** | **Active plants** | **Mean** | **p25** | **Median** | **p75** |
| 1928 | 36 | 25,969 | 15,898 | 21,159 | 31,014 |
| 1929 | 37 | 25,648 | 16,218 | 21,318 | 29,028 |
| 1930 | 46 | 35,592 | 14,300 | 18,980 | 31,000 |
| 1931 | 44 | 36,289 | 9,914 | 19,500 | 34,150 |
| 1932 | 47 | 22,978 | 14,149 | 18,910 | 35,500 |
| 1933 | 48 | 25,007 | 14,674 | 23,694 | 33,099 |
| 1934 | 44 | 26,559 | 16,630 | 22,944 | 30,800 |
| 1935 | 42 | 26,502 | 14,937 | 20,873 | 32,546 |
| 1936 | 39 | 25,590 | 15,712 | 23,134 | 32,546 |
| 1937 | 37 | 23,927 | 15,741 | 21,266 | 28,822 |
| Total | 420 | 27,531 | 15,122 | 21,318 | 31,464 |
| **Panel A (cont.). Chinese plants — spindle-equivalents** | | | | | |
| **Year** | **Active plants** | **Mean** | **p25** | **Median** | **p75** |
| 1928 | 36 | 41,708 | 24,435 | 32,860 | 54,290 |
| 1929 | 37 | 42,054 | 24,300 | 34,280 | 55,000 |
| 1930 | 46 | 40,265 | 22,400 | 31,334 | 54,012 |
| 1931 | 44 | 40,495 | 19,200 | 33,875 | 57,029 |
| 1932 | 47 | 44,194 | 25,000 | 34,352 | 55,152 |
| 1933 | 48 | 46,912 | 26,776 | 34,152 | 62,830 |
| 1934 | 44 | 50,386 | 27,566 | 37,374 | 65,498 |
| 1935 | 42 | 61,278 | 30,272 | 40,340 | 74,968 |
| 1936 | 39 | 51,325 | 25,580 | 39,100 | 67,768 |
| 1937 | 37 | 48,583 | 33,024 | 37,858 | 63,754 |
| Total | 420 | 46,691 | 25,000 | 35,454 | 61,040 |
| **Panel B. Zaikabo — spindle-equivalents** | | | | | |
| **Year** | **Active plants** | **Mean** | **p25** | **Median** | **p75** |
| 1926 | 30 | 47,194 | 23,040 | 30,464 | 54,222 |
| 1927 | 29 | 41,923 | 23,800 | 34,210 | 59,586 |
| 1928 | 30 | 42,725 | 24,000 | 35,481 | 60,800 |
| 1929 | 29 | 45,845 | 24,000 | 36,752 | 62,400 |

| | | | | | |
|---|---|---|---|---|---|
| 1930 | 27 | 52,781 | 30,800 | 49,200 | 67,956 |
| 1931 | 28 | 55,976 | 32,596 | 48,058 | 72,283 |
| 1932 | 28 | 61,969 | 38,650 | 57,095 | 73,974 |
| 1933 | 28 | 64,708 | 39,006 | 57,669 | 81,556 |
| 1934 | 29 | 65,324 | 39,106 | 59,786 | 80,152 |
| 1935 | 29 | 68,109 | 45,119 | 62,496 | 70,790 |
| 1936 | 31 | 64,823 | 34,288 | 58,400 | 77,200 |
| 1937 | 33 | 66,615 | 34,288 | 54,936 | 77,870 |
| Total | 351 | 56,580 | 29,600 | 49,288 | 67,705 |

Note: Active plants are those with a positive value of the respective variable in that year; the statistics report the cross-sectional distribution across plants within each year. Chinese firms are omitted for 1926 and 1927, where recorded yarn output is zero. The table covers only the geo-referenced firms that enter the distance-based estimation and is therefore smaller than the firm counts plotted in Figure 2, which are based on the full digitised panel. Of roughly 120 Chinese plants in the raw data, about 95 could be geo-located and 51 enter the estimation sample with positive output; the gap between this table and Figure 2 thus reflects both firms that could not be geo-referenced — and so do not enter the distance-weighted spillover — and plant-years without positive recorded output.

***Table A3: Robustness — FDI spillover on alternative measures of total factor productivity***

| | *(1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* |
|---|---|---|---|---|---|---|
| | | | | *Dep. var.: Δ log TFP* | | |
| | *CD-OLS* | *CD-FE* | *Translog* | *Solow* | *Solow* | *Solow* |
| | | | | *s_L=0.5* | *s_L=0.6* | *s_L=0.7* |
| *pres_zaikabo_weighted* | 0.577*** | 0.593*** | 0.536*** | 0.546*** | 0.556*** | 0.565*** |
| | (0.196) | (0.197) | (0.196) | (0.198) | (0.197) | (0.196) |
| *Observations* | [403] | [403] | [403] | [403] | [403] | [403] |
| *R-squared* | *0.345* | *0.357* | *0.344* | *0.355* | *0.355* | *0.358* |

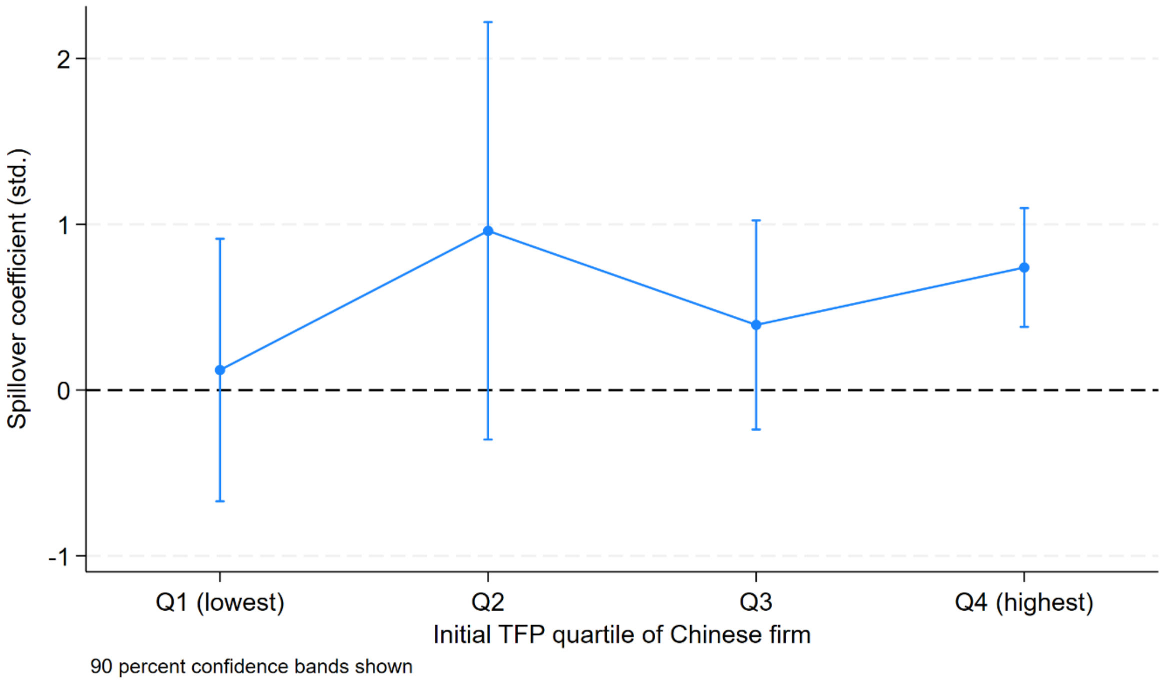
*Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All columns include firm fixed effects and time fixed effects. Each column re-estimates the headline output spillover (pres_zaikabo_weighted) using a different definition of total factor productivity as the dependent variable: pooled-OLS Cobb-Douglas (CD-OLS), within-firm Cobb-Douglas (CD-FE), translog, and Solow residuals under imposed labour shares of 0.5, 0.6 and 0.7.*

*Table A4: Heterogeneity by Yarn Count of Zaikabo*

| | Baseline (all) | High vs low twisted-yarn share |
|---|---|---|
| | b/se/conley_se | b/se/conley_se |
| *pres_zaikabo_weighted (all Zaikabo)* | 0.608*** | |
| | (0.196) | |
| | 0.187 | |
| *pres_zaikabo_weighted (high twisted-yarn share)* | | 0.405** |
| | | (0.177) |
| | | 0.160 |
| *pres_zaikabo_weighted (low twisted-yarn share)* | | 0.269*** |
| | | (0.077) |
| | | 0.096 |
| log spindles | 0.168* | 0.166* |
| | (0.090) | (0.090) |
| | 0.104 | 0.103 |
| log workers | 0.557*** | 0.555*** |
| | (0.092) | (0.091) |
| | 0.109 | 0.106 |
| Observations | 403 | 403 |
| R-squared | 0.773 | 0.775 |

Robust standard errors in parentheses; Conley HAC standard errors in square brackets.Twisted-yarn share = spindletwistedyarn / (spindle + spindletwistedyarn), computed per plant as the mean across observed years. Used as a partial proxy for production complexity / yarn quality. All columns include firm fixed effects and time fixed effects. Spillover terms are reported as elasticities at the sample mean.

*Figure A1: Heterogeneity by Quartiles of Initial TFP*



**Appendix B: Measurement of key variables**

We apply the following unit conventions throughout. Yarn output is reported in Tan (the standard East-Asian unit of weight) up to and including 1934 and in yards from 1935 onward; we convert Tan to yards at the standard formula 1 Tan = 25 yards, which is constant across years and across firms. For cotton output, we additionally multiply square yard by 1.55 to express the volume in package-equivalents, the conventional trade unit in the cotton-textile industry of the period, which makes the magnitudes directly comparable to industry and customs statistics. The number of spindles is converted into a single capital-stock measure using the spindle-equivalent formula of Kiyokawa (1974), 15 × (number of looms) + number of spindles, which we use throughout the empirical analysis. Capital assets are originally reported in either Tael (silver) or Yuan depending on the firm and year. We uniformly convert Tael to Yuan at the official rate fixed by the 1933 currency reform of the Republic of China, 1 Yuan = 0.715 Tael, and apply this rate to all pre-1933 observations. We acknowledge that, prior to 1933, silver and Yuan circulated in parallel and the city-level silver-Yuan exchange rate varied (e.g. Kann (1926) and Ma and Zhao (2020)); the implied measurement error in the pre-1933 capital-assets values, however, does not affect our identification, because the dependent variable in our baseline regression (yarn output, in physical units) and the spillover term (constructed from spindle equivalents and pairwise Euclidean distances) are independent of the currency conversion. Capital assets enter the analysis only in model extensions.

During the preparation of this work, the authors used anthropic claude for coding support. The authors reviewed and edited the output as needed and take full responsibility for the content of the published article.

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