Technology Transfer and Early Industrial Development: Evidence from the Sino-Soviet Alliance

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This paper studies the short and long-run effects of international technology transfer on early industrial development, using evidence from the Sino-Soviet Alliance. Between 1950 and 1957, the Soviet Union supported the so-called "156 technology transfer projects" in China, that involved the construction of large capital-intensive plants in heavy industries, the transfer of state-of-the-art Soviet machinery and equipment, as well as technical assistance and know-how diffusion from Soviet engineers to the Chinese counterpart. We hand-collected archival data on the 156 projects that we complemented with plant, firm and provincial-level information from 1949 to 2013. To estimate the causal effect of the program we exploit that, due to unanticipated political tensions between the two countries, some projects were built as planned with Soviet machinery and technical assistance (*treated projects*), while others were eventually realized by China only without any Soviet technology or assistance (*comparison projects*). We find that: 1) plants in treated projects had better performance that plants in comparison projects in both the short and the long run; 2) Soviet technical assistance diffused industry-specific knowledge through the training of Chinese engineers that further increased plant outcomes; 3) the program generated local horizontal and vertical spillovers; 4) there was a substantial reallocation of production in treated project counties from state-owned to privately-owned companies after the waves of privatization started in 2005.

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1 Introduction

Technology transfer is a key driver of economic development. As its international diffusion allows less developed countries to catch up with the most advanced ones, foreign technology adoption at the firm-level can determine a substantial boost in plant productivity and performance (Pavcnik, 2002; Mel et al., 2008; Goldberg et al., 2009; Bruhn et al., 2018; Giorcelli, 2019; Hardy and Jamie, 2020). Nevertheless, there is limited causal evidence on the effects of international technology transfer on early industrial development, primarily due to lack of data and arguably exogenous variation. In fact, the specific technologies used by firms are rarely observed, and even when they are known, their adoption is correlated with firm outcomes (Doms et al., 1997). While randomized control trials (RCTs) could be used to overcome these issues (Bloom et al., 2013a; Atkin et al., 2017), their relatively small sample size and short time horizon make it hard to assess long-run and spillover effects within and across industries. Moreover, little is known about the impact of capital-embodied foreign new technologies relative to the acquisition of "tacit" knowledge and industry-specific know-how, usually included with such transfers.

This paper studies the causal effect of technology transfer on early industrial development, using evidence from the Sino-Soviet Alliance. After its foundation in 1949, China was primarily an agricultural economy. To promote its industrialization, the Soviet Union supported the so-called "156 technology transfer projects" to build large, capital-intensive plants in heavy industries. These projects could be of two types: "complete", for which the Soviet Union provided state-of-the-art machinery and equipment, as well as technical assistance, know-how and training for Chinese engineers; and "partial", for which the Soviet Union only provided machinery and equipment, without any form of assistance or training. This program was considered a vital factor in the Chinese industrial development. Its investments accounted for 45 percent of Chinese GDP in 1949 and allowed the country to receive the most advanced technology available in the Soviet Union, that in some specific industries, like steel and iron, was the best in the world (Lardy, 1995).

We use newly assembled data from historical archives on the "156 technology transfer projects" approved under the Sino-Soviet Alliance. For each project, we collected and digitized detailed information on its location, industry, size, and whether it involved a complete or a partial technology transfer. We then matched the newly-built plants with declassified data on their performance yearly until 2000 for those in the steel industry and in the longer run (1985 and between 1998-2013) for those in all the industries. We complement such outcomes with declassified county- and province-level data yearly from 1949 to 2000.

Our identification strategy relies on some unanticipated political tensions between China and the Soviet Union since 1959 that caused the end of the Sino-Soviet Alliance, known as Sino-Soviet split. As a result, projects that had received the technology transfer before the split maintained the Soviet machinery and the equipment, while the remaining ones were completed by China only, without any Soviet machinery and equipment nor technical assistance. In turn, the fact that some projects were completed before the Sino-Soviet split – therefore with the Soviet technology transfer (*treated projects*) – and some others after the split – therefore by China only (*comparison projects*) – did not depend on their characteristics or the potential to be successful, but on the unexpected and unforeseen delays in their implementation from the Soviet counterpart that arose after each project had been approved and started. Notably, we show that treated and comparison projects were very similar in their observable characteristics. Moreover, we use an IV strategy in which we instrument the probability of receiving the Soviet technology transfer with the delays projects experienced. While the delays strongly predict whether a project was completed before or after the split, they are uncorrelated with project characteristics.

We find three key results. First, using plant-level data for the steel industry from 1949 to 2000, we show that the technology transfer program had large and persistent effects on plant performance. Treated plants increased output quantity and quality relative to the comparison plants and were on yearly average 23.5 percent more productive, with similar level of workers and inputs usage. At the time of the program, treated plants started using more modern production processes related to the adoption of the Soviet machinery. After 1985, when China gradually opened to trade, these plants updated their equipment to a much larger extent than comparison plants by importing foreign machineries. While the number of workers did not differentially change between treated and comparison plants, the former employed more engineers and high-skilled technicians than the latter. All these results are robust and similar in magnitude to the IV specifications.

Second, declassified firm-level data in 1985 and between 1998 and 2013 for firms in all industries not only confirm the long-lasting effect of technology transfer, and further indicate that, relative to comparison firms, treated firms produced at lower costs, diversified their production in terms of total number of products and new products more and engaged in exports to a greater extent. Comparing the performance of treated and comparison firms with the other Chinese firms show that in 1985 and between 1998 and 2004, treated firms were performing better, while comparison firms had larger size and assets, but were not more productive. However, when China started a huge wave of privatization in 2005, firms that became privately owned had higher value added and become more productive than treated firms, but no higher employment or fixed assets. Nevertheless, treated firms remained more productive than the other public firms and comparison plants maintained larger size and assets.

Third, receiving the complete technology transfer (Soviet machinery and technical assistance) rather than the partial technology transfer (Soviet machinery only) had an additional positive effect on performance. Plants that received the complete technology transfer made the Soviet machinery productive faster in lieu of the complementarities between physical and human capital, produced more and better quality output, employed a higher fraction of engineers and in the long-run had a higher variety of products and exports. These results suggest that receiving foreign on-the-job training can diffuse tacit industry-specific knowledge that complements the transfer of technologies embodied in capital goods.

The major goal of the technology transfer program was to create large industrial plants to push local industrial development. Did the program generate such spillover effects? We document that between plant opening year and 1985 a higher number of plants operating in the same industry of treated plants located within 50 km of them relative comparison plants. Spatial proximity to treated plants generate positive horizontal spillovers, due to knowledge more than technology diffusion. In fact, only firms located close to treated plants that received the complete technology transfer had higher production and productivity than firms at the same distance of comparison plants. This result was driven by an improvement in existing processes, that relates to the diffusion of industry-specific knowledge by the Soviet-trained engineers in nearby treated plants. Conversely, until 1985 technology diffusion appeared limited. In fact, at the time China had limited capacity of building the Soviet-imported machineries on its own and was facing an embargo from the US and its Allied countries, which strongly limited the possibility of importing technologies from abroad. As soon as these constraints became less binding in the mid-1980s, firms close to treated firms imitate their technology by importing the same foreign advanced machinery. By contrast, the flow of knowledge did not face the same constraints and therefore diffused between plants treated with the complete technology transfer and nearby firms, even when China was a closed economy. In terms of vertical spillovers, firms within 50km of an upstream treated plant, relative to an upstream comparison plant, could rely on a better quality of inputs that increased their productivity, but did not experience any technology transfer. Firms within 50km of a downstream treated plant had higher volume of production, mostly driven by the increased demand from the treated plants themselves.

We further examine how technology adoption interacted with institutional changes associated to the large wave of privatization in China in 2000s. Our results indicate that firms located close to treated plants had better outcomes if they became private-owned after 2005 and were economically related to the such plants. We therefore explore the mechanisms behind these findings. Specifically, we document that counties where treated plants were located had higher competition and a higher level of human capital than counties where comparison plants were located. These two factors likely interacted with the market economy characteristics, pushing privately-owned firms to adapt faster to the changing market conditions and to employ better workers to remain competitive. Conversely, we do not find a differential share of government investments in treated and comparison counties.

Finally, we assess the contribution of the technology transfer program to the Chinese aggregate growth rate between 1950 and 2000. First, we show that having one technology transfer project more completed by the Soviet Union increased the province-level output on average by 13.2 percent per year. Second, we compute the cross-sectional fiscal multiplier: for every $1 additional technology transfer investments per capita that a province received (compared to others), its GDP per capita increased by $0.85. A back-of-the-envelope calculation shows that the program contributed to roughly half of the Chinese real GDP per capita growth between 1953 and 1978, confirming the vital importance of technology transfer for Chinese early industrial development, as underscored by the historical records.

The contribution of this paper is threefold. First, it contributes to the literature studying the effects of technology adoption and know-how diffusion across countries. While previous papers have documented the positive effects of technology adoption on short run firm performance (Pavcnik, 2002; Mel et al., 2008; Goldberg et al., 2010; Bruhn et al., 2018; Hardy and Jamie, 2020) and the barriers to technology diffusion (Atkin et al., 2017; Bloom et al., 2013a, 2020; Juhász et al., 2020), our work examines the short and long-run role of international technology transfer on early stages of industrial development. Moreover, the coexistence of complete and partial technology transfer projects allows us to disentangle the impact of the diffusion of technology embodied in foreign capital goods from that of tacit industry-specific knowledge (Mostafa and Klepper, 2018).

Second, this paper relates to the large literature on spillover effects. Existing research has shown sizable spillovers determined by opening of new large plants (Javorcik et al., 2008; Greenstone et al., 2010; Alfaro-Urena et al., 2019), technology externalities (Javorcik et al., 2008), worker mobility (Stoyanov and Zubanov, 2012), and managerial knowledge diffusion (Bloom et al., 2020; Bianchi and Giorcelli, 2020b). This paper complements their findings by looking at spillovers in the context of a planned economy, its transition to a market economy, and by studying the long-run mechanisms.

Finally, this paper contributes to the economic history literature examining the international technology transfer programs in the aftermath of WWII. A number of studies have examined the effects of US-sponsored technology transfer program, underscoring their importance for the Western Europe and Japanese recover from WWII and their subsequent economic growth (Cusumano, 1985; Yamazaki and Wooldridge, 2013; Giorcelli, 2019). To the best of our knowledge, this is the first paper to provide a comprehensive analysis of the Soviet-sponsored technology transfer over a more than 50 years time horizon.

The rest of the paper is organized as follows. Section 2 describes the institutional background of the technology transfer program introduced in China. Section 3 describes the data sources used in the paper and presents a set of basic stylized facts. Section 4 presents the empirical framework and discusses the identification strategy and assumptions. Section 5 studies the effects of the technology transfer on firm-level outcomes. Section 6 examines the agglomeration effects, as well as the horizontal and vertical spillovers of the technology transfer program. Section 7 estimates the aggregate effects of the technology transfer program. Finally, Section 8 concludes.

2 The Sino-Soviet Alliance and Technology Transfer

2.1 The Birth of the Sino-Soviet Alliance

With the end of WWII, a bipolar international order emerged, dominated by the confrontation and competition between the United States and the Soviet Union. Both countries tried to expand their area of influence by offering help to war-torn countries. While the US provided substantial economic and financial aid to Western Europe under the Marshall Plan (1948-1952), the Soviet Union responded with the Molotov Plan (1947-1949), later expanded into the COMECON (1949-1991), a system of bilateral trade agreements and an economic alliance with Eastern Europe.

In this situation, for both powers a strategic alliance with China became crucially important. Since 1927, China was intermittently involved in a Civil War fought between the Kuomintang (KMT)-led government of the Republic of China (ROC) and the Communist Party of China (CPC). The U.S. government supported the Kuomintang and the government of the ROC by providing military, economic, and political assistance,[1] but in 1949 the War came to an end with the victory of the CPC and the foundation of the People's Republic of China (PRC). The newly-formed government adopted a centralized planned-economy model, based on the state ownership of all economic activities and large collective units in agriculture. Despite some initial distrusts, the PRC inspiring principles and its economic system provided the ideological basis for cooperation with the Soviet Union. On February 14, 1950, the two countries signed "Sino-Soviet Treaty of Friendship, Alliance and Mutual Assistance", that marked the start of a large-scale economic and military cooperation and the official recognition of PRC as a strategic partner by Soviet Union (Zhang et al., 2006). As a response to Sino-Soviet Alliance, the United States and its allies imposed economic sanctions against the PRC in the 1950s and stopped any trade activities with the country.

[1] On December 16, 1945, US President Truman described the policy of the United States with respect to China as follows: "It is the firm belief of this government that a strong, united and democratic China is of the utmost importance to the success of the United Nations Organization and for world peace" (United States of America Government Printing Office, 1945, p.945).

2.2 Setup of the Technology Transfer Program

At the end of the Civil War, China's economy was largely premodern. Almost two-thirds of output was originated in agriculture, less than one-fifth in industry, and the few firms built under the Japanese occupation had been destroyed during WWII bombing (Lardy, 1995, p.144). Only 10% of aggregate output was produced with modern methods and 90% of the workforce, mostly concentrated in agriculture, was employing traditional technologies (Lardy, 1995, p.167).

As declared in the First Five Year Plan (1953-1957), one of the major goals of the newly-formed government was to build a modern industrial system. However, the country was lacking technical knowledge and expertise to do so on its own. The Chinese leaders wrote in their 1955 memories that, "[...] at the beginning [they] didn't quite understand what should be done first and what should be done later in industrial development, and how to coordinate various departments given limited inputs." Therefore, PRC officials pressed hard for economic aid and technology transfer from the Soviet Union (Zhang et al., 2006, p.110). As a result, between 1950 and 1957, the two countries reached various agreements in support of the so-called "156 technology transfer projects", which involved the construction of large-scale, capital intensive plants in heavy industries. The total value of such investments amounted to 2020 USD 80 billion (20.2 billion in 1955 RMB), equivalent to 45.7 percent of Chinese GDP in 1949 and 144.3 percent of its industrial output.[2]

The Chinese government aimed at mimicking the development model of the Soviet Union in the 1930s, whose industrialization focused on heavy industry, as Mao Zedong urged at the first meeting of the Central People's Government Committee in June 1954: "How long does it take to build a great socialist country? [...] Would it take three Five-Year Plans – fifteen years? What can we build now? We can make tables, chairs, and teapots, can grow grains, [...] However, for cars, airplanes, tanks, we can not make at this stage." Consequently, technology transfer projects focused on heavy industrial sectors, such as metallurgy, machinery, manufacturing, electricity, coal, petroleum, and chemical raw materials, as well as aerospace and military products, to achieve military parity with foreign powers.

[2] The Soviet Union did not provide any aid in form of grants and loaned to China only 2020 USD $2.9 billion (1955 USD 300 million) in response to a Chinese request 10 times higher. According to historical archives, in 1949 Mao Zedong planned to visit Moscow, hoping that the Soviet Union would provide a loan equivalent to 1955 USD 3 billion (2020 USD $29.3 billion). On June 27, 1949, Stalin and the USSR government agreed to loan 1955 USD 300 million to the Chinese government within 5 years at an annual interest rate of 1% by signing the "Agreement on Loans from the Soviet Union to the People's Republic of China." This loan shall be used to "repay the Soviet Union's delivery of machinery and equipment, including power stations, metal and machinery, coal mining and mining equipment, railways and other transport equipment [...]". China shall trade raw materials, tea, agricultural products at foreign exchange rates to repay principal and interest from December 31, 1954 to December 31, 1963. The prices of machinery, equipment, raw materials and other commodities were calculated according to world market prices.

The technology transfer projects were of two types: "complete technology transfer" projects, for which the Soviet Union provided state-of-the-art machinery and equipment, as well as technical assistance and know-how, and "partial technology transfer" projects, for which the Soviet Union only provided machinery and equipment, without technical assistance. More specifically, declassified documents from telegram conversations between the Chinese and Soviet leaders indicate how the Soviet assistance to the "complete technology transfer" projects was comprehensive, ranging from Soviet technical assistance in prospecting and surveying geological conditions, selecting plants site, supplying the design, and directing the construction, to the provision and installation of machinery and equipment, the supply of industrial products, and the training of Chinese personnel (Lardy, 1995, p.177).[3] According to the Chinese official archives, "by 1959, China had obtained close to 4,000 product designs from the Soviet Union. These technical information improved the production of high-quality steel, vacuum instruments and other industrial products." Conversely, for the "partial technology transfer" projects, the Soviet Union supplied machineries and equipment, but it did not provide training for Chinese engineers nor product design.

Through this program, China received the most advanced technology available in the Soviet Union, that in some specific industries was the best in the world. For instance, in the iron and steel industry, during the 1950s Soviet Union built and operated the world's best blast furnaces, that were installed in Chinese plants in Wuhan and Paotou (Lardy, 1995, p.178).

The location of Soviet-assisted plants was chosen based on geological conditions and the access to natural resources, where coal, mining and water were considered the most important inputs, according to the discussions between the Chinese and Soviet engineers. For example, the experts from the Soviet Ministry of Metallurgy offered advice on how to develop the non-ferrous metal industry: "The copper smelting cannot be carried out anywhere, and the necessary conditions must be met — [the plants] must be built on copper rich ore. That is, the construction of the plant should have the copper reserves below and the copper content of the ore should be tested during the site selection. The copper smelting must also pass the certain technical requirement, with the specific air volume, air temperature, and product standards. Large enterprises such as Guizhou Aluminum Company are very dangerous to build without the exact ore reserves tests conducted by the state." Beside the

[3] In spite of numerous references to Soviet technical personnel in the Chinese press, no reliable totals are available on the number of Soviet military and civilian specialists assigned to Communist China. According to the statistics recorded by the Soviet Ministry of Foreign Affairs, 5,092 Soviet technical personnel had been working in China during this period prior to the Sino-Soviet Split. For example, the Soviet Union sent 340 engineers to work at Anshan Iron and Steel Group.Among them, 56 of them served as management consultants, and the other 92 involved in production through training Chinese engineers side-by-side. In addition, Anshan Iron and Steel Group successively sent cadres, technicians and workers to Soviet iron and steel enterprises, research institutes and colleges and universities to learn about the Soviet metallurgical production technology, construction and management experience for 1-3 years.

geological conditions, the Chinese leaders had a strong preference in choosing inner regions and mountain areas for national defense purposes to isolate these areas from potential military attacks, as documented from their memoirs. For these reasons, the technology transfer projects were concentrated in the northeastern regions (Heilongjiang, Jilin, Liaoning) and the inner regions (Shaanxi, Shanxi, Gansu, and Hubei, Figure 1). In this respect, the Soviet assistance shaped the geographical distribution of Chinese industrialization, since before that the few existing firms were almost uniquely located along the coasts (Lardy, 1995, p.145).

2.3 Implementation of the Technology Transfer Program

The technology transfer program implementation was substantially slower than initially planned by the Chinese and Soviet leaders. In fact, while the different projects mostly started as scheduled, unexpected or unforeseen issues on both sides slowed down their completion. First, the Soviet Union faced repeated constraints in the production of equipment to be delivered to China. As early as 1949, Stalin wrote in an official telegram to Mao Zedong: "Right now, we do not have equipment in reserve and the request for industrial goods must be submitted ahead of time". Soon after, the Soviets fell short in their effort to meet the Chinese demand, as the country needed "too much too soon" (Zhang et al., 2006, p.117). For instance, between 1955 and 1960, the steel rolling equipment provided to China amounted to one third of the Soviet's annual production and some machineries were delivered before even being employed in the Soviet factories (Lardy, 1995, p.178).

Second, Chinese experts themselves were uncertain on which equipment requests they should submit to Soviet Union. Replying to Stalin telegram in 1949, Mao Zedong argued that "[they were] having difficulties in putting together a request for equipment, as the industrial picture [was] still unclear". While the Soviet experts should have helped in deciding which projects prioritize, their limited supply limited the advices they could give. Similarly, lack of Soviet experts created additional delays after the plant construction started since the Chinese counterpart lacked experience to substitute their role. Finally, the different languages spoken by Chinese and Soviet experts required the constant presence of translators who were available in limited numbers, a factor that slowed slowing down the technical assistance component of the program. As a result, while the expected length of a project was 2.9 years, the actual length ended up being 5.3 years.

2.4 The Sino-Soviet Split

The Sino-Soviet alliance went in turmoil since 1958 due to some political and ideological reasons. In addition to the initial distrust that characterized the Sino-Soviet relationship, Mao

Zedong started limiting Soviet control over China.[4] Moreover, the Chinese leader did not agree with Khrushchev's idea of a peaceful coexistence with the Western World[5] and, in response to that, the Soviet Union declared its neutrality in the Sino-Indian war (Lardy, 1995, p.501).[6] Finally, different interpretations and practical applications of Marxism–Leninism created also an ideological opposition. Despite the attempt to maintain bilateral relationship in the early 1960s, no agreement could be reached and the Sino-Soviet cooperation formally ended in 1963.

However, well before the formal end of the alliance, the technology transfer program was dramatically reduced in its scope, as in 1960 the Soviet Union withdrew its experts from China and interrupted the provision of machineries and equipment. By then, 80 out of the 139 technology transfer approved projects were already completely. These projects maintained the Soviet-designed machinery and the equipment installed by its engineers and technicians. However, the remaining 59 approved projects – for which location, industry and type of equipment had already been decided and that were about to start – were canceled. In practice, this meant that the China completed such projects on its own, but without relying on Soviet machinery and equipment nor on Soviet specialists technical assistance.[7]

3 Data

We analyze the effects of the Soviet technology transfer on Chinese industrial development by combining different types of historical and administrative data collected from primary sources. In this Section, we document the data collection process and we describe the data collected. Additional details on the data collection could be found in Appendix B. A list of all the all the variables used in the paper with their definitions, aggregation level, time period and sources could be found in Appendix Table B.1.

[4] On 31 July 1958, Krushchev secretly visited Beijing to negotiate with Mao Zedong, who refused an offer to establish a joint Soviet-Sino submarine fleet and to build a military broadcasting station in China. The diplomatic relations between the two countries begun to erode as Krushchev's visit to Beijing proved to be fruitless (Lardy, 1995, p.482).

[5] In 1959, Soviet Premier Khrushchev met with US President Eisenhower to decrease Soviet-American geopolitical tensions. Mao Zedong saw the event as an indication of Soviet Union being politically untrustworthy as an orthodox Marxist country.

[6] The Sino-Indian war was caused by a dispute between India and China around the Himalayan border. In 1959, when India granted asylum to the Dalai Lama, Chinese officials warned Moscow that New Delhi had provoked the border dispute. However, Moscow implicitly rejected the Chinese position by taking a complete neutral stand on the "incident" (Lardy, 1995, p.512). The war was actually fought between October 20 and November 20 1962, when China declared a unilateral ceasefire after having reached its claimed portion of the border.

[7] 105 industrial projects were under discussion in the late 1950s for a second phase of the technology transfer program, but had not been formally approved at the time of split. Almost all these projects for which location, industry and type of equipment hadn't been discussed yet, ended up not being implemented.

3.1 Technology Transfer Projects

We started our data collection by retrieving the list of the technology transfer projects signed under the Sino-Soviet Alliance from the official agreements between the Soviet Union and PRC, stored at the National Archives Administration of China. These documents indicate that, while the initial discussions between Chinese and Soviet leaders aimed at 156 technology transfer projects, between 1950 and 1958, 139 ones were eventually approved. For each of them, we collected detailed information on the project name and location, the name of plant built, industry, size and capacity, whether the project involved a complete or a partial technology transfer, and whether it was completed with the Soviet assistance or by China only due to the Sino-Soviet split.

Out of the 139 approved projects, 80 (57.55 percent) were completed before the Sino-Soviet Split, while the remaining 59 (42.45 percent) were completed after it, therefore by China only without Soviet equipment, machinery, and technical assistance. Complete technology transfer projects were 83 (59.7 percent) and partial technology transfer ones were 56 (40.3 percent). Most technology transfer projects were located in the northeastern regions and the inner regions for strategic reasons and for closeness to natural resources. The technology transfer projects involved the construction of large industrial plants, employing on average 27,690 workers, for a total of around 4 million workers. While this number represented only 2 percent of the total workforce, it amounted to 26.6 percent of employment in the industrial sector. As asked by Chinese leaders, projects were concentrated in heavy industries. Specifically, electricity sector accounted for 23.0 percent of approved projects, machinery sector for 21.6 percent, coal sector for 20.1 percent and steel and non-ferrous metal for 14.4% and 10.1% (Appendix Figure A.1). Only 2 projects (1.4 percent) were in light industry. Almost 77 percent of the projects were approved between 1950 and 1952, and 80 percent of them were started between 1952 and 1954 (Table 1). The average planned investment per plant amounted to 2020 USD 579.4 million and the average actual investment to 2020 USD 569.5 million. The average plant capacity was 107.48 thousand tons per KW.[8]

Notably, projects completed under the technology transfer program and projects completed by China only appear similar in their characteristics (Table 1, columns 5 and 6, Panel A). The only difference is represented by the delays in completion. While projects completed under the technology transfer program had an average delay of 2.9 years, the projects completed by China only were delayed by 5.3 years.

[8] This information is only available for 57 projects in coal, electricity, oil and steel industries.

3.2 Firm-Level Data

We manually collected and digitized plant-level restricted annual reports compiled yearly by the Steel Association for the 94 steel plants operating in China from 1949 to 2000. The reports contain rich information on plant performance, such as quantity and type of steel products, inputs utilization, the specific machinery in use, capital, fixed investment, profits, and number and types of workers (unskilled workers, high-skilled workers, and engineers). Using plant name, location, county, and province, we manually and uniquely matched the 20 steel plants that were supposed to participate in the technology transfer program with their outcomes in the Steel Association reports. Specifically, half of the plants belong to projects that received the Soviet technology transfer, while the other half belong to projects completed by China only.

We also accessed confidential firm-level data from the Second Industrial Survey, conducted by Statistics China in 1985 and declassified for this project, which is considered the most comprehensive data on industrial enterprises between 1949 and the early 1990s. The Survey covers more than 40 industries within the industrial sector and contains firm-level data for the 7,592 largest firms operating in China in 1985. For each of them, the Survey gathered data on output, sales, profits, fixed assets, raw materials, total wages, number of employees, finished product inventory, main products, production equipment, and year of establishment, that we manually collected and digitized. Using plant name, location and province, we manually and uniquely matched all the 139 plants that were supposed to participate in the technology transfer program to their performance in 1985. To the best of our knowledge, this is the first paper that systematically uses Chinese steel plant-level data and firm-level data prior 1990s. From the Survey, we also collected and digitized county-level and prefecture-level industrial production data.[9]

Finally, we manually matched all the 139 plants that were supposed to participate in the technology transfer program with their performance between 1998 and 2013, contained in the China Industrial Enterprises database. The China Industrial Enterprises database, compiled yearly from 1998 and 2013, covers more than 1 million industrial publicly listed and private enterprises above a designated size in China.[10] It includes a rich set of information on firms: firm output, number of employees, profits, as well as ownership structure and capital investment.

[9] Counties are Chinese administrative areas, comparable to US counties. Provinces are Chinese administrative areas, comparable to US states. Prefecture cities are Chinese administrative areas, larger than counties, but smaller than states.

[10] The data include firms with asset value exceeds 5 million yuan prior to 2011, and 20 million yuan after 2011.

3.3 Statistical Yearbooks

We manually collected and digitized province-level data on GDP, population, capital, investment, and number of workers from the Statistical Yearbooks compiled yearly between 1949 and 2000 by Statistics China. This data confirms that PRC was little industrialized at the time of its foundation. In 1950, the average share per province of firms in agricultural sector was 85 percent, that accounted for 80 percent percent of total provincial output. By contrast, the share of provincial output in heavy industries was relatively small, representing less than 18 percent of the total provincial production.

Between 1952 and 1985, the situation gradually changed. Heavy industries uniformly increased their shares of production, at the expenses of light industries (Appendix Figure A.2, Panel A). For instance, the machinery industry expanded its capacity from 11.4 percent to 22 percent and chemical industry from 4.8 percent to 11.8 percent during these 30-year period (Appendix Figure A.2, Panel B).

In the first 15 years of PRC, as adopting the Soviet model, the government control over industry dramatically increased. In 1952, were 48.7 percent of the firms were privately-owned, while state-owned corporations were only 20.2 percent. However, in 1965 more than 90 percent of firms were state owned (Appendix Figure A.3, Panel A). During the same period, the agriculture industry was commonly organized into state-controlled cooperatives. Also the location of industrial activities gradually changed, moving from the coastal regions to the inner part of the country (Appendix Figure A.3, Panel B). This is consistent with the fact that most technology transfer projects were located in inner regions for strategic reasons and for proximity to natural resources.

4 Identification Strategy

We estimate the effects of the technology transfer program via the following equation run over the sample of plants built in projects completed under the Soviet technology transfer (*treated* projects) and in those completed by China only (*comparison* projects):

$$\text{outcome}_{ist} = \alpha + \beta \cdot \text{Treatment}_i + \theta_{st} + \epsilon_{it} \tag{1}$$

where outcome_{ist} is one of several key performance metrics, such as logged output, TFP,[11] fixed assets, and workers of firm i in industry s at time t; Treatment_i is an indicator that equals one for plants that belong to projects completed under the Soviet technology transfer and zero for plants that belong to projects completed by China only, and θ_{st} are industry-

[11] According to the possibility of measuring firm physical output or deflated revenues, we compute TFPQ or TFPR. Details about their estimation could be found in Appendix C.

year fixed effects. For firms operating in the steel industry, we observe yearly outcomes since firms started operating to 2000 and in estimating equation 1 we replace the industry-year fixed effects θ_{st} with year fixed effects. For all the firms, we observe outcomes in 1985 and between 1998 and 2013. Standard errors are clustered at the firm level. For firms in the steel industry we use the wild bootstrap to solve a "small number of clusters" issue (Cameron et al., 2008). Appendix D.3 provides robustness to alternative clustering level.

The identification assumption of our strategy is that the fact that some projects were completed before the Sino-Soviet split, and therefore with the Soviet technology transfer, and some others after the split, and therefore by China only, did not depend on their characteristics or the potential to be successful, but on the unexpected and unforeseen delays in their implementation that arose after each project had been approved and started.

As described in Section 2.3, the historical records explain that the delays in projects completion did not depend on their attributes, but were originated by constraints on Soviet production capacity, lack of China expertise, and limited supply of Soviet experts and translators (Lardy, 1995). Consistently with this evidence, we find that treated and comparison projects are statistically indistinguishable in terms of their characteristics. Specifically, a mean comparison between treated and comparison projects in the fraction of complete vs partial technology transfer projects, the approve and start years, number of workers, the planned and actual investments, and the capacity indicate that their values are remarkably similar (Table 1, Panel A, columns 5 and 6). In all these cases, we fail to reject the null hypothesis of mean equality between the two groups of projects (Table 1, Panel A, column 7). The only large and statistically significant difference between treated and comparison projects is given by the delays in their completion, that are on average 2.9 years in the former and 5.3 years in the latter. The results are substantially unchanged if we restrict the comparison to projects in the steel industry, for which we observe yearly data from their completion (Table 1, Panel B).

Despite the similarity in their observable characteristics, treated projects may have been located in more developed regions, whose firms would have grown more regardless of the technology transfer program. This is an unlikely scenario since, when the program started, Chinese industrialization was extremely limited and concentrated along the coast, while the technology transfer projects were located in inner regions for strategic purposes, as shown in Section 2.2. However, to investigate this potential issue further, we provide two pieces of evidence. First, we regress the Treatment variable on a full set of province fixed effects. None of the 16 estimated coefficients – corresponding to the 16 Chinese provinces in which at least a project was located, using Beijing as the excluded province – is statistically significant, confirming lack of correlation between projects location and the probability of receiving the treatment (Figure A.4).

Second, we show that the share of completed projects in each province is independent from province outcomes and its pre-program trends. More specifically, the share of completed projects is uncorrelated with province GDP, both aggregate and divided into primary and secondary sector, population, number of workers, number of firms, industrial output, investment by the government outside the technology transfer program, capital productivity and total factor productivity between 1949 and 1951, the year before the program started (Table A.1, column 1). The results are robust to the addition of controls such as provincial technology transfer investments and total number of approved projects (Table A.1, column 2), as well as year fixed effects (Table A.1, column 3). Moreover, the share of completed projects appear independent from the province time trend in the three years before the start of the program. The 10 estimated coefficients on the interaction between a linear pre-trend and the share of completed projects are never significantly different from zero (Table A.2, column 1). Similarly, we can never reject the null hypothesis that the coefficient on the share of completed projects is significant, confirming the lack of correlation between this variable and project characteristics (Table A.2, column 2).

4.1 IV Estimation

Since the probability of eventually participating in the program depended on the delays on project completion, we also propose an IV approach in which we instrument the Treatment variable with such delays, defined as the difference between the actual and the planned year of project completion. The exclusion restriction implies that the delays affected plant outcomes only through the treatment itself. As the delays in project completion depended on unexpected issues that emerged after the projects were approved and started, they are uncorrelated with project characteristics. Approve year, start year, fraction of complete technology transfer projects, number of workers, planned and actual investments, and capacity never predict project delays (Table A.3, Panel A, columns 1-4). The results are robust to controlling for province and sector fixed effects (Table A.3, Panel A, columns 5 and 6). Albeit the smaller sample, the results are similar if we restrict our sample to projects in the steel industry (Table A.3, Panel B). However, delays predict whether a project was finished before the Sino-Soviet split. Conditional on approve date, start date, complete (or partial) technology transfer, number of workers, investment and size, projects that lasted one year more than planned were 16.7 percent less likely to be completed with the Soviet technology transfer (Table A.4, Panel A, columns 1-3). We find a similar results if we estimate the marginal effects of a Probit model (Table A.4, Panel A, column 4) and if we control for province and sector fixed effects (Table A.4, Panel A, columns 5 and 6). Similarly, in the steel industry, projects that lasted one year more than planned were 23.8 percent less likely to be completed with the Soviet technology transfer assistance, a result confirmed by the Probit estimation that indicate a 21.7 percent lower probability (Table A.4, Panel A, columns 1 and 4).

Taken together, the results presented in this Section indicate lack of correlation between project and province characteristics and the probability of receiving the treatment, and a strong and negative correlation between project delays and the probability of receiving the treatment.

5 Effects of Technology Transfer on Firm Performance

In this section we study the effect of the technology transfer program on firm-level outcomes. For the steel industry, we have a panel dataset at the plant-level from the year of plant opening to 2000. For the other industry, we use firm-level data in 1985 and between 1998 and 2013.

5.1 Plant-Level Results in Steel Industry

The results of estimating equation 1 on treated and comparison plants in the steel industry indicate that the technology transfer program had large and persistent effects. Between plant opening and 2000, treated plants produced on average a 24.1 percent yearly higher quantity of steel than comparison plants (Table 2, Panel A, column 1). These results are confirmed by the IV specification, whose estimates indicate a 30.3 percent average yearly higher quantity of steel for treated plants relative to the comparison ones (Table A.5, Panel A, column 1). Conversely, the number of workers, fixed assets, and inputs quantities, such as coke and iron, are not significantly different between treated and comparison plants, according to both the OLS (Table 2, Panel A, columns 3-5) and the IV specifications (Table A.5, Panel A, columns 3-5). Treated plants had a higher total factory productivity quantity (TFPQ) than comparison plants,[12] with an estimated yearly difference of 23.5 percent according to the OLS specification (Table 2, Panel A, column 6) and of 29.6 percent according to the IV specification (Table A.5, Panel A, column 6). The increase in TFPQ was mostly driven by the increase in quantity of steel produced as inputs were not differentially affected by the program. The effects of the program on TFPQ were persistent over time. As shown in Figure 2, Panel A, the estimated annual coefficients indicate that the impact of technology transfer on TFPQ became significant in treated plants relative to the comparison ones 3 years after its implementation, continued to systematically raise until 9 years after it, when they reached a 38.6 percent higher level, and remained large and significant, albeit not increasing, until 50 years after the program.

[12] Details about TFPQ estimation could be found in Appendix C.

The technology transfer program had also an impact on the quality of the production. Treated plants increased the production of crude steel, considered the best-quality steel, by 25.2 percent yearly after the program, and reduced the production of pig iron, considered of a lower quality given its higher carbon content, by 17.8 percent (Table 2, Panel B, columns 1 and 2). These findings are confirmed by the IV estimation, that show a 20.9 increase of crude steel production and a 31.4 reduction in pig iron production (Table A.5, Panel B, columns 1 and 2). To relate these changes to the Soviet technology transfer, we analyze the processes employed in the steel production process. After participating in the technology transfer program, treated firms increased the quantity of steel produced with open heart furnaces by 37.9 percent and that produced with basic oxygen steelmaking by 33.5 percent (Table 2, Panel B columns 3 and 4). Both processes were the most advanced steel production methods available at the time. Specifically, the open heart furnaces allowed the production of better quality steel compared to the most diffused Bessemer steel process, as they did not expose the steel to excessive nitrogen (which would cause the steel to become brittle), were easier to monitor, and allowed the melting and refining of large amounts of scrap iron and steel. As indicated by Lardy (1995), in the 1950s the Soviet Union had the best open heart furnaces in the world. Similarly, the basic oxygen steelmaking, developed as late as 1948, improved the Bessemer converter by replacing air blowing with blowing oxygen blowing. This technological change allowed to reduce capital usage, time of smelting, and labor requirements in the industry decreased by a factor of 1,000, from more than three man-hours per metric ton to just 0.003. This is consistent with our finding of increased production with a substantially unchanged labor force. The treated plants adopted better technologies well after the end of the Soviet assistance. In the late 1980s, the open heart furnace technology became obsolete and was replaced by the "continuous casting" process. This process allowed to continuously pour the molten metal into a "semifinished" billet, bloom, or slab for subsequent rolling in the finishing mills, improving yield, quality, productivity and cost efficiency. In the 1980s, when China started gradually opening up to trade and imports from Western countries, treated plants increased the steel production from the continuous casting process 23.2 percent more relative to comparison plants (Table 2, Panel B, column 5). The differential effects between treated and comparison plants were not confined to the Chinese standards. Information about the quantities of steel that met international standard requirements available since 1985 indicate that treated plants were producing 51.1 percent yearly more steel above such standards relative to comparison ones (Table 2, Panel B, column 6). All these results are confirmed by the IV estimates (Table A.5, Panel B, columns 3-6). Finally, treated plants used less polluting types of energy: they reduced the energy coming from coal and heavy oil by 20.7 and 23.7 percent respectively, relative to comparison plants, and increased the usage of cleaner type of energy, like natural gases and electricity, by 17.2 and 23.1 percent respectively (Table A.6, Panel A, columns 1-4).

Next, we investigate the effects of the technology transfer on plant human capital. While the total number of workers did not differentially change between treated and comparison plants, treated plants increase the employment of engineers by 9.7 percent more and that of high-skilled technicians by 4.4 percent more, and reduced the number of unskilled workers by 14.2 percent relative to comparison plants (Table 2, Panel C, columns 1-3). This effect is likely due to that new machineries and equipment required more high-skilled labor to be used and reduced the need of unskilled workers. In line with principles of planned economy, we do not observe differences in total and average wages between treated and comparison plants (Table 2, Panel C, columns 4 and 5). The IV results are consistent with the OLS estimates (Table A.5, Panel C, columns 1-6).

Finally, there are two things that are worth noting. First, in most specifications the OLS and IV estimations are close in magnitude. This is consistent with the fact that whether plants supposed to receive the Soviet technology transfer eventually got it did not depend on economic or political reasons, but was determined by the unexpected and unforeseen delays that emerged after projects were approved and started. Second, as a potential challenge for our estimations is given by its small cross-sectional number of plants in the steel industry, we implement permutation tests and the Ibragimov and Muller (2010) procedures, largely employed in experimental settings, where small sample size is common (Bloom et al., 2013a). These tests are described in Appendix D and in all cases confirm the significance level reported in Table 2 (Appendix Table D.1).

5.2 Medium and Long-Run Firm-Level Results in All Industries

For the year 1985 and between 1998 and 2013, the availability of large-scale firm level data allows us to match all the treatment and comparison firms with their medium- and long-run economic outcomes. The estimation of equation 1 on this sample corroborate the finding on the steel industry that the program had large and persistent effects on firm performance.

In the medium-run treated firms were still performing better than comparison firms. In 1985, when the Second Industrial Survey is available, the value added of treated firms was 27.1 percent higher than that of comparison firms according to the OLS specification, and 18.6-percent higher according to the IV specification (Table 3, Panel A, columns 1 and 2). While the number of workers and fixed assets was not differentially affected by the program, OLS estimates also indicate that TFPR was 22.3 percent higher in treated firms relative to comparison firms,[13] a result confirmed by IV estimates (Table 3, Panel A, columns 3-8).

[13] Details about TFPR estimation could be found in Appendix C.

The increase in TFPR is driven by the raise in value added, as the workers and fixed assets were statistically the same between treated and comparison firms.[14]

A potential concern in interpreting these results is that the firm supervisors or the local governments may have had incentives to misreport some data. It is worth noting that, after the Sino-Soviet, the Chinese government wanted to close any relationship with Soviet Union as fast as possible.[15] Therefore, if any manipulation occurred, this should have aimed at underestimating rather than overestimating the effects of the technology transfer program, especially in the long run, which goes against us finding results. In addition to that, in Appendix C we describe the checks we did about the our data that appear accurate and fully consistent across all the different sources we collected.

Looking at the long-run, between 1998 and 2013, value added of treated firms was 24.1 percent higher than that of comparison companies based on the OLS specification, and 28.0 percent higher based on the IV specification (Table 3, Panel B, columns 1 and 2). Similarly to the 1985 results, the number of workers and fixed assets were not statistically significant, and TFPR in treated firms was 20.8 percent larger than in comparison firms (Table 3, Panel B, column 3), a finding consistent with the IV estimation that indicate a 22.9 percent higher TFPR (Table 3, Panel B, column 4). Notably, these results are close in magnitude to both the IV specification (Table 3, Panel B, columns 6 and 8) and the 1985 results, confirming the long-lasting impact of the technology transfer program on firm performance.

The 1998-2013 data contain additional outcomes, not available in 1985, that allows us to explore further the long-term differences between treated and comparison firms. Treated firms were more efficient than comparison firms, being able to produce at 24.6 percent lower costs than the comparison ones (Table 3, Panel C, column 1). Moreover, they diversified their production more. The number of products produced in a given year is 16.5 percent higher in treated firms relative to comparison firms. Similarly, the former had a 20.2 percent higher value of output from new products (defined as products not produced in the year before) than the latter (Table 3, Panel C, columns 3 and 5). Consistently, with the increased production efficiency and products variety, treated firms were systematically more likely to engage in exports. Their value of exports was 30.5 percent higher than comparison firms between 1998 and 2013 (Table 3, Panel C, column 7). In all these cases, the OLS estimates are close in magnitude to the IV ones (Table 3, Panel C, columns 2, 4, 6, and 8).

Finally, we compare the performance of treated and comparison firms with the other

[14] An alternative explanation for the increase in TFPR could be that it might depend on a differential price increase between treated and comparison plants, rather than a higher "true" technical efficiency level, as explained in Foster et al. (2008). However, in the context of a planned economy, the prices of outputs and inputs were set by the government each year, so firms in the same industry all faced the same prices. As a consequence, this variation is capture by the industry-year fixed effects θ_{st}.

[15] For instance, at the time of the Sino-Soviet Split, China rushed up to repay Soviet loan immediately, even though it could have done so within ten years (Zhang et al., 2006).

Chinese firms. In 1985 and between 1998 and 2004, treated firms outperformed the other Chinese firms in terms of value added, employment, assets and productivity (Table A.7, Panels A and B, columns 1-4). Notably, comparison firms had larger size and assets than the other Chinese firms, but were not more productive. As most Chinese firms were publicly-owned and the government allocated production quotas to them, the overall competition faced by firms was fairly low. The situation radically changed in 2005, when China started a huge wave of privatization, which, however, did not involved treated and comparison plants which remained publicly-owned. Firms that became privately owned had higher value added and become more productive than treated firms, but no higher employment or fixed assets. Treated firms remained more productive than the other public firms and comparison plants maintained larger size and assets (Table A.7, Panel B, columns 1-4).

5.3 The Effects of Complete and Partial Technology Transfers

In addition to the transfer of foreign technologies embodied in capital goods, firm performance could be raised by diffusing industry specific knowledge, through, for instance, on-the-job training by foreign companies (Mostafa and Klepper, 2018). In fact, industry knowledge has tacit components that become embedded within the workers' skills and abilities. Despite its importance, measuring this knowledge flow is particularly challenging, since it is rarely observed.

The unique setting of the Soviet technology transfer allows us to disentangle the effect of transferring foreign technologies from that of transmitting industry specific knowledge. In fact, some plants received a "complete technology transfer", which included both state-of-the-art machinery and equipment, and technical assistance and know-how through engineer training, while some others received a "partial technology transfer", which only included Soviet machinery and equipment. We therefore estimate the differential effects of these two type of transfers by estimating the following equation:

$$\text{outcome}_{ist} = \alpha + \beta \cdot \text{Treatment}_i + \gamma \cdot \text{Treatment}_i \cdot \text{Complete TT}_i + \theta_{st} + \epsilon_{it} \qquad (2)$$

where Complete TT is an indicator variable that equals 1 for the projects which received complete technology transfer from the Soviet Union and 0 otherwise, and the other variables are defined as in equation 1.

Receiving complete technology transfer from Soviet Union had an additional positive effect on firm performance, relative to firms that received the partial technology transfer. Quantity of steel produced by plants treated with complete technology transfer was on average 5.9 percent higher than in plants treated with partial technology transfer (Table 4, Panel A, column 1), but there were not significant differences in the number of workers, fixed assets, and inputs, such as coke and iron (Table 4, Panel A, columns 2-5). Driven by the increased quantities, TFPQ in plants treated with complete technology transfer was 6.7 percent percent higher than that in plants treated with partial technology transfer (Table 4, Panel A, column 6). The estimates of the annual coefficients separately for firms that received the complete and the partial technology transfer indicate that the effects of the program became significant the year after opening for plants that received the complete technology transfer, but only four years after that for plants that received the partial technology transfer (Figure 2, Panel B). The impact of the program continued to grow for 10 years after its start in plants that received the complete technology transfer and until 7 years after the program in plants that received the partial technology transfer. While plants that received the complete technology transfer had higher TFPQ than the plants that received the partial technology transfer in each year after the plant opening (with the difference being statistically significant since 6 years after that), for both types of projects the effects remained positive and significant for 50 years after the program.

The increase in the quality of steel produced appears stronger in firms that received the complete technology transfer, as it directly relates to engineers knowledge. Plants that received the partial technology transfer increased the production of better-quality crude steel by 3.4 percent and reduced the production of the lower-quality pig iron by 4.0 percent relative to comparison plants. However, plants which received the complete technology transfer increased the production of crude steel by an additional 15.3 percent, and reduced the production of pig iron by an additional 13.5 percent (Table 4, Panel B, columns 1 and 2). In terms of production processes, plants which received the complete technology transfer increased the quantity of steel produced with open heart furnaces by 4.2 percent and that produced with basic oxygen steelmaking by 3.6 percent (Table 4, Panel B, columns 3 and 4), which is consistent with complementarity effects between human and physical capital. Even in the longer run, when the open heart furnace technology was replaced by the "continuous casting" process, plants treated with the complete technology transfer were faster in adopting new the new technologies. In fact, after 1985 they increased the steel production from the continuous casting process by 3.2 percent, relative to plants treated with the partial technology transfer, and had were producing 4.1 percent yearly more steel that met international standard requirements (Table 4, Panel B, columns 5 and 6).

Finally, treated plants that got the complete technology transfer employed 8.4 percent more engineers, while firms that received the partial technology transfer did not employ more engineers than the comparison plants. The fraction of high-skilled technicians is not differential between plants that received the complete and the partial transfer (Table 4, Panel C, columns 1 and 2). In fact, high-skilled technicians were needed to operate the new machineries and the different types of technology transfer received did not affect their employment, since all treated firms received Soviet capital goods. However, engineers were only trained in plants that received the complete technology transfer and and were actively involved in innovation and developing new technologies. These firms may have, in turn, diffused the industry specific acquired knowledge by hiring and training more engineers, which explains a higher employment only in these plants. Average wages and total wages appear unaffected by the specific transfer received (Table 4, Panel C, columns 5 and 6). All these results presented so far hold if we estimate the IV specification (A.8, Panels A-C). The permutation tests and the Ibragimov and Muller (2010) procedures of Appendix D always confirm the significance level reported in Table A.8 (Appendix Table D.2 and D.3).

These results are confirmed by an analysis on all the firms that participated in the technology transfer program in 1985 and between 1998 and 2013. Firms that received the complete technology transfer had between 3.6 and 4.8 percent higher value added, and 3.3 and 3.7 percent higher TFPR, respectively in 1985 and between 1998 and 2013 (Table A.9, Panel A, columns 1-4). The number of workers and fixed assets are not statistically different between the two groups of firms (Table A.9, Panel A, columns 5-8). Notably, the magnitude of the estimate coefficients appear similar in the two time period, confirming a substantial persistence of the results.

Looking at additional outcome available only in the 1998-2013 time frame, firms that received the complete technology transfer were still producing at 4.8-percent lower costs, compared to firms that received the partial technology transfer, had a 19.1 higher number of products, a 16.0 percent higher output from new products and exported 9.4 percent more output (Table A.9, Panel B, columns 1-4). Interestingly, the higher number of products and new products is not significantly different between firms that received the partial technology transfer and comparison firms. While we do not observe the composition of the workforce outside the steel sector, this result is consistent with the higher number of engineers employed by firms that received the complete technology transfer, who were likely to be in charge in working on new product and processes design.

These results of this section suggest that receiving foreign on-the-job training further boosted firm performance, allowed the new machinery to be immediately productive, and contributed to explain the long-lasting effects of the program.

6 Spillover Effects

One of the goals of the technology transfer program was to create large industrial plants able to push local industrial development. In this section, we examine whether the program was successful in doing so and the type of short and long-run spillovers that it generated.

6.1 Agglomeration Effects

We start our analysis by investigating whether new firms were more likely to be located close to treated plants, relative to comparison plants. Out of 7,592 firms operating in China in 1985, when the Second Industrial Survey was conducted, 6,134 (80.8 percent) were founded after 1952, the year in which the technology transfer projects started being built.[16] We therefore estimate how many entrant firms located in the radius of 10, between 10 and 25, 25 and 50, and 50 and 100 km from treated and comparison plants.

The results indicate that, between 1952 and 1985, a higher number of firms located nearby treated plants. Specifically, 18.1 percent more new firms located within 10 km of a treated plant, with respect to comparison plants. If treated plants received the complete technology transfer, there are additional 4.7 percent of new firms (Table A.10, Panel A, column 1). Similarly, 16.1 percent more firms located between 10 and 25km of treated plants, and 13.5 percent more firms between 25 and 50km (Table A.10, Panel A, columns 2 and 3). If treated plants received the complete technology transfer, there is an additional number of firms 3.3 percent higher between 10 and 25km, and 5.5 percent higher between 50 and 100km. By contrast, there is no differential firm entry between 50 and 100km (Table A.10, Panel A, column 4).

These findings are largely driven by the entry of firms in related industries (same industry or upstream/downstream industries) of treated and comparison plants. The estimated number of new firms in related sectors is 18.6 percent higher within 10 km of a treated firm compared to the same distance of a comparison firm, 17.2 percent higher within 10 and 25 km, 13.3 percent higher between 25 and 50 km, and not significant beyond 50 km (Table A.10, Panel A, columns 5-8). In case of complete technology transfer, the additional increase in firms reaches 4.9 percent within 10km, 3.6 percent between 10 and 25, and 4.8 percent between 25 and 50 (Table A.10, Panel A, columns 5-8). Conversely, there is no higher concentration of new firms operating in unrelated industries (Table A.10, Panel A, columns 9-12).

Repeating the same analysis on the 20 plants that belong to the steel industry lead to similar results, despite the small sample size. A higher percentage of entrant firms located within 50km of treated plants, relative to comparison plants, in related industries, while the difference in unrelated sectors is not statistically different between treated and comparison plants (Table A.10, Panel B, columns 1-12).

[16] Even though we don't have data on firm performance except for the steel industry back then, the 1985 Second Industrial Survey contains information on firm location and foundation year that we use to perform such analysis.

6.2 Horizontal Spillovers

Did firms in the steel industry that located close to treated steel plants perform better than firms close to comparison plants? To answer this question, we estimate the following specification on the sample of steel firms that located within 50 km of a treated or comparison plant between 1949 and 1985:

$$\text{outcome}_{jt} = \alpha + \beta \cdot \text{Close Treatment}_j + \gamma \cdot \text{Close Complete TT Treatment}_j + \delta_t + \epsilon_{jt} \quad (3)$$

where outcome_{it} is the same performance metrics used in equation 1 of firm j located within 50 km of a treated or comparison plant i at time t; Close Treatment is an indicator that equals 1 if plant j is within 50km of a treated plant and 0 otherwise; Close Complete TT is an indicator that equals 1 if plant j is within 50km of a treated plant that received the complete technology transfer and 0 otherwise; and the other variables are defined as in equation 1.

We first focus on horizontal spillovers by examining steel firms located spatially close to treated and control steel plants. Such firms may have been exposed to positive spillovers, for instance by imitating new technologies from treated plants or by benefitting from the knowledge and expertise of the Soviet-trained engineers that worked in treated plants. On the other hand, they may have suffered from negative spillover effects coming from the competition of inputs in the local labor market (Greenstone et al., 2010).

Our results indicate the existence of positive horizontal spillover effects, related to knowledge more than technology diffusion. In fact, steel firms located close to treated steel plants had a 11.8-percent higher production and a 10.5 percent higher TFPQ than firms close to comparison steel plants only if treated plants received the complete technology transfer, with non statistically significant differences in the number of workers, fixed assets, and inputs, such coke and iron (Table 5, Panel A, columns 1-5).

The raise in quantities produced and TFPQ is likely driven by an improvement in existing processes, that allowed firms to produce more output with the same amount of inputs, and that relates to the diffusion of industry specific knowledge by the Soviet-trained engineers in nearby treated plants. This is further confirmed by the fact that firms located close to plants treated with the complete technology transfer produced 11.1-percent more better-quality crude steel and 4.9-percent less lower-quality pig iron (Table 5, Panel B, columns 1 and 2). The better quality is related to knowledge specific industry of the engineers that were 6.7 percent higher in firms close to treated firms that received the complete technology transfer (Table 5, Panel C, column 1). Not surprisingly, we documented a similar in firms treated with the complete technology transfer relative to firms treated with the partial technology transfer (Table 2, Panel B, columns 1 and 2).

By contrast, technology diffusion from treated plants appear limited. The production processes related to the machineries employed in steel firms close to treated and comparison plants were comparable, with statistically equivalent quantities of steel produced with the open heart furnace or the basic oxygen techniques (Table 5, Panel B, columns 4 and 5) and no higher employment of high-skilled technicians responsible to operate technologically advanced machineries (Table 5, Panel C, column 2). However, starting in the mid-1980s, when China gradually opened to trade, firms close to treated plants were able to adopt better technologies, as the treated plants themselves did. Firms close to treated plants produced 11.1-percent more steel using the newly-developed continuous casting process and 9.5-percent more steel whose quality was above the international standards, relative to firms close to comparison plants (Table 5, Panel B, columns 5 and 6).

This result indicate that technology diffusion that may have occurred between treated and nearby plants was limited by the specific conditions China was facing at the time of the transfer. In fact, the country had limited capacity of building the Soviet-imported machineries on its own and was facing an embargo from the US and its Allied countries, which strongly limited Chinese possibility of importing technologies from abroad. As long as these constraints became less binding in the mid-1980s, firms close to treated firms imitate their technology adoption. By contrast, the flow of knowledge did not face the same constraints and therefore diffused between plants treated with the complete technology transfer and nearby firms.

Finally, we do not find evidence of negative spillovers from competition for the local market inputs. This result is consistent with the historical records: in fact, at time time, China was a planned economy, with specific production quotas allocated to the firms and sector fixed prices for inputs, as well as a large labor supply that could be reallocated from the agricultural to the industrial sector (Lardy, 1995).

6.3 Vertical Spillovers

Firms located close to treated plants may have also experienced upstream or downstream vertical spillovers. To estimate these effects, we estimate equation 3 on steel firms located within 50km of treated and comparison plants in non-steel sectors, dividing them in upstream and downstream companies. Being a firm close to an upstream treated plant, relative to being close to an upstream comparison plant, is not associated with significant differences in the quantity of steel produced, number of workers or fixed assets, but determines a reduction of 7.8 percent in coke use and of 6.4 percent in iron use and an increase of TFPQ by 13.9 percent (Table 6, Panel A, columns 1, 3, 5, 7, and 9). Under the assumption of inputs supplied in a local market, as confirmed by Lardy (1995), this decrease in coke and iron usage is likely caused by better quality of materials supplied by treated plants in the extraction sector (Table 6, Panel B, columns 1 and 3) that allowed firms to produce the same output with fewer inputs. The quality of output, the processes used and the composition of human capital are not statistically different between firms close to treated and comparison plants (Table 6, Panels A and B). These results suggest that the vertical upstream spillovers mostly occurred through the inputs supplied, and not due technology or knowledge transfer.

Being a firm close to a downstream treated plant, relative to being close to a downstream comparison plant, is associated with higher volume of production. The quantity of steel produced is 9.5-percent higher in the former compared to the latter, the number of workers 5.9 percent higher, and the use of coke and iron 2.3 and 3.1 percent higher (Table 6, Panel A, columns 2, 4, 6, 8, and 10). By contrast, TFPQ, quality of products, processes used, and the composition of human capital are not statistically different between firm close to a downstream treated or a downstream comparison plant (Table 6, Panel A, column 12, and Panels B and C). These findings are consistent with the increased production of downstream treated plants. As such plants produced more, they likely demanded more inputs from their suppliers. In fact, we find that firms close to plants treated with the complete technology transfer, which increased their production more, experienced an additional increase in steel produced, number of workers and inputs usage (Table 6, Panel A, columns 2, 4, 8 and 10).

6.4 Spillover Effects in 1985 and between 1998-2013

For the year 1985 and between 1998 and 2013, we can extend our analysis to firms in all sectors. Regarding the horizontal spillovers, firms located within 50 km of treated plants had higher value added and TFPR than firms located close to a comparison plants, only if the treated plants received the complete technology transfer (Table A.11, Panel A, columns 1 and 3). Conversely, we do not find differential effects in terms of fixed assets and number of workers (Table A.11, Panel A, columns 3 and 4). In terms of vertical spillovers, firms close to upstream treated plants, had 14.3-percent higher value added and 12.9-percent higher TFPR, relative to those close to upstream comparison plants, with no significant differences in fixed assets and number of workers (Table A.11, Panel B, columns 1, 3, 5, and 7). Firms close to downstream treated plants showed a 11.4-percent higher output and 5.5-percent more workers (Table A.11, Panel B, columns 2, 4, 6, and 8). Notably, the estimates in 1985 are close in magnitude to the estimates between 1952 and 1985 in the steel industry. Finally, looking at firms not related to treated and comparison plants we do not observe any statistically significant difference which corroborates the fact that spillover effects were driven by the technology transfer program (Table A.11, Panel C).

For the year 1998-2013, we can examine whether the spillover effects interacted with China transition from a planned to a market economy. Our results indicate that firms spatially close to treated plants in the same sector had better performance in terms of value added and TFPR than firms spatially close to comparison plants only if they became privately-owned after 2005 (Table 7, Panel A, columns 1-4). Privately-owned firms were also able to get a larger advantage from market liberalization. In fact, they increased the variety of their products and systematically engaged more in exports (Table 7, Panel A, columns 7 and 8). Interestingly, we find similar effects for privately-owned firms in the supply chain of treated and comparison plants. Firms close to upstream or downstream treated plants had higher value added, TFPR, number of products and exports than firms close to upstream or downstream comparison plants (Table 7, Panel B, columns 1-12). Finally, firms not related with treated plants but located close to them did not show higher performance than firms not related but close to comparison plants (Table 7, Panel C, columns 1-6).

Taken together, these results indicate that in the long-run, being located to treated plants gave competitive advantage to firms only if they became private-owned and only if they were economically related to treated plants. In the next section, we will explore the mechanisms that drove these results.

6.5 Mechanisms

In the previous section we showed that firms spatially close and economically related to treated plants had better performance than firms close to comparison plants if they privatized after 2005. This result suggests that the technology transfer created some local conditions that interacted with the transition from a planned to a market economy. In this section we examine the potential mechanisms.

We start our analysis by examine whether counties in which treated plants were located (*treated counties*) were exposed to a higher market competition than counties in which comparison plants were located (*comparison counties*). In Section 6.1, we showed that a higher number of firms in related industries located close to treated plants relative to comparison plants. Between 2005 and 2013, the agglomeration effects persist. Specifically, treated counties had 24 percent higher number of firms in related industries to treated plants than comparison counties (Table 8, Panel A, columns 2 and 3). After 2005, treated counties had a 15.0 percentage points higher share of firms that became privately-owned in related industries than comparison counties (Table 8, Panel A, columns 5 and 6), with no differential effects in unrelated industries. If treated counties had plants that received the complete technology transfer, there was an additional 6.6 percentage points increase in the fraction of privately-owned businesses. These findings indicate that in treated counties there was a higher reallocation of production from state-owned to privately-owned firms. In turn, privately-owned firms in treated counties had to be more flexible in adapting to the changing market conditions since they were facing more competition in the input and output markets, as well as in the export markets. This is consistent with the evidence that even treated and comparison firms lost their competitive advantage at the expenses of privately-owned firms after 2005, as we described in Section 5.2.

Second, we test if treated counties had a higher concentration of human capital. The fact that treated plants were employing more engineers and/or high-skilled workers than comparison plants may have created some local industry specific knowledge that persisted over time. Consistently, we find that in treated counties the number of college graduates is 21.9 percent higher than in comparison counties, for both men and female (Table 8, Panel B, columns 1-3). The presence of plants that received the complete technology transfer generated an additional 4.7 percent increase in the number of college graduates. Similarly, treated counties had a 7.5 percent higher number of high-skilled technicians (Table 8, Panel B, columns 4-6).[17] When firms started competing in the input markets, privately-owned companies may have been able to capture the best workers which allowed them to be more competitive.

Finally, the government may have invested more resources in treated counties, allowing firms located there to perform better. However, we do not observe a higher government investment in treated counties relative to comparison counties, neither in related nor in unrelated industries (Table 8, Panel C). As a result, government investments do not seem to be the underlying mechanism in this case.

7 The Role of the Technology Transfer Program on Chinese Growth Miracle

Between 1953 and 1978, China experienced an average real GDP per capita growth rate of 7 percent, that scaled up to 11.9 percent between 1979 and 2008, a pace described by the World Bank as "the fastest sustained expansion by a major economy in history" (Morrison, 2019). To what extent did the technology transfer program contribute to such an outstanding economic growth? In this section we aim at answering this question.

First, we estimate the effects of the technology transfer projects on the long-run development of provinces in which they were located. Specifically, we estimate the following equation:

$$\text{outcome}_{pt} = \beta \cdot (\text{Share Treated Projects}_p \cdot \text{Post 1952}_t) + \alpha_p + \delta_t + \epsilon_{pt} \tag{4}$$

[17] It is worth noting that the increase in high-skilled technicians is related to the presence of treated plants, but not to the specific presence of plants treated with the complete technology transfer. Notably, this result is fully consistent with our findings in the steel industry. In fact, we documented that complete technology transfer was not associated to an additional increase in the number of high-skilled technicians relative to the partial technology transfer (Table 4).

where outcome_{pt} is logged industrial output, industrial employment, GDP per capita, investment, and number of industrial projects, discussed but not approved under the Sino-Soviet Alliance; Share Treated Projects_p is the share of technology transfer projects completed by Soviet Union over the total number of approved technology transfer projects under the Sino-Soviet Alliance in province p. Post 1985 is an indicator that equal one for years after 1952, when the technology transfer program started; α_p are province fixed-effects; and δ_t are year fixed effects. Standard errors are block-bootstrapped at the province level.

A one-percent increase in the share of projects completed by Soviet Union in a given province increases the logged industrial output on average by 1.2 percent per year. Considering that the average number of completed project per province is 8.6, having an additional project completed by Soviet Union increases on average the logged industrial output by 13.2 percent per year (Table 9, Panel A, column 1). Similarly, an additional project completed by the Soviet Union is associated with a 4.9 percent higher employment in the industrial sector and a 17.6 percent higher GDP per capita (Table 9, Panel A, columns 2 and 3). By contrast, the share of projects completed by the Soviet Union is unrelated with government investments and the number of other industrial projects that were discussed but not approved under the Sino-Soviet Alliance (Table 9, Panel A, columns 4 and 5).

Second, we estimate the cross-sectional fiscal multiplier of the technology transfer investments on provincial real GDP, via the equation:

$$\Delta\text{GDP per capita}_{pt} = \beta \cdot \frac{\text{Investment TT}_p}{\text{Population}_{p,1949}} + \alpha_p + \delta_t + \epsilon_{it}$$

where $\Delta\text{GDP per capita}_{pt}$ is the change in real GDP per capita in province p between year t and year t-1 with $t \in [1949, 2008]$; $\frac{\text{Investment TT}_p}{\text{Population}_{p,1949}}$ is the amount of investments in technology transfer projects completed by Soviet Union in province p; α_p are province fixed-effects; and δ_t are year fixed effects. Similarly to the IV strategy described in Section 4.1, we instrument the investments in technology transfer projects completed by Soviet Union with the with the average province-level delays. The exclusion restriction requires that the average province-level delays is affecting province-level outcomes only through their effects on the share of completed projects. While the exclusion restriction is not directly testable, the average province-level delays do not predict any province-level characteristics between 1949 and 1951(Table A.1, columns 4-6).

The OLS estimates indicate that a province which invested \$1 per capita more in the technology transfer program relative to other provinces experienced an increase of between \$0.85 and \$0.90 in its real GDP per capita between 1953 and 1978, and between \$0.61 and \$0.68 between 1953 and 2008 (Table 9).

Next, we use our cross-sectional fiscal multiplier to assess the impact of the technology transfer program on the aggregate Chinese real GDP per capita. The cross-sectional multiplier does not necessarily coincide with the aggregate multiplier if the government responds to fiscal policy with monetary policy. Nakamura and Steinsson (2014) explains that a strict "leaning-against-the-wind" policy to address the inflationary effect of higher government spending can substantially decrease the aggregate multiplier. A "leaning-against-the-wind" policy could describe the Chinese monetary policy during the 1950s and 1960s, when containing the inflation after the Civil War was one of the primary goals of the newly formed government (Lardy, 1995, p.118). We therefore use the calibration in Nakamura and Steinsson (2014) and compute an aggregate multiplier equal to 0.20 between 1953 and 1978 and to 0.15 between 1953 and 2008.[18] We then perform a back-of-the-envelope calculation of the effects of the technology transfer program on the national Chinese real GDP per capita growth rate. Specifically, we compute the effect of the technology transfer program on real GDP growth as $\frac{NFM \cdot \text{Investment TT}}{Y}$, where *NFM* is the national fiscal multiplier of 0.20 in the medium run and of 0.15 in the long run, *Investment TT* is the total value of the technology transfer treated projects (2020 USD 46.16 billion) and Y is the Chinese GDP in 1952 (2020 USD 268.92 billion). Therefore, without the technology transfer program, the Chinese national real GDP growth rate would have been 3.4 percent points lower in the medium run and 2.6 percent points lower in the long run. Considering an average annual real GDP per capita growth rate of 7 percent between 1953 and 1978 and of 11.9 percent between 1953 and 2008, without the program such growth rates would have been 3.6 percent (51 percent lower) between 1953 and 1978 and 9.3 percent between 1953 and 2008 (21.8 percent lower). While these findings are fairly large, they are consistent with the historical evidence that considers the technology transfer program as vital in Chinese early industrial development (Lardy, 1995; Zhang et al., 2006).

Finally, we compute the return on investment of the program as the ratio between the benefits and costs of the technology transfer between 1953 and 1978. Using the estimate of the aggregate multiplier, we calculate that the program accounted for a yearly average increase in nominal GDP of 2020 USD 9.2 billion during these 25 years. We compute the direct costs of the program as the sum of the total value of the technology transfer treated projects (2020 USD 46.16 billion) and the loan China received from Soviet Union and paid back in 10 years at an interest rate of 1 percent (2020 USD 2.93 billion). However, when the Chinese leaders decided to push the industrial development, they did so at the expenses of the agricultural sector, a decision later referred to as "lots of guns and not enough butter". We therefore estimate the opportunity costs of the program as the crowding out of the agricultural sector. Specifically, between 1952 and 1978, the share of agriculture sector out

[18] 0.20=0.85×0.24, where 0.85 is our estimated medium-run cross-sectional multiplier (Table 9, column 1) and 0.24 comes from the ratio between 0.20 and 0.83 in Table 6, row 1 from Nakamura and Steinsson, 2014; 0.15=0.61*0.24, where 0.61 is our estimated long-run cross-sectional multiplier (Table 9, column 4).

of GDP decreased from 51% to 28.2%, which corresponds to an average annual reduction of 2020 USD 2.6 billion. Therefore, the benefits of the technology transfer program were twice higher than the costs.

Comparison of technology transfer programs in planned and market economies. During the 1950s both the United States and the Soviet Union were producing state-of-the-art technologies (Lardy, 1995; Boel, 2003) and therefore sponsored massive technology transfer programs in their allied countries. To what extent the specific market conditions affect the success of such technology transfers? While comparison of cost-benefit analyses across countries are usually difficult to interpret, it is worth noting that in the aftermath of WWII both sets of countries were facing serious constraints in accessing foreign technology. China, for instance, was dealing with an embargo from the Western world and had severe liquidity problems. Similarly, in Western Europe and Japan the dollar shortage would have made very difficult to buy US machinery without subsidized programs (ECA, 1949; Lardy, 1995). In the context of small and medium-sized Italian firms that participated in the Productivity Program during the 1950s, Giorcelli (2019) estimates that it would not have been profitable for such companies to buy the US state-of-the-art machinery without the program, mostly due to credit constraints and high interest rates, and their limited effects on firm performance. By contrast, the return of the Sino-Soviet technology transfer program doubled its costs. These different results could be explained by the initial level of economic development of Western and Eastern economies. In fact, despite WWII, Western European firms had not completely lost their production capacity and the Productivity Program did not attempt to reshape the preexisting patterns of industrialization. As a result, US technologies may have been too advanced and too large scale to be adapted to European SME. Conversely, the Sino-Soviet technology transfer program promoted Chinese industrialization from an almost non-exisiting level and aims at reproducing Soviet plants in China, offering specific training for Chinese engineers. This component of the program likely created less friction in technology adoption. Moreover, Chinese and Soviet experts were directly involved in deciding the location of the new plants, therefore the program strongly affected and changed Chinese pattern of industrialization.

8 Conclusions

This paper studies the short and long-run effects of technology transfer on early industrial development, using evidence from the Sino-Soviet Alliance. We collected data on the "156 technology transfer projects," that we complement with plant and firm-level outcomes from 1949 to 2013. To identify the causal effects of the program, we exploit unanticipated political tensions between China and the Soviet Union since 1959, known as Sino-Soviet split:

technology transfer projects that had been already completed before the split maintained the Soviet machinery and the equipment, while the others were completed by China only, without Soviet machinery and equipment nor technical assistance. We find that the program had large and persistent effects on plant performance, in terms of quantity and quality of output produced, productivity, exports and product variety. The technical assistance part of the program played an important role in diffusing industry-specific knowledge, even when technology diffusion was limited by China lack of access to international trade. Moreover, the program generated horizontal and vertical spillovers and a substantial reallocation of production from state-owned to privately-owned companies after 2005. Finally, the program shaped Chinese industrial development, by creating industrial development in the inner and northeastern regions at the expenses of the historically more developed costal areas.

What are the policy implications of this paper? After the Civil War, China was an agricultural country comparable to some developing countries today, where technology transfers are among the most common forms of active support firms (McKenzie and Woodruff, 2012). However, such policies are usually evaluated over a limited number of months or years and using relatively small samples. In contrast, our paper provides evidence in the short, medium and long run and separate the impact of technology adoption from that of the diffusion of industry-specific knowledge. Moreover, the availability of data on firms not targeted by the program allows to estimate spillover effects and to assess the aggregate effects of the program.

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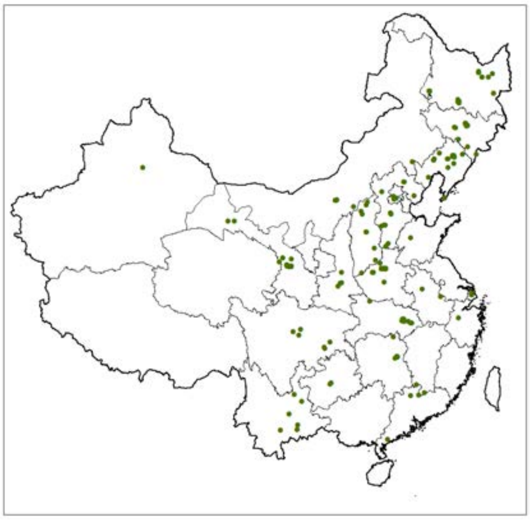
Figures and Tables

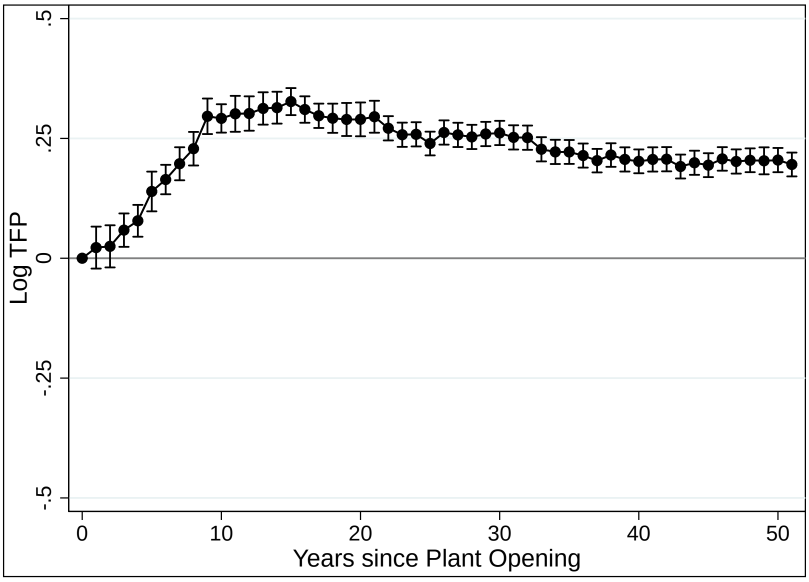
Figure 1: Distribution of the 139 Approved Technology Transfer Projects



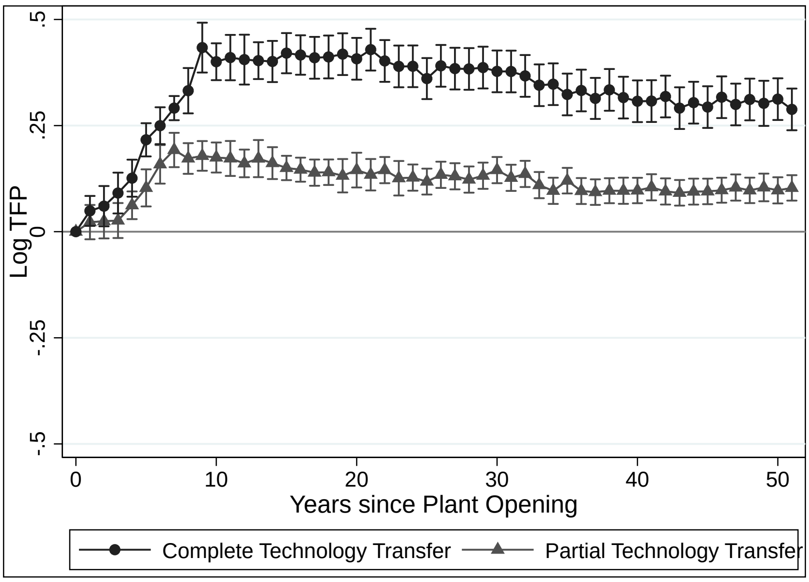
Notes. 139 approved technology transfer approved projects under the Sino-Soviet Alliance. Data are provided at project-level from the National Archives Administration of China.

Figure 2: Yearly Effects of the Technology Transfer Program on Plant TFPQ

Panel A: All Projects



Panel B: By Complete and Partial Technology Transfer Projects



Notes. β_t annual coefficients estimated from the equation Log TFPQ$_{it} = \nu_t + \sum_{\tau=0}^{50} \beta_\tau[\text{Treatment} \cdot (\text{Year}{=}\tau)] + \epsilon_{it}$ in Panel A and γ_t and δ_t annual coefficients estimated from equation Log TFP$_{it} = \nu_t + \sum_{\tau=0}^{50} \delta_\tau[\text{Treatment}\cdot(\text{Year}{=}\tau)\cdot\text{Complete TT}_i] + \sum_{\tau=0}^{50} \gamma_\tau[\text{Treatment}\cdot(\text{Year}{=}\tau)\cdot\text{Partial TT}_i] + \epsilon_{it}$, where *log TFPQ* is logged physical productivity; *Treatment* is an indicator variable that equals 1 for plants that participated in the technology transfer program; *Complete TT* and *Partial TT* are indicator variables that equals 1 for plants that received the complete (machinery and equipment + technical assistance) or the partial (machinery and equipment only) Soviet technology transfer respectively; ν_t is year fixed-effects. Data are provided at the plant-level from the Steel Association Reports between 1949 and 2000. Standard errors are wild bootstrapped at the plant-level (Cameron et al., 2008).

Table 1: The 139 Technology Transfer Approved Projects

Panel A: All Projects

	All Projects				Treatment	Comparison	
	Mean	SD	Min	Max	Mean	Mean	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Complete Transfer	0.59	0.49	0	1	0.58	0.62	0.539
Approve Year	1951.12	1.21	1950	1954	1951.23	1959.98	0.246
Start Year	1952.99	1.32	1952	1955	1953.09	1952.86	0.144
Number of Workers (k)	27.7	20.3	2.8	49.6	27.5	27.9	0.317
Planned Investment (m)	579.4	213.2	8.0	1,813.2	579.2	579.9	0.853
Actual Investment	569.5	208.9	9.8	2,135.2	569.6	569.2	0.985
Capacity	117.58	75.77	1.9	351	117.47	117.74	0.989
Delay	3.92	1.89	1	10	2.89	5.32	0.000
Observations	139	139	139	139	80	59	139

Panel B: Steel Industry Project

	All Projects				Treatment	Comparison	
	Mean	SD	Min	Max	Mean	Mean	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Complete Transfer	0.60	0.51	0	1	0.62	0.58	0.779
Approve Year	1951.60	1.07	1949	1953	1951.40	1951.70	0.409
Start Year	1953	0.66	1952	1954	1952.90	1953.1	0.944
Number of Workers (k)	27.4	24.4	3.6	70.6	27.3	27.5	0.456
Planned Investment (m)	540.5	559.6	109.2	1,813.2	539.7	541.7	0.342
Actual Investment (m)	536.9	638.0	861.2	2,135.3	533.9	538.9	0.367
Capacity	169.72	92.01	67.60	320.00	170.03	169.01	0.569
Delay	4.00	1.05	1.20	5.00	3.00	5.00	0.000
Observations	20	20	20	20	10	10	20

Notes. Summary statistics for the 139 technology transfer projects (Panel A) and for the 20 technology transfer projects in steel industry (Panel B). Data are provided at project-level from the National Archives Administration of China. *Complete Transfer* is an indicator equal to 1 for projects that got machinery, equipment and technical assistance and to 0 for projects that got machinery and equipment only; *Approve/Start Year* is the year in which each project was approved/started under the Sino-Soviet Alliance; *Number of Workers* is the total number of plant employees in thousands; *Planned/Actual Investment* are, respectively, the investment planned at the approval time and the investment eventually realized, measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Capacity* is measured in 10,000 tons per kilowatt and is available for 57 projects in coal, electricity, oil and steel industries; *Delay* is the year difference between the planned and actual length of each project. *p-value* is the p-value of testing equality between treated and comparison projects.

Table 2: Effects of Technology Transfer Program on Steel Plants, OLS

Panel A: Plant Outputs, Inputs, and TFPQ

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.216***	-0.079	-0.004	0.005	-0.008	0.225***
	(0.079)	(0.059)	(0.025)	(0.009)	(0.055)	(0.086)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel B: Quality of Products and Production Processes

	Log C. Steel	Log Pig Iron	Log Furn.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.225***	-0.164***	0.322***	0.289***	0.209***	0.413***
	(0.086)	(0.051)	(0.060)	(0.054)	(0.039)	(0.172)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log. Av. Wages	Log Total Wages
	(1)	(2)	(3)	(4)	(5)
Treatment	0.093***	0.043***	-0.133***	-0.040	-0.086
	(0.034)	(0.016)	(0.028)	(0.031)	(0.067)
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757

Notes. Data are provided at plant-level from the Steel Association Reports between 1949 and 2000. *Treatment* is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed by China only. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages* and *Log Total Wages* are average and total wages. Standard errors are wild bootstrapped at plant-level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table 3: Effects of Technology Transfer Program in 1985 and 1998-2013

Panel A: Value Added, TFPR, Assets and Workers, 1985

	Log Value Added		Log Workers		Log Fixed Assets		Log TFPR	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.240***	0.171***	0.006	0.008	0.009	0.004	0.201***	0.232***
	(0.055)	(0.059)	(0.008)	(0.016)	(0.016)	(0.020)	(0.061)	(0.064)
Model	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Year FE	No	No	No	No	No	No	No	No
Observations	273	273	273	273	273	273	273	273

Panel B: Value Added, TFPR, Assets and Workers, 1998-2013

	Log Value Added		Log Workers		Log Fixed Assets		Log TFPR	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.216***	0.247***	0.008	0.010	0.007	0.004	0.189***	0.206***
	(0.033)	(0.047)	(0.016)	(0.013)	(0.010)	(0.023)	(0.058)	(0.065)
Model	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925

Panel C: Additional Outcomes, 1998-2013

	Log Costs		Log # Products		Log Value New Prod.		Log Exports	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	-0.220***	-0.230**	0.153***	0.169***	0.184***	0.179***	0.266***	0.254***
	(0.085)	(0.095)	(0.037)	(0.033)	(0.054)	(0.043)	(0.095)	(0.105)
Model	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925

Notes. Data are provided at firm-level for the Second Annual Survey in 1985 (Panel A) and from the China Industrial Enterprises between 1998 and 2013 (Panel B). *Treatment* is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed by China only. *Log Value Added, Fixed Assets, Costs, Value New Products,* and *Exports* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Value New Prod.* is the value of output from new products, defined as products not produced in the year before; *Log TFPR* is logged total factor productivity revenue computed with the Ackerberg et al. (2015)'s method; *Log Workers* is logged total number of workers; *Log # Products* is logged number of products realized in a given year. Standard errors are clustered at the firm-level. ***p<0.01, **p<0.05, *p<0.1.

Table 4: Effects of Complete and Partial Technology Transfer on Steel Plants, OLS

Panel A: Plant Performance

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.198***	-0.070	-0.002	0.006	-0.003	0.181***
	(0.075)	(0.080)	(0.005)	(0.008)	(0.005)	(0.075)
Treatment *	0.058***	-0.008	0.004	0.004	-0.004	0.069***
Complete TT	(0.021)	(0.009)	(0.005)	(0.003)	(0.005)	(0.019)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel B: Quality of Products and Processes

	Log C. Steel	Log Pig Iron	Log. Fun.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.033***	-0.039***	0.313***	0.243***	0.187***	0.377***
	(0.011)	(0.012)	(0.070)	(0.064)	(0.043)	(0.098)
Treatment *	0.142***	-0.126***	0.041***	0.035***	0.032***	0.042***
Complete TT	(0.046)	(0.039)	(0.011)	(0.012)	(0.010)	(0.009)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log Av. Wages	Log Tot. Wages
	(1)	(2)	(3)	(4)	(5)
Treatment	0.026	0.038***	-0.042***	-0.029	-0.031
	(0.034)	(0.013)	(0.009)	(0.035)	(0.030)
Treatment *	0.081***	0.010	-0.078***	0.006	0.005
Complete TT	(0.020)	(0.008)	(0.011)	(0.007)	(0.009)
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757

Notes. Data are provided at plant-level from the Steel Association Reports between 1949 and 2000. *Treatment* is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed by China only. *Complete TT* is an indicator equal to 1 for projects that got machinery, equipment and technical assistance and to 0 for projects that got machinery and equipment only. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages and Log Total Wages* are average and total wages. Standard errors are wild bootstrapped at plant-level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table 5: Horizontal Spillovers in Steel Industry

Panel A: Plant Performance

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Close Treat.	-0.018	0.066	0.010	0.143	0.072	-0.016
	(0.042)	(0.076)	(0.012)	(0.091)	(0.046)	(0.038)
Close Treat. *	0.112***	0.030	0.005	-0.013	-0.006	0.100***
Complete TT	(0.037)	(0.068)	(0.006)	(0.082)	(0.041)	(0.033)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,400	1,400	1,400	1,400	1,400	1,400

Panel B: Quality of Products and Processes

	Log C. Steel	Log Pig Iron	Log. Fun.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Close Treat.	-0.017	0.007	0.012	0.016	0.105***	0.091***
	(0.039)	(0.009)	(0.070)	(0.061)	(0.043)	(0.035)
Close Treat. *	0.105***	-0.048***	0.023	0.013	0.004	0.007
Complete TT	(0.034)	(0.015)	(0.028)	(0.015)	(0.005)	(0.009)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,400	1,400	1,400	1,400	1,400	1,400

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log Av. Wages	Log Tot. Wages
	(1)	(2)	(3)	(4)	(5)
Close Treat.	0.026	0.008	-0.003	0.012	0.011
	(0.034)	(0.009)	(0.005)	(0.037)	(0.015)
Close Treat. *	0.065***	0.010	-0.060***	0.010	0.015
Complete TT	(0.022)	(0.008)	(0.014)	(0.019)	(0.018)
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	1,400	1,400	1,400	1,400	1,400

Notes. Data are provided at plant-level from the Steel Association Reports between 1949 and 2000. *Close Treat.* is an indicator equal to 1 for firms located within 50km of a treated plant and 0 for firms located within 50km of a comparison plant; *Complete TT* is an indicator equal to 1 for firms located within 50km of projects that got machinery, equipment and technical assistance and to 0 for firms located within 50km of projects that got machinery and equipment only. *Log Steel, Coke, Iron, C. Steel, Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages and Log Total Wages* are average and total wages. Standard errors are wild bootstrapped at plant-level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table 6: Vertical Spillover Effects in Steel Industry

Panel A: Plant Performance

	Log Steel		Log Workers		Log Fixed Assets		Log Coke		Log Iron		Log TFPQ	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Close Treat.	0.008	0.091**	0.036	0.058***	0.008	0.010	-0.075***	0.023***	-0.062***	0.030***	0.131***	0.020
	(0.012)	(0.029)	(0.035)	(0.012)	(0.015)	(0.012)	(0.008)	(0.007)	(0.019)	(0.011)	(0.0634)	(0.036)
Close Treat. *	0.009	0.032***	0.012	0.003	0.003	0.008	-0.009	0.015***	-0.007	0.011***	0.016	-0.012
Complete TT	(0.015)	(0.010)	(0.010)	(0.004)	(0.008)	(0.009)	(0.006)	(0.005)	(0.015)	(0.003)	(0.050)	(0.020)
Industry	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100

Panel B: Quality of Products and Processes

	Log C. Steel		Log Pig Iron		Log. Fun.		Log Oxy.		Log Cast.		Log Int. St.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Close Treat.	-0.005	-0.008	0.006	0.005	0.008	0.009	-0.095	-0.005	0.020	-0.011	0.004	-0.009
	(0.011)	(0.019)	(0.009)	(0.006)	(0.034)	(0.010)	(0.080)	(0.008)	(0.036)	(0.012)	(0.004)	(0.014)
Close Treat. *	0.009	0.014	-0.003	-0.008	0.008	-0.002	0.055	0.015	-0.012	0.005	-0.008	-0.007
Complete TT	(0.014)	(0.015)	(0.005)	(0.012)	(0.009)	(0.007)	(0.049)	(0.019)	(0.020)	(0.009)	(0.013)	(0.011)
Industry	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100

(continues)

Table 6: Vertical Spillover Effects in Steel Industry – Continued

Panel C: Human Capital

	% Engineers		% Tech.		% Unskilled		Log Av. Wages		Log Tot. Wages	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Close Treat.	0.007	-0.004	0.010	0.007	-0.013	-0.009	0.012	0.009	0.011	-0.006
	(0.014)	(0.008)	(0.013)	(0.009)	(0.015)	(0.017)	(0.010)	(0.017)	(0.015)	(0.005)
Close Treat. *	0.005	0.003	0.009	0.003	0.006	0.010	0.010	0.005	0.005	0.008
Complete TT	(0.012)	(0.009)	(0.011)	(0.007)	(0.014)	(0.024)	(0.019)	(0.015)	(0.008)	(0.010)
Industry	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100	1,000	1,100

Notes. Data are provided at plant level from the Steel Association Reports between 1949 and 2000. *Close Treat.* is an indicator equal to 1 for firms located within 50km of a treated plant and 0 for firms located within 50km of a comparison plant; *Complete TT* is an indicator equal to 1 for firms located within 50km of projects that got machinery, equipment and technical assistance and to 0 for firms located within 50km of projects that got machinery and equipment only. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages* and *Log Total Wages* are average and total wages. Standard errors are wild bootstrapped at plant-level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table 7: Spillover Effects, 1998-2013

Panel A: Horizontal Spillovers

	Log Value Added	Log Workers	Log Fixed Assets	Log TFPR	Log # Products	Log Exports
	(1)	(2)	(3)	(4)	(5)	(6)
Close Treat.	0.013	-0.011	-0.007	-0.005	-0.015	-0.012
	(0.025)	(0.013)	(0.1029)	(0.018)	(0.017)	(0.015)
Close Treat.*Private	0.235***	0.063***	0.059***	0.125***	0.113***	0.154***
	(0.031)	(0.026)	(0.015)	(0.028)	(0.036)	(0.043)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	332,102	332,102	332,102	332,102	332,102	332,102

Panel B: Vertical Spillovers

	Log Value Added		Log Workers		Log Fixed Assets		Log TFPR		Log # Products		Log Exports	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Close Treat.	0.013	-0.005	0.010	-0.022	-0.015	-0.012	-0.007	-0.011	-0.071***	-0.051***	-0.035***	-0.022***
	(0.025)	(0.018)	(0.059)	(0.034)	(0.017)	(0.015)	(0.1029)	(0.013)	(0.022)	(0.012)	(0.010)	(0.007)
Close Treat.	0.265***	0.222***	0.076***	0.056***	0.025***	0.022***	0.144***	0.133***	0.245***	0.231***	0.233***	0.254***
*Private	(0.031)	(0.028)	(0.016)	(0.021)	(0.005)	(0.004)	(0.015)	(0.026)	(0.037)	(0.037)	(0.043)	(0.043)
Industry	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	112,345	115,676	112,345	115,676	112,345	115,676	112,345	115,676	112,345	115,676	112,345	115,676

(continues)

Table 7: Spillover Effects, 1998-2013 – Continued

Panel C: Not Related Firms

	Log Value Added	Log Workers	Log Fixed Assets	Log TFPR	Log # Products	Log Exports
	(1)	(2)	(3)	(4)	(5)	(6)
Close Treat.	0.012	-0.004	-0.003	-0.015	0.002	-0.005
	(0.015)	(0.011)	(0.018)	(0.016)	(0.007)	(0.012)
Close Treat.	0.005	-0.0043	-0.004	0.008	-0.002	-0.005
*Private	(0.005)	(0.012)	(0.007)	(0.011)	(0.004)	(0.008)
Model	OLS	OLS	OLS	OLS	OLS	OLS
Year FE	No	No	No	No	No	No
Observations	324,762	324,762	324,762	324,762	324,762	324,762

Notes. Data are provided at firm level from the China Industrial Enterprises between 1998 and 2013. *Close Treat.* is an indicator equal to 1 for firms located within 50km of a treated plant and 0 for firms located within 50km of a comparison plant. *Private* is an indicator equal to 1 for firms that became private after 2005. *Log Value Added, Fixed Assets* and *Exports* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPR* is logged total factor productivity revenue computed with the Ackerberg et al. (2015)'s method; *Log Workers* is logged total number of workers; *Log # Products* is logged number of products realized in a given year. Standard errors are clustered at the firm-level. ***p<0.01, **p<0.05, *p<0.1.

Table 8: Channels of Persistence of the Technology Transfer Program

Panel A: Competition

	Log Number of Firms			Fraction Privately-Owned Firms		
	All	Related	Unrelated	All	Related	Unrelated
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.436***	0.421***	0.006	0.155***	0.150***	0.008
	(0.128)	(0.155)	(0.011)	(0.021)	(0.027)	(0.009)
Treatment *	0.421***	0.409***	-0.007	0.066***	0.061***	-0.003
Complete TT	(0.134)	(0.122)	(0.012)	(0.020)	(0.015)	(0.005)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,250	2,250	2,250	2,250	2,250	2,250

Panel B: Human Capital

	College Graduates			High-Skilled Workers		
	All	Male	Female	All	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.198***	0.238***	0.155***	0.072***	0.113***	0.051***
	(0.030)	(0.037)	(0.044)	(0.015)	(0.032)	(0.015)
Treatment *	0.046***	0.051***	0.035***	-0.023	0.025	-0.015
Complete TT	(0.010)	(0.014)	(0.011)	(0.027)	(0.039)	(0.026)
Year FE	No	No	No	No	No	No
Observations	2,250	2,250	2,250	2,250	2,250	2,250

Panel C: Government Investments

	Log Government Investments		
	All	Related Industries	Unrelated Industries
	(1)	(2)	(3)
Treatment	0.006	-0.011	0.015
	(0.051)	(0.044)	(0.028)
Treatment *	-0.004	0.009	-0.005
Complete TT	(0.030)	(0.003)	(0.010)
Year FE	No	No	No
Observations	2,250	2,250	2,250

Notes. Data are provided at the county-level from the Statistical Yearbook from 2005 to 2013. *Treatment* is an indicator equal to 1 for counties where treated projects were located and 0 for counties where comparison projects were located; *Complete TT* is an indicator equal to 1 for counties where treated projects received the complete technology transfer; *Log Number Firms* is the logged number of firms per county; *Frac. Private Firms* is the fraction of firms per county that became private after 2005; *College Graduate* and *High-Skilled Workers* are the logged number of college graduate and senior technicians per county; *Log Government Investments* is measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Related Sectors* includes firms in the same, upstream or downstream industry of treated and comparison plants; *Unrelated Sectors* includes firms not in the same, upstream or downstream industry of treated and comparison plants. Standard errors are wild bootstrapped at the county level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table 9: Aggregate Effects of the Technology Transfer Program

Panel A: Province-Level Outcomes

	Log Ind. Output	Log Ind. Empl.	Log GDP cap.	Log Invest.	Log Oth. Projects
	(1)	(2)	(3)	(4)	(5)
Share Projects*	1.213***	0.445***	1.603***	-0.054	0.021
Post 1952	(0.426)	(0.157)	(0.107)	(0.075)	(0.038)
Observations	963	963	963	963	963
Province FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Panel B: Cross-Sectional Multiplier

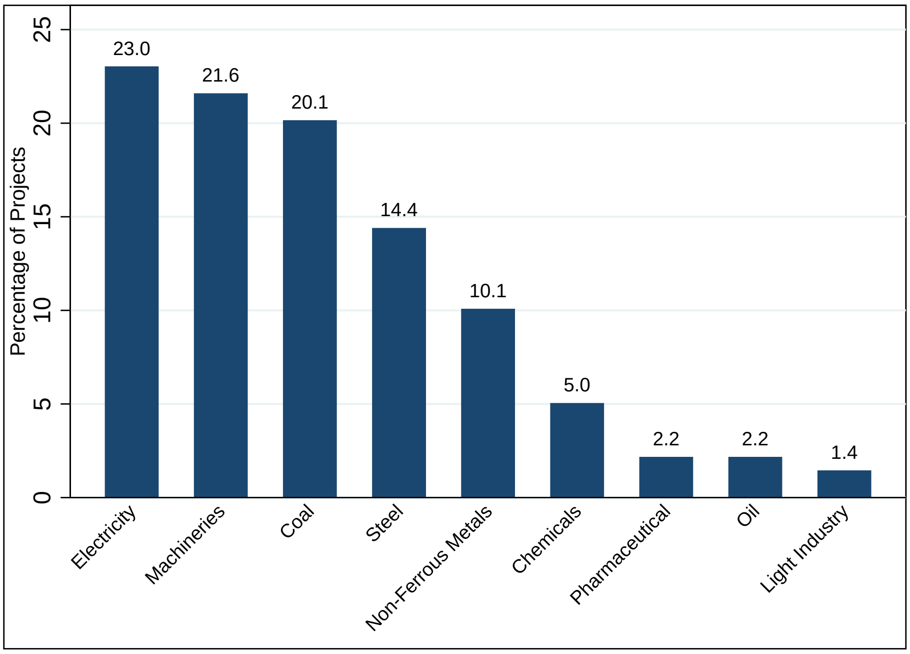
	ΔGDP capita					
	Medium Term (1949-1978)			Long Term (1949-2008)		
	(1)	(2)	(3)	(4)	(5)	(6)
Treated Projects capita	0.851***	0.878***	0.903***	0.611***	0.633***	0.682***
	(0.233)	(0.228)	(0.238)	(0.202)	(0.211)	(0.209)
Observations	963	963	963	963	963	963
Model	OLS	OLS	IV	OLS	OLS	IV
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Linear Trend	No	Yes	Yes	No	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes. Data are provided at the province-level from the Statistical Yearbooks between 1949 and 2008. *Share Projects* is the share of projects completed by Soviet Union out of the total projects approved under the Sino-Soviet Alliance. *Post 1952* is an indicator equal to 1 for years after 1952. *Log Ind. Output, Log Ind. Empl., Log GDP cap., Log Invest.* and *Log Oth. Projects* are the logged industrial output, industrial employment, GDP per capita, government investments and number of industrial projects discussed but not approved under the Sino-Soviet Alliance; *Treated Projects Capita* is the province investment in the treated projects over population; ΔGDP per capita$_{pt}$ is the variation in GDP per capita in province p between year t and year t-1 with $t \in [1949, 2008]$. Standard errors are wild bootstrapped at province level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Online Appendix - Not for Publication

Additional Figures and Tables

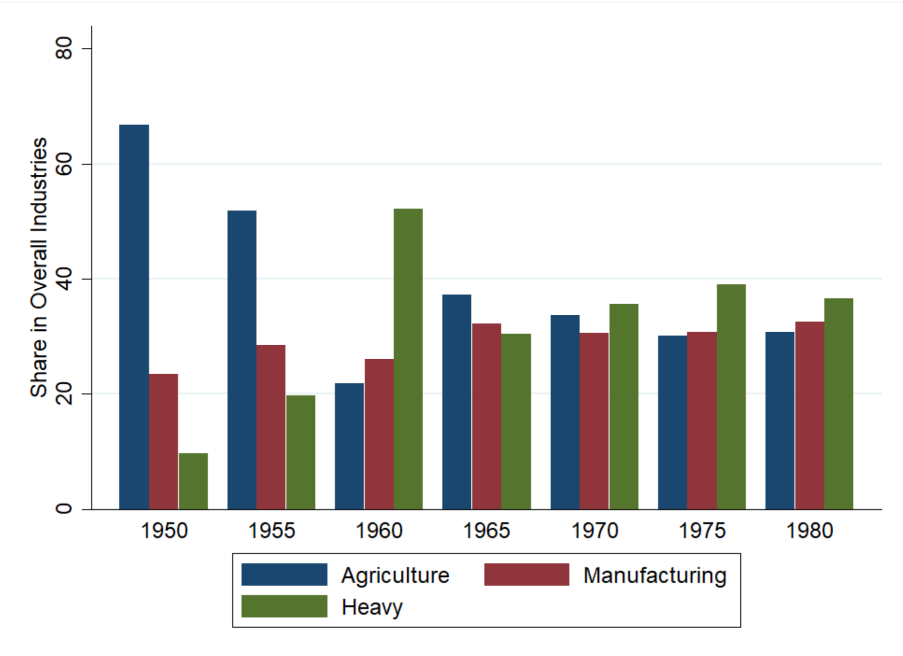
Figure A.1: Technology Transfer Projects by Industry



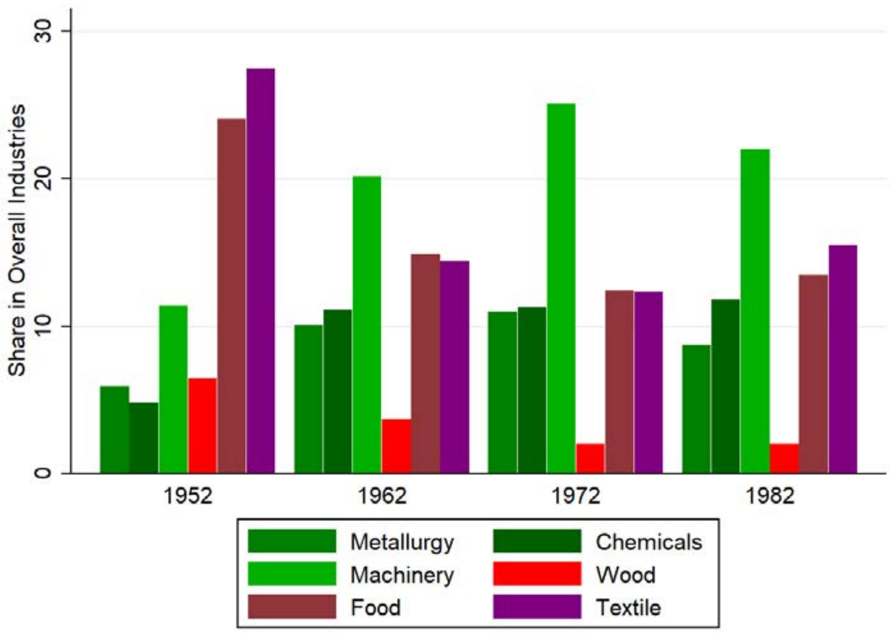
Notes. Distribution of the 139 approved technology transfer projects by industry. Data are provided at project-level from the National Archives Administration of China.

Figure A.2: Industry Dynamics

Panel A: By Sector



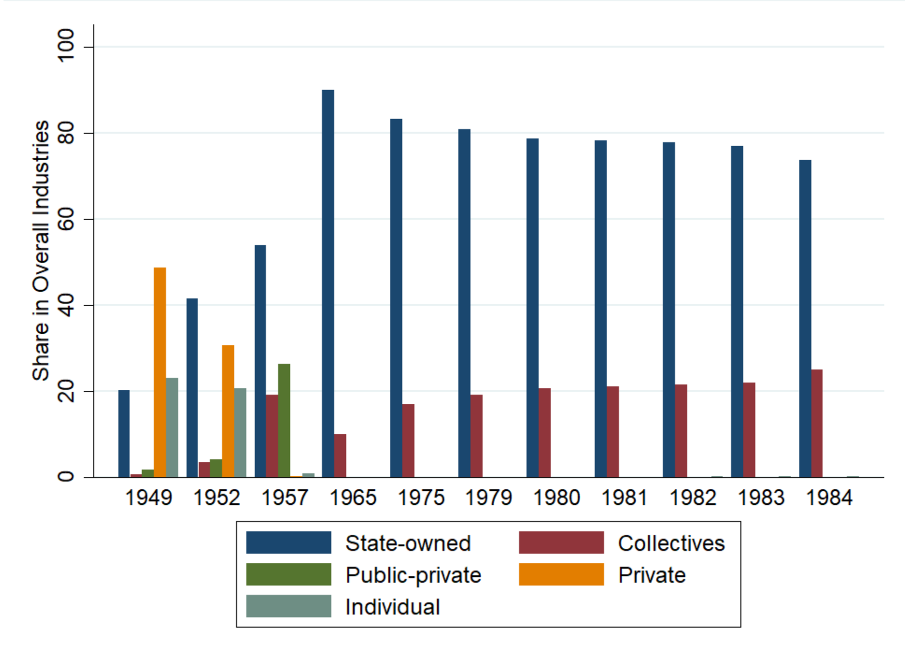
Panel B: By Industry



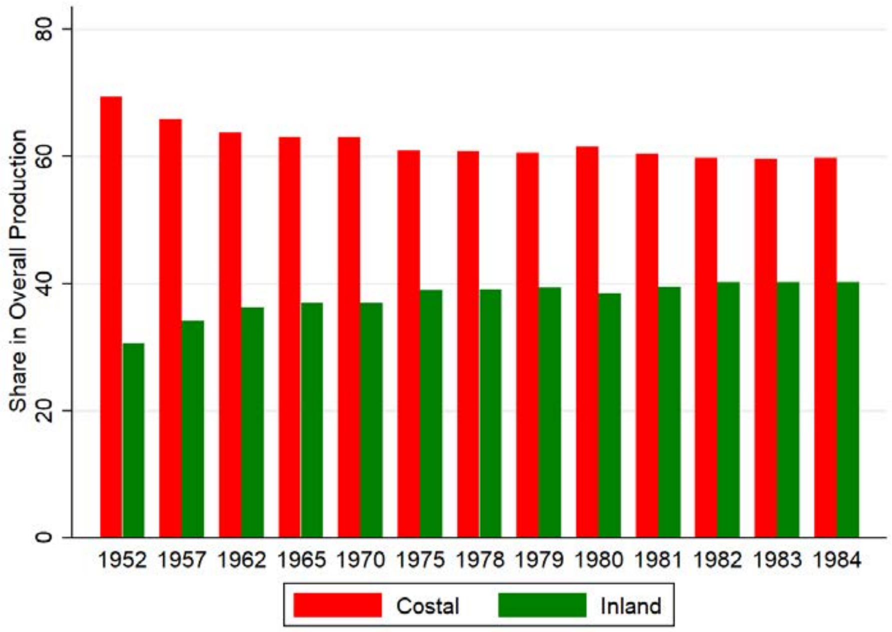
Notes. Panel A shows the percentage of firms in the agriculture, manufacturing, and heavy industry respectively from 1949 to 1985. Panel B show the detailed industry distribution in heavy industries (metallurgy, chemicals, and machinery), and manufacturing related industries (wood, textile, food). Data are provided at the province-level from the Statistical Yearbooks between 1949 and 1985.

Figure A.3: Ownership and Regional Allocation

Panel A: Ownership Allocation

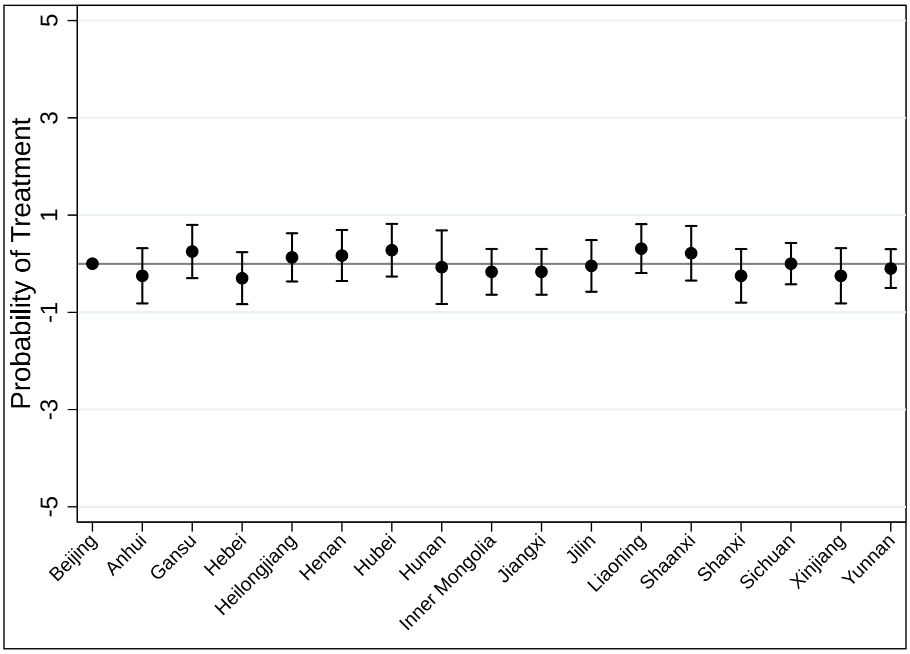


Panel B: Regional Allocation



Notes. Panel A shows changes in the percentage of firms operate in the state-owned, collectives, public-private, private, and individual firms respectively from 1949 to 1985. Panel B displays the production allocation between Coastal regions and Inland regions. Data are provided at the province-level from the Statistical Yearbooks between 1949 and 1985.

Figure A.4: Technology Transfer Projects by Industries



Notes. Province coefficients and 95% confidence intervals obtained by regressing the probability of receiving the Soviet technology transfer program on provincial indicators. The excluded province is Beijing. Data are provided at project-level from the National Archives Administration of China.

Table A.1: Province-Level Balancing Tests

	Share Treated Projects			Average Province Delays		
	(1)	(2)	(3)	(4)	(5)	(6)
Log GRP	0.280	0.373	0.373	-0.030	-0.094	-0.094
	(0.346)	(0.374)	(0.353)	(0.137)	(0.155)	(0.146)
Log GRP Primary	0.089	0.599	0.599	0.249	0.025	0.025
	(0.450)	(0.439)	(0.436)	(0.173)	(0.184)	(0.183)
Log GRP Secondary	0.123	0.273	0.273	0.094	0.127	0.127
	(0.247)	(0.242)	(0.210)	(0.096)	(0.099)	(0.086)
Log Population	-0.091	-0.116	-0.116	-0.237	-0.145	-0.145
	(0.396)	(0.378)	(0.386)	(0.152)	(0.154)	(0.157)
Log Workers	-0.056	-0.109	-0.109	-0.007	-0.003	-0.003
	(0.142)	(0.153)	(0.156)	(0.056)	(0.063)	(0.064)
Log Number of firms	-0.045	-0.060	-0.060	0.071	0.101	0.101
	(0.183)	(0.199)	(0.200)	(0.071)	(0.081)	(0.081)
Log Industrial Output	-0.009	0.229	0.229	0.125	-0.047	-0.047
	(0.273)	(0.251)	(0.246)	(0.106)	(0.104)	(0.102)
Log Total Investment	0.099	0.053	0.053	-0.060	-0.068	-0.068
	(0.138)	(0.147)	(0.135)	(0.054)	(0.060)	(0.055)
Log Capital Productivity	-0.059	-0.268	-0.268	-0.023	0.014	0.014
	(0.454)	(0.483)	(0.398)	(0.178)	(0.199)	(0.164)
Log Labor Productivity	-0.022	-0.021	-0.021	-0.032	-0.027	-0.027
	(0.170)	(0.185)	(0.162)	(0.067)	(0.076)	(0.067)
Province FE	No	Yes	No	No	Yes	No
Year FE	No	No	Yes	No	No	Yes
Observations	51	51	51	51	51	51

Notes. Data are provided at the province-level from the Statistical Yearbooks between 1949 and 1951. *Share Treated Projects* is the share of treated projects out all the total approved projects per province. *Average Province Delays* is the average years of delay between the expected and the actual length of the approved technology transfer projects. *Log GRP, GRP Primary, GRP Secondary, Population, Workers, Number of Firms, Industrial Output, Total Investment, Capital Productivity*, and *Labor Productivity* are logged real province product, real gross province product from primary sector, real gross province product from secondary sector, total population, number of workers, real industrial output, capital productivity defined as real industrial output over capital, labor productivity defined as real industrial output over workers. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.2: Test for Pretrends

	Pretrend * Share	Share Treated Projects	Linear Pretrend
	(1)	(2)	(3)
Log GRP	0.015	0.251	0.266
	(0.402)	(0.868)	(0.230)
Log GRP Primary	-0.000	0.089	0.206
	(0.549)	(1.186)	(0.314)
Log GRP Secondary	-0.046	0.215	0.273*
	(0.272)	(0.588)	(0.155)
Log Population	-0.009	-0.073	0.035
	(0.495)	(1.070)	(0.283)
Log Workers	-0.005	-0.046	0.019
	(0.178)	(0.384)	(0.102)
Log Number of firms	0.036	-0.116	-0.062
	(0.227)	(0.490)	(0.130)
Log Industrial Output	-0.011	0.013	0.136
	(0.333)	(0.719)	(0.190)
Log Total Investment	-0.005	0.109	0.110
	(0.161)	(0.349)	(0.092)
Log Capital Productivity	-0.268	-0.910	-0.161
	(0.398)	(1.006)	(0.266)
Log Labor Productivity	0.107	-0.236	-0.042
	(0.212)	(0.458)	(0.121)
Observations	51	51	51

Notes. Data are provided at the province-level from the Statistical Yearbooks between 1949 and 1951. *Share Treated Projects* is the share of treated projects out all the total approved projects per province. *Linear Pretrend* is a linear province pre-trend between 1949 and 1951. *Log GRP, GRP Primary, GRP Secondary, Population, Workers, Number of Firms, Industrial Output, Total Investment, Capital Productivity*, and *Labor Productivity* are logged real province product, real gross province product from primary sector, real gross province product from secondary sector, total population, number of workers, real industrial output, capital productivity defined as real industrial output over capital, labor productivity defined as real industrial output over workers. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.3: Correlation Between Project Characteristics and Delays in Their Completion

Panel A: All Projects

	Delay					
	(1)	(2)	(3)	(4)	(5)	(6)
Approve Year	-0.002	-0.002	-0.001	-0.002	-0.000	-0.002
	(0.002)	(0.003)	(0.004)	(0.002)	(0.004)	(0.002)
Start Year	-0.001	-0.002	-0.005	-0.001	0.001	-0.000
	(0.002)	(0.003)	(0.007)	(0.002)	(0.002)	(0.002)
Number of Workers	-0.003	0.002	0.002	0.001	-0.002	0.003
	(0.006)	(0.005)	(0.002)	(0.003)	(0.002)	(0.004)
Complete Transfer	-0.002	-0.002	-0.002	-0.002	-0.001	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.007)	(0.004)
Planned Investment		-0.003		-0.001	-0.014	
		(0.008)		(0.022)	(0.025)	
Actual Investment			-0.004	-0.002	0.006	
			(0.008)	(0.023)	(0.026)	
Capacity				0.000		
				(0.000)		
Province FE	No	No	No	No	Yes	No
Sector FE	No	No	No	No	No	Yes
Observations	139	139	139	57	139	139

Panel B: Steel Industry Projects

	Delay			
	(1)	(2)	(3)	(4)
Approve Year	0.015	0.013	0.013	0.014
	(0.008)	(0.008)	(0.008)	(0.008)
Start Year	-0.005	-0.007	-0.008	-0.012
	(0.004)	(0.004)	(0.004)	(0.007)
Number of Workers	-0.004	0.001	-0.002	-0.002
	(0.005)	(0.002)	(0.003)	(0.004)
Complete Transfer	0.014	0.011	0.011	0.015
	(0.009)	(0.009)	(0.008)	(0.010)
Planned Investment		-0.008		0.051
		(0.007)		(0.068)
Actual Investment			-0.008	-0.056
			(0.007)	(0.064)
Capacity				0.001
				(0.008)
Province / Sector FE	No	No	No	No
Observations	20	20	20	20

Notes. Data are provided at project-level from the National Archives Administration of China. Panel A includes all the 139 technology transfer projects and Panel B the 20 projects in steel industry. *Approve/Start Year* is the approval/start year of each project; *Complete Transfer* is 1 for projects that got machinery, equipment and technical assistance and 0 for projects that got machinery and equipment only; *Number of Workers* is the total number of plant employees; *Planned/Actual Investment* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *capacity* is measured in 10,000 tons per kilowatt, available for 57 projects in coal, electricity, oil and steel industries; *Delay* is the difference between the actual and planned length of each project. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.4: Correlation Between Delay and Participation in Technology Transfer Program

Panel A: All Projects

	Treatment					
	(1)	(2)	(3)	(4)	(5)	(6)
Delay	-0.167***	-0.167***	-0.167***	-0.157***	-0.167***	-0.155***
	(0.017)	(0.017)	(0.017)	(0.012)	(0.017)	(0.018)
Complete Transfer		-0.053	-0.051	-0.150	-0.093	-0.078
		(0.068)	(0.069)	(0.276)	(0.071)	(0.074)
Number of Workers		0.013	0.015	-0.014	-0.011	-0.012
		(0.018)	(0.021)	(0.019)	(0.010)	(0.014)
Approve Year		0.012	0.012	0.083	0.015	0.023
		(0.031)	(0.031)	(0.121)	(0.032)	(0.033)
Start Year			0.026	0.005	0.017	0.031
			(0.042)	(0.167)	(0.043)	(0.045)
Planned Investment			-0.001	-0.036	-0.014	-0.007
			(0.015)	(0.056)	(0.017)	(0.016)
Model	OLS	OLS	OLS	Probit	OLS	OLS
Province FE	No	No	No	No	Yes	No
Sector FE	No	No	No	No	No	Yes
Observations	139	139	139	139	139	139

Panel B: Steel Industry Project

	Treatment			
	(1)	(2)	(3)	(4)
Delay	-0.238***	-0.237***	-0.217***	-0.169***
	(0.095)	(0.085)	(0.087)	(0.004)
Complete Transfer	0.064	0.067	0.012	0.059
	(0.058)	(0.081)	(0.049)	(0.017)
Number of Workers		0.014	0.012	0.011
		(0.016)	(0.015)	(0.014)
Approve Year		0.077	0.092	0.0779
		(0.117)	(0.169)	(0.121)
Start Year			-0.038	
			(0.273)	
Planned Investment			0.000	
			(0.000)	
Model	OLS	OLS	OLS	Probit
Province/Sector FE	No	No	No	No
Observations	139	139	139	139

Notes. Data are provided at project-level from the National Archives Administration of China. Panel A includes all the 139 technology transfer projects and Panel B the 20 projects in steel industry. *Treatment* is is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed. *Approve/Start Year* is the approval/start year of each project; *Complete Transfer* is an indicator equal to 1 for projects that got machinery, equipment and technical assistance and to 0 for projects that got machinery and equipment only; *Number of Workers* is the total number of plant employees; *Planned/Actual Investment* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *capacity* is measured in 10,000 tons per kilowatt, available for 57 projects in coal, electricity, oil and steel industries; *Delay* is the difference between the actual and planned length of each project. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.5: Effects of Technology Transfer Program on Steel Plants, IV

Panel A: Plant Outputs, Inputs, and TFPQ

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.265***	-0.068	-0.003	-0.001	-0.036	0.190**
	(0.094)	(0.094)	(0.005)	(0.008)	(0.028)	(0.090)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel B: Quality of Products and Production Processes

	Log C. Steel	Log Pig Iron	Log Furn.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.190**	-0.273***	0.363***	0.327***	0.236***	0.388**
	(0.090)	(0.044)	(0.140)	(0.125)	(0.092)	(0.195)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel C: Human Capital

	% Engineers	% Staff	% Unskilled	Log. Av. Wages	Log Total Wages
	(1)	(2)	(3)	(4)	(5)
Treatment	0.109***	0.051***	-0.168***	0.072	0.056
	(0.040)	(0.021)	(0.040)	(0.105)	(0.227)
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757

Notes. Data are provided at plant-level from the Steel Association Reports between 1949 and 2000. *Treatment* is 1 for projects completed with the Soviet technology transfer and 0 for projects completed by China only. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages and Log Total Wages* are average and total wages. Standard errors are wild bootstrapped at the plant-level with 200 replications (Davidson and MacKinnon, 2010). ***p<0.01, **p<0.05, *p<0.1.

Table A.6: Effects of Technology Transfer Program on Additional Outcomes

Panel A: Energy Utilization, OLS

	Log Cok. Coal	Log Heavy Oil	Log Nat. Gases	Log Electricity
	(1)	(2)	(3)	(4)
Treatment	-0.188***	-0.213***	0.159***	0.208***
	(0.091)	(0.095)	(0.015)	(0.017)
Year FE	Yes	Yes	Yes	Yes
Observations	757	757	757	757

Panel B: Energy Utilization, IV

	Log Cok. Coal	Log Heavy Oil	Log Nat. Gases	Log Electricity
	(1)	(2)	(3)	(4)
Treatment	-0.206**	-0.228**	0.153***	0.256***
	(0.234)	(0.244)	(0.034)	(0.039)
Year FE	Yes	Yes	Yes	Yes
Observations	757	757	757	757

Notes. Data are provided at plant-level from the Steel Association Reports between 1949 and 2000. *Treatment* is 1 for projects completed with the Soviet technology transfer and 0 for projects completed by China only. *Log cok. coal, heavy oil, nat. gases and electricity* are logged quantities of the energy usage from coking coal, heavy oil, natural gases, and electricity. Standard errors are wild bootstrapped at the plant-level with 200 replications (Cameron et al., 2008).

Table A.7: Comparison between Treated and Comparison Plants and the Other Firms

Panel A: In 1985

	Log Value Added	Log Workers	Log Fixed Assets	Log TFPR
	(1)	(2)	(3)	(4)
Treated Plants	0.246***	0.128***	0.150***	0.199***
	(0.043)	(0.031)	(0.045)	(0.045)
Comparison Plants	0.006	0.122***	0.140***	0.009
	(0.014)	(0.035)	(0.043)	(0.008)
Year FE	No	No	No	No
Observations	7,515	7,515	7,515	7,515

Panel B: In 1998-2013

	Log Value Added	Log Workers	Log Fixed Assets	Log TFPR
	(1)	(2)	(3)	(4)
Treated Plants	0.247***	0.132***	0.154***	0.207***
	(0.044)	(0.035)	(0.033)	(0.054)
Comparison Plants	0.025	0.128***	0.145***	0.021
	(0.028)	(0.033)	(0.045)	(0.028)
Privately-Owned	0.010	-0.017	0.009	-0.013
	(0.017)	(0.016)	(0.011)	(0.018)
Treated Plants*Post 2005	0.220***	0.133***	0.138***	0.190***
	(0.025)	(0.033)	(0.009)	(0.028)
Comparison Plants*Post 2005	0.021	0.127***	0.131***	0.018
	(0.024)	(0.031)	(0.039)	(0.020)
Privately-Owned*Post 2005	0.355***	0.020	0.024	0.320***
	(0.022)	(0.026)	(0.025)	(0.021)
Year FE	No	No	No	No
Observations	545,166	545,166	545,166	545,166

Notes. Data are provided at firm-level for the Second Annual Survey in 1985 (Panel A) and from the China Industrial Enterprises between 1998 and 2013 (Panel B). *Treated Plants* is an indicator equal to 1 for projects completed with the Soviet technology transfer; *Comparison Plants* is an indicator equal to 1 for projects completed completed by China only; *Privately-Owned* is an indicator equal to 1 for firms that became private after 2005; *Post2005* is an indicator equal to 1 for years after 2005. *Log Value Added* and *Log Fixed Assets* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Log TFPR* is logged total factor productivity revenue computed with the Ackerberg et al. (2015)'s method; *Log Workers* is logged total number of workers. Standard errors are clustered at the firm-level. ***p<0.01, **p<0.05, *p<0.1.

Table A.8: Effects of Complete and Partial Technology Transfer on Steel Plants, IV

Panel A: Plant Performance

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.202***	-0.055	-0.004	-0.003	-0.012	0.175**
	(0.091)	(0.090)	(0.008)	(0.005)	(0.018)	(0.053)
Treatment *	0.066***	-0.008	-0.003	-0.004	-0.016	0.048**
Complete TT	(0.023)	(0.009)	(0.005)	(0.005)	(0.018)	(0.019)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel B: Quality of Products and Inputs

	Log C. Steel	Log Pig Iron	Log. Fun.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.045***	-0.053***	0.333**	0.228***	0.202***	0.398***
	(0.012)	(0.015)	(0.062)	(0.076)	(0.042)	(0.099)
Treatment *	0.155***	-0.133***	0.057***	-0.049***	0.031***	0.041***
Complete TT	(0.048)	(0.041)	(0.015)	(0.015)	(0.011)	(0.012)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757	757

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log Av. Wages	Log Tot. Wages
	(1)	(2)	(3)	(4)	(5)
Treatment	0.025	0.043***	-0.045***	0.032	0.039
	(0.040)	(0.011)	(0.015)	(0.045)	(0.032)
Treatment *	0.075***	0.005	-0.080***	0.007	0.009
Complete TT	(0.025)	(0.005)	(0.022)	(0.009)	(0.012)
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	757

Notes. Data are provided at plant-level from the Steel Association Reports between 1949 and 2000. *Treatment* is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed by China only. *Complete TT* is an indicator equal to 1 for projects that got machinery, equipment and technical assistance and to 0 for projects that got machinery and equipment only. *Log Steel, Coke, Iron, C. Steel, Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages* and *Log Total Wages* are average and total wages. Standard errors are wild bootstrapped at the plant-level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table A.9: Effects of Complete vs Partial Technology Transfer in 1985 and 1998-2013

Panel A: Value Added, Assets, Workers, and TFPR in 1985 and 1998-2013

	Log Value Added		Log Fixed Assets		Log Workers		Log TFPR	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.190***	0.167***	0.029	0.033	-0.008	-0.010	0.122***	0.101***
	(0.055)	(0.066)	(0.028)	(0.043)	(0.008)	(0.020)	(0.023)	(0.031)
Treatment	0.035***	0.055***	0.009	0.008	0.003	0.006	0.032***	0.036***
x Complete TT	(0.012)	(0.014)	(0.018)	(0.013)	(0.007)	(0.011)	(0.011)	(0.015)
Years	1985	1998-2013	1985	1998-2013	1985	1998-2013	1985	1998-2013
Firm and Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	273	1,925	273	1,925	273	1,925	273	1,925

Panel B: Additional Outcomes, 1998-2013

	Log Costs	Log # Products	Log New Output	Log Exports
	(1)	(2)	(3)	(4)
Treatment	-0.058***	0.007	0.009	0.077***
	(0.015)	(0.010)	(0.008)	(0.012)
Treatment x Complete TT	-0.047***	0.175***	0.148***	0.090***
	(0.011)	(0.055)	(0.037)	(0.022)
Firm FE	No	No	No	No
Year FE	Yes	Yes	Yes	Yes
Observations	1,925	1,925	1,925	1,925

Notes. Data are provided at firm-level for the Second Annual Survey in 1985 (Panel A, columns 1, 3, 5, and 7) and from the China Industrial Enterprises between 1998 and 2013 (Panel A, columns 2, 4, 6, 8, and Panel B). *Treatment* is is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed by China only. *Complete TT* is an indicator equal to 1 for projects that got machinery, equipment and technical assistance and to 0 for projects that got machinery and equipment only. *Log Value Added, Fixed Assets, Costs, Value New Products,* and *Exports* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Value New Prod.* is the value of output from new products, defined as products not produced in the year before; *Log TFPR* is logged total factor productivity revenue computed with the Ackerberg et al. (2015)'s method; *Log Workers* is logged total number of workers; *Log # Products* is logged number of products realized in a given year. Standard errors are clustered at the firm-level. ***p<0.01, **p<0.05, *p<0.1.

Table A.10: Entry of New Firms Spatially Close to Treated and Comparison Plants

Panel A: All Firms

	Number of New Firms											
	All Firms (1-4)				Related Sectors (5-8)				Unrelated Sectors (9-12)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Treatment	0.181***	0.161***	0.135***	-0.007	0.186***	0.172***	0.133***	-0.006	-0.001	0.010	0.018	-0.004
	(0.040)	(0.044)	(0.043)	(0.046)	(0.042)	(0.045)	(0.044)	(0.047)	(0.009)	(0.010)	(0.013)	(0.020)
Treatment x	0.047***	0.033***	0.055***	-0.003	0.049***	0.036***	0.048***	-0.002	-0.009	-0.002	0.012	-0.001
Complete TT	(0.013)	(0.011)	(0.015)	(0.042)	(0.008)	(0.009)	(0.012)	(0.042)	(0.008)	(0.009)	(0.012)	(0.019)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radius	<10	10-25	25-50	50-100	<10	10-25	25-50	50-100	<10	10-25	25-50	50-100
Observations	139	139	139	139	139	139	139	139	139	139	139	139

Panel B: Steel Industry

	Number of New Firms											
	All Firms (1-4)				Related Sectors (5-8)				Unrelated Sectors (9-12)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Treatment	0.155***	0.187***	0.103***	-0.025	0.180***	0.115***	0.135***	-0.020	-0.029	-0.035	0.025	0.055
	(0.038)	(0.045)	(0.029)	(0.105)	(0.045)	(0.033)	(0.137)	(0.105)	(0.027)	(0.029)	(0.044)	(0.064)
Treatment x	0.038***	0.037***	0.035***	-0.033	0.041***	0.039***	0.034***	-0.013	-0.040	-0.013	0.011	0.008
Complete TT	(0.005)	(0.006)	(0.007)	(0.106)	(0.010)	(0.013)	(0.011)	(0.019)	(0.027)	(0.029)	(0.045)	(0.015)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radius	<10	10-25	25-50	50-100	<10	10-25	25-50	50-100	<10	10-25	25-50	50-100
Observations	20	20	20	20	20	20	20	20	20	20	20	20

Notes. Data are provided at the firm-level from the Second Industrial Survey of 1985. *Number of New Firms* is the logged number of new firms that located within 10km, between 10 and 25km, between 25 and 50km, and between 50 and 100k of treated and comparison plants between 1952 and 1985. *Treatment* is is an indicator equal to 1 for projects completed with the Soviet technology transfer and to 0 for projects completed by China only. *Complete TT* is an indicator equal to 1 for projects that got machinery, equipment and technical assistance and to 0 for projects that got machinery and equipment only. In Panel A the distance is calculated between new firms and any treated and comparison plants; in panel B the distance is calculated between new firms and any treated and comparison plants in steel industry only. *Related Sectors* includes firms in the same, upstream or downstream industry of treated and comparison plants; *Unrelated Sectors* includes firms not in the same, upstream or downstream industry of treated and comparison plants. Standard errors are wild bootstrapped at the county level with 200 replications. ***p<0.01, **p<0.05, *p<0.1.

Table A.11: Spillover Effects in 1985

Panel A: Horizontal Spillovers

	Log Value Added	Log Fixed Assets	Log Workers	Log TFPR
	(1)	(2)	(3)	(4)
Close Treat.	0.026	0.129	0.127	0.024
	(0.051)	(0.215)	(0.096)	(0.046)
Close Treat. * Complete TT	0.193***	-0.257*	-0.081	0.176***
	(0.030)	(0.129)	(0.063)	(0.027)
Year FE	No	No	No	No
Observations	2,250	2,250	2,250	2,250

Panel B: Vertical Spillovers

	Log Value Added		Log Workers		Log Fixed Assets		Log TFPR	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Close Treatment	0.134***	0.108**	0.074	0.154***	0.063	0.073	0.122***	-0.020
	(0.047)	(0.050)	(0.078)	(0.047)	(0.271)	(0.278)	(0.042)	(0.042)
Close Complete	0.077	-0.036	-0.036	-0.016	0.077	-0.028	0.030	-0.030
TT Treatment	(0.072)	(0.046)	(0.035)	(0.043)	(0.243)	(0.254)	(0.038)	(0.039)
Model	Up	Down	Up	Down	Up	Down	Up	Down
Year FE	No	No	No	No	No	No	No	No
Observations	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100

Panel C: Not Related Firms

	Log Value Added	Log Workers	Log Fixed Assets	Log TFPR
	(1)	(2)	(3)	(4)
Close Treat.	-0.030	0.012	0.012	-0.034
	(0.135)	(0.150)	(0.015)	(0.050)
Close Treat. * Complete TT	0.088	-0.008	-0.010	0.041
	(0.124)	(0.137)	(0.017)	(0.060)
Model	OLS	OLS	OLS	OLS
Year FE	No	No	No	No
Observations	3,140	3,140	3,140	3,140

Notes. Data are provided at firm-level for the Second Annual Survey in 1985. *Close Treat.* is an indicator equal to 1 for firms located within 50km of a treated plant and 0 for firms located within 50km of a comparison plant; *Complete TT* is an indicator equal to 1 for firms located within 50km of projects that got machinery, equipment and technical assistance and to 0 for firms located within 50km of projects that got machinery and equipment only. *Log Value Added* and *Fixed Assets* are measured in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Log TFPR* is logged total factor productivity revenue computed with the Ackerberg et al. (2015)'s method; *Log Workers* is logged total number of workers. Standard errors are clustered at the firm-level. ***p<0.01, **p<0.05, *p<0.1.

Table A.12: IV First Stage

	Share Treated Projects		
	(1)	(2)	(3)
Average Project Delays	-0.268***	-0.267***	-0.267**
	(0.074)	(0.087)	(0.094)
Planned Investment		-0.000	-0.000
		(0.000)	(0.000)
Province Projects		0.001	0.002
		(0.008)	(0.009)
Log Population			-0.049
			(0.087)
Log GRP			0.046
			(0.099)
Observations	17	17	17

Notes. Data are provided at the province-level from the Statistical Yearbooks in 1949. *Share Treated Projects* is the share of treated projects out all the total approved projects per province. *Average Province Delays* is the average years of delay between the expected and the actual length of the approved technology transfer projects. *Planned Investment* is the average province planned investment. *Province projects* is the number of industrial projects discussed but not approved under the Sino-Soviet Alliance; *Log Population* is logged population; *Logged GRP* is the logged real gross province product. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

B Data Collection and Dataset Construction

In this Appendix we provide a detailed description of the primary sources of our data, the dataset construction, and a list of all the variables used in the paper with their definitions, aggregation level, time period and sources (Appendix Table B.1). When needed, we also provide additional details on the variable construction.

B.1 Description of Primary Sources

The data collection targeted the "156 technology transfer projects" approved under the Sino-Soviet Alliance between 1950 and 1958. To retrieve the list of such projects we relied on the official agreements signed between Soviet Union and China from the National Archives Administration of China, whose access is restricted and was occasionally granted for this paper. For each project, we collected and digitized detailed information on the project name and location, the name of plant built, industry, size and capacity, whether the project involved a complete or a partial technology transfer, and whether it was completed with the Soviet assistance or by China only due to the Sino-Soviet split. To make sure we collected the official agreements for all the approved projects, we also gathered data from the *Selected Archival Materials on the PRC's Economy*, a collection of documents on PRC's economic development between 1949 and 1957, including detailed summaries of the "156 technology transfer projects". A comparison between these summaries and the official agreements indicate that the former do not contain any additional project or any additional project information than the latter.We then constructed a panel dataset of plant performance and county/province outcomes gathering data from four difference sources.

Steel Association Reports (1949-2000). The Steel Association Reports, compiled yearly from 1949 to 2000 contained restricted data on all the 94 Chinese plants in the steel industry. This data contains detailed information on plant quantity and type of steel products, inputs utilization, the specific machinery in use, capital, fixed investment, profits, and number and types of workers (unskilled workers, high-skilled workers, and engineers), that we manually collected and digitized.

Second Industrial Survey (1985). In early 1980s, the Chinese government started to implement several reforms on market liberalization. However, since RPC foundation, there was lack of systematic data on firm and industry structure. The Second Industrial Survey was therefore undertaken for policy makers to learn about the structure of the industries and enterprises, the products, the state of technology and equipment, the economic value of enterprises, and the quality of their workforce. This information should have been used as a guide for subsequent policies and reforms. As such, the Second Industrial Survey, conducted by Statistics China in 1985, covered more than 40 industries within the secondary sector. It is considered the most comprehensive data on industrial enterprises since PRC foundation to the early 1990s.[1] The firm-level data portion of such survey, still confidential today, has been declassified for this project and covers the 7,592 largest firms operating in China in 1985.[2] For each of them, the Survey gathered data on output, sales, profits, fixed assets, raw materials, total wages, number of employees, finished product inventory, main products, production equipment, and year of establishment, that we manually collected and digitized. We have also manually collected and digitized the county-level and prefecture-level industrial production data reported in the Survey, stored internally at Statistics China in Beijing (China).

China Industrial Enterprises database (1998-2013). The China Industrial database, compiled by Statistics China yearly between 1998 and 2013 to compute the Gross Domestic Product, covers than 1 million industrial publicly listed and private enterprises with asset value exceeds 5 million yuan prior to 2011, and 20 million yuan after 2011. All industrial firms in the database are required to file an annual report of their production activities, accounting and financial information. The Statistics China implemented standard and strict double checking procedures for verifying the accuracy of firm reported information. For each firm, the database contains data on output, number of employees, profits, ownership structure and capital investment.

Statistical Yearbook of China (1949-2000). We manually collected and digitized province-level data from all the published Statistically Yearbooks compiled by Statistics China between 1949 and 2000. This data contains province-level information on GDP, population, capital, investment, and number of workers.

To rule out the potential concern that the local governments or the firms may have misreported some data, we do the following checks. First, summarize the industrial output of firms in the Second Industrial Survey by counties and prefectures and we compare this data with the county-level and prefecture-level industrial output data reported in the Survey. The two sets of data appear very similar, with a correlation of 0.989. Second, we summarize the industrial output of firms in the Second Industrial Survey by provinces

[1] A First Industrial Survey was conducted in 1950, right after PRC foundation with the goal of estimating the basic situation of the national industrial and mining enterprises, as a basis for the Civil War recovery and subsequent development. However, this survey does not contain any firm-level data and is pre-existing to the construction of treated and comparison plants. For this reason, it is not a source employable in our paper.

[2] The Second Industrial Survey reported that in 1985 there were 437,200 firms operating in China and that it collected firm-level data for the 7,592 largest ones, but the official guidelines of the Survey do not provide a formal size threshold to be included in the Survey itself. However, we we computed that, while the surveyed companies were only 1.74 percent of total Chinese firms, they produced 62.46% of the industrial output in 1985.

and we compare it with total province industrial output from the Statistical Yearbook of China in 1985. The two sets of data are comparable and show a correlation of 0.974. Third, we validate the province industrial output from the Statistical Yearbook with province-level data on industrial production collected by Statistics China only for the years 1952, 1957, 1965, 1970, 1978, and 1984. The Statistics China data appears fully consistent with the Statistical Yearbook data.

Data Digitization. Between August 2019 and November 2020, we hired four research assistants (undergraduate students at Tsinghua University and Peking University) to digitize the newly-collected data. On top of manually performing the data-entry, the research assistants were asked to cross-check their work to make sure all the data were correctly digitized. Bo Li also personally checked the accuracy of 70 percent of the data-entries.

B.2 Matching across Different Data Sources

To match the plants built in the "156 technology transfer projects" with their outcomes across different sources, we proceed as follows. For plants in the steel industry, we used plant name, location, county, and province and we manually and uniquely matched all the 20 steel plants eligible to participate in the technology transfer program with their annual reports. For plants in all the industry, we used firm name, location, county, and province and we manually and uniquely matched all the 139 firms eligible to participate in the technology transfer program with their outcomes in 1985 and between 1998 and 2013.

B.3 Geo-localization of Treated and Comparison Plants

The Second Industrial Survey records firm address in 1984. To geo-localize the firms, we search the 1984 address of each of them on Gaode Map, a GPS browser providing an online high-quality map of China. If we could find the 1984 address in Gaode Map, we use Gaode Map's geocoding API to transfer the 1984 address to the geographic location, based on latitude and longitude. For 3426 of the total 7592 firms covered by the Second Industrial Survey (45 percent), their 1984 addresses cannot be found as the name of streets, villages, or towns changed. We therefore manually searched these 1984 addresses on the websites of local governments that keep track of name changes and found how the addresses change from 1984 and the corresponding current addresses. In this way, we were able to obtain the geographic locations of all the firms based on the current addresses.[3]

Between 1998 and 2013, the China Industrial Enterprises database records the firm name only. We search a firm by its name in Tianyancha, a comprehensive database on all registered Chinese firms, which provides the firm's current address. We obtain all firms' addresses and use Gaode Map's geocoding API to transfer the addresses to geographic locations, based latitudes and longitudes.

B.4 Identification of Firms Economically Related to Treated and Comparison Plants

We construct a list of firms economically related to treated and comparison plants through the following steps. We retrieve firm two-digit industry from the Steel Association Reports or the Second Industrial Survey from which we observe the firm products. If firms had the same two-digit industry of treated and comparison plants, we consider them operating in the same industry and include them in the horizontal spillover analysis. If firms had a different two-digit industry, we use the input-output tables of the closest available year to assess whether firm products were upstream and downstream, relative to the products of the treated and comparison plants. If products were neither upstream or downstream, we consider firms not economically related to treated and comparison plants. After the National Bureau of Statistics of China (NBS) compiled the 1987 Input-Output Tables, every 5 years, (i.e., in the year ending with 2 or 7), the NBS conducts the national input-output survey and compiles the benchmark input-output tables of the corresponding year. We therefore used the Input-Output Tables 1987 (for the Second Industrial Survey data of 1985) and the 1997, 2002, 2007 and 2012 Input-Output Tables (for the China Industrial Enterprises database of 1998-2013).

[3] From 1990-2013, Chinese prefecture cities were subject to some changes in the jurisdiction. However, as we retrieve firm latitude and longitude, these changes do not affect the firm geo-localization.

Table B.1: List and Definition of Variables and Their Sources

Variable	Definition	Level, Source and Years of Coverage
Steel	Logged tons of steel produced	Plant-year, Steel Association, 1949-2000
Coke/Iron/Pig Iron	Logged tons of coke/ iron/ pig iron used as input	Plant-year, Steel Association, 1949-2000
Log TFPQ	Total Factor Productivity Quantity; for estimation see Appendix C.	Plant-year, Steel Association, 1949-2000
Log Furnace/Oxygen	Logged tons of steel produced with the open heart furnace/basic oxygen	Plant-year, Steel Association, 1949-2000
Log Continuous Casting	Logged tons of steel produced with the continuous casting	Plant-year, Steel Association, 1985-2000
Log International Standard	Logged tons of steel above international standard	Plant-year, Steel Association, 1985-2000
% Engineers	Share of engineers out of total employment	Plant-year, Steel Association, 1949-2000
% Technicians	Share of high-skilled technicians out of total employment	Plant-year, Steel Association, 1949-2000
% Unskilled	Share of unskilled workers out of total employment	Plant-year, Steel Association, 1949-2000
Log Av./Total Wages	Logged deflated average/total wages	Plant-year, Steel Association, 1949-2000
Log Workers	Total number of workers	Plant-year, Steel Association, 1949-2000
		Firm-year, Second Industrial Survey, 1985
		Firm-year, China Industrial Enterprises, 1998-2013
Log Value Added	Difference between firm gross income and intermediate inputs	Firm-year, Second Industrial Survey, 1985
		Firm-year, China Industrial Enterprises, 1998-2013
Log Fixed Assets	Logged value of land, buildings, and machines owned by the firm	Firm-year, Second Industrial Survey, 1985
		Firm-year, China Industrial Enterprises, 1998-2013
Log TFPR	Total Factor Productivity Revenue; for estimation see Appendix C.	Firm-year, Second Industrial Survey, 1985
		Firm-year, China Industrial Enterprises, 1998-2013
Log Costs	Sum of production costs	Firm-year, China Industrial Enterprises, 1998-2013
Log # Products	Logged Sum of production costs	Firm-year, China Industrial Enterprises, 1998-2013
Log Value New Production	Logged value of output from products not produced in the year $t-1$	Firm-year, China Industrial Enterprises, 1998-2013
Log Exports	Logged value of exports	Firm-year, China Industrial Enterprises, 1998-2013
Log Industrial Output	Logged value of industrial production	Province-year, Statistical Yearbook, 1949-2013
Log Industrial Employment	Logged number of workers in industrial sector	Province-year, Statistical Yearbook, 1949-2013
Log GDP Capita	Logged GDP per capita	Province-year, Statistical Yearbook, 1949-2013
Log Investment	Logged value of government investments	Province-year, Statistical Yearbook, 1949-2013
Log College Graduates	Logged number of college graduates	County-year, Statistical Yearbook, 2005-2013
Log High-Skilled Workers	Logged number of high-skilled workers	County-year, Statistical Yearbook, 2005-2013

C Estimation of TFPQ and TFPR

We assume a Cobb-Douglas production function

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} M_{it}^{\beta_m} \tag{C.1}$$

where Y_{it} is the output of plant i in year t, K_{it} is capital, L_{it} is total employment, M_{it} is materials, and A_{it} is the Hicksian-neutral productivity. Taking natural logs, equation C.1 results in the linear production function

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + a_{it} \tag{C.2}$$

where lower-case letters refer to natural logarithms and β_0 measures the mean efficiency level across plants and over time.

Estimating equation C with OLS is likely to generate biased estimates of factor elasticities as productivity shocks could be correlated with capital, labor, and materials. To solve this issue, we estimate the production function following Ackerberg et al. (2015), henceforth ACF. This methodology controls for the simultaneity bias that arises because input demand and unobserved productivity are positively correlated. More specifically, the ACF methodology extends the framework of Olley and Pakes (1996), henceforth OP, and Levinsohn and Petrin (2003), henceforth LP. The OP and LP methodologies use investment or intermediate inputs proxy for productivity shocks. Specifically, they assume that labor is the nondynamic input, capital is the dynamic input, and that

$$m_{it} = f_t(k_{it}, a_{it}) \tag{C.3}$$

where m_{it} is investment in the Olley and Pakes (1996)'s method and intermediate inputs in the Levinsohn and Petrin (2003)'s method and is function of capital k_{it} and productivity ω_{it}.[4]

Assuming that C.3 is invertible, then

$$a_{it} = f_t^{-1}(k_{it}, m_{it}) \tag{C.4}$$

and substituting in equation C.2,

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + f_t^{-1}(k_{it}, m_{it}) \tag{C.5}$$

[4] Petrin et al. (2004) propose to use intermediate inputs rather than investment as a proxy for productivity shocks, because investment is lumpy due to substantial adjustment costs and, so, it might not smoothly respond to the productivity shock.

where f_t^{-1} is treated as nonparametric. The estimation consists of two steps. First, equation C.5 is estimated by using semiparametric techniques. This allows estimating β_l, but does not identify β_k, since it is collinear with the nonparametric function. Second, assuming that ω follows a first-order Markov process implies that

$$a_{it} = E[a_{it}|m_{it-1}] + \xi_{it} = E[a_{it}|a_{it-1}] + \xi_{it} \tag{C.6}$$

where ξ is the "innovation" component of ω, such that $E[\xi_{it}|m_{it-1}] = 0$. Since capital at time t is decided at time $t-1$, $E[\xi_{it}|k_{it}] = 0$.[5] Variation in k_{it} conditional on a_{it-1} is the exogenous variation used to identify β_k, which is estimated via GMM using the following moment conditions:

$$\frac{1}{T}\frac{1}{N}\sum_t\sum_i \xi_{it}(\beta_k)\cdot k_{it} \tag{C.7}$$

The ACF methodology solves the possible collinearity problem between labor and investment or intermediate inputs. This collinearity problem may arise because labor and investment or intermediate inputs have the same data generation process (DGP). Therefore, it is not possible to simultaneously estimate a fully nonparametric (time-varying) function of (a_{it}, k_{it}) along with a coefficient on a variable that is only a (time-varying) function of those same variables (q_{it}, k_{it}). The Ackerberg et al. (2006, 2015) method assumes that l_{it} is chosen by firms at time $t-b$ $(0 < b < 1)$, after k_{it} was chosen at time $t-1$, but before m_{it} being chosen at time t. In this setup,

$$m_{it} = f_t(a_{it}, k_{it}, l_{it})$$

In the first stage, β_l is not identified, but it is possible to estimate $\Phi_t(m_{it,}k_{it}, l_{it}) = \beta_k k_{it} + \beta_l l_{it} + f_t^{-1}(m_{it}, k_{it}, l_{it})$, which represents output net of the untransmitted shock η_{it}. In the second stage, the moment condition on capital is $E[\xi_{it}|k_{it}] = 0$ (which comes from a following a first order Markov process and implies $E[\xi_{it}\cdot k_{it}] = 0$) and the moment condition on labor is $E\left[\xi_{it}|\begin{matrix} k_{it} \\ l_{it-1}\end{matrix}\right] = 0$ (since l_{it-1} was chosen at time $t-b-1$ and this implies $E\left[\xi_{it}\cdot\begin{matrix} k_{it} \\ l_{it-1}\end{matrix}\right] = 0$).

For plants in the steel industry, we estimate total factor productivity quantity (TFPQ), which represents the true physical productivity (Foster et al., 2008), as we observe the physical quantities of output produced. Notably, in our setting, we also observe physical quantities of the materials (coke and iron) and the specific capital used (number of furnaces), so our estimates do not suffer from the potential input price bias that arises due

[5] Olley and Pakes (1996) also control for selection, by introducing an exit rule for firms.

to the use of industry input deflators (De Loecker et al., 2016). For plants in all the industries, we estimate total factor productivity revenue (TFPR), where output is proxied by value added and capital is estimated from the fixed gross assets using the Perpetual Inventory Method (PIM). [6] All the nominal variables are deflated using the year-industry specific deflator provided by Statistics China, with base-year 1980. A potential problem in using the year-industry specific deflators is that they cannot control for plant-specific price shocks (De Loecker and Warzynski, 2012). However, this is not an issue in our context. In fact, China was a planned economy until 2000s, meaning that the output and input prices were set yearly by the government and were the same for all firms in the same industry.

Appendix Table C.1 reports the coefficients on labor and capital estimated by using the Ackerberg et al. (2015) method. For robustness, we also report the labor and capital coefficients estimated with the OP and LP methodologies, OLS and the factor shares (Solow's residuals). It is worth noting that all the coefficients are remarkably similar to the OLS ones, indicating that the correlation between factor elasticities and productivity shocks is neglectable. This is related to the planned economy context: production quotas were allocated by the government, which may have not been as responsive to productivity shocks as plants in market economies.

[6] To obtain a measure of firm capital stock from the fixed gross assets (*fga*), we use the Perpetual Inventory Method (PIM). First, we compute investment I as the difference between the deflated current and the lagged *fga*, and use the PIM formula $P_{t+1}K_{t+1} = P_{t+1}(1-\delta)P_tK_t + P_{t+1}I_{t+1}$, where K is the quantity of capital, P is its price (set equal to one percent, the interest rate to be paid back to the Soviet Union for the loan granted to China for the technology transfer program), I is investment, and δ is the depreciation rate (set equal to 3.5 percent, according to the average estimated life of machine of 30 years (Lardy, 1995). However, this procedure is valid only if the base-year capital stock (the first year in the data for a given firm) can be written as P_0K_0 , which is not the case here because *fga* is reported at its historic cost. To estimate its value at replacement cost, we use the R^G factor suggested by Balakrishnan et al. (2000), $R^G = \frac{[(1+g)^{\tau+1}-1](1+\pi)^{\tau}[(1+g)(1+\pi)-1]}{g\{[(1+g)(1+\pi)]^{\tau+1}-1\}}$, where τ is the average life of machines (assumed to be 30 years, according to Lardy, 1995), π is the average capital price $\frac{P_t}{P_{t-1}}$ equal to one percent, and g is the (assumed constant) real investment growth rate $\frac{I_t}{I_{t-1}}$ from 1949 to 1978 (equal to 1.07821, as from Statistics China). We multiply *fga* in the base year 1949 by R^G to convert capital to replacement costs at current prices, which we then deflate using the price index for machinery and machine tools to express it in real terms. Finally, we apply the PIM formula.

Table C.1: Estimation of Production Function

	Panel A: Steel Industry		Panel B: All Industries	
	β_l	β_k	β_l	β_k
	(1)	(2)	(3)	(4)
ACF	0.67***	0.44***	0.62***	0.43***
	(0.20)	(0.15)	(0.17)	(0.13)
LP	0.65***	0.46***	0.60***	0.44***
	(0.19)	(0.13)	(0.14)	(0.15)
OP	0.65***	0.45***	0.61***	0.42***
	(0.21)	(0.12)	(0.16)	(0.13)
OLS	0.67***	0.45***	0.61***	0.44***
	(0.18)	(0.15)	(0.19)	(0.11)
Factor Share	0.66	0.43	0.62	0.44

Notes. Coefficients on labor (β_l) and capital (β_k) estimated with the Ackerberg et al. (2015) (ACF), Petrin et al. (2004) (LP), Olley and Pakes (1996)(OP) methodologies, OLS and factor shares (Solow's residuals). The sample include 20 plants eligible to participate in the technology transfer program in the steel industry from 1949 and 2000 (Panel A) and 139 firms eligible to participate in the technology transfer program in all the industries in 1985 and between 1998 and 2013 (Panel B). *** denotes 1%, ** denotes 5%, and * denotes 10% significance.

D Small Sample Tests

A potential challenge of estimating equation 1 in the steel industry is given by the small cross-sectional sample size. In fact, we have data on only 20 plants, 10 in the treatment group and 10 in the comparison group. To address this issue, we perform permutation tests and the Ibragimov and Muller (2010) procedure, employed in experimental settings where small sample size is common (Bloom et al., 2013). This Section briefly describes these procedures and the required assumptions and show that our main analysis is robust to these tests. We also show that different levels of standard errors clustering do not affect our the level of significance of our estimates.

D.1 Permutation Tests

Permutation tests rely on the fact that order statistics are sufficient and complete to obtain critical values for test statistics. We first employ permutation tests on the null hypothesis of no treatment effect in the OLS specification of equation 1. Such procedures calculate the OLS coefficient for every possible combination of 10 treatment plants out of our 20 overall plants in the steel industry. Once 184,756 possible treatment assignments are computed,[7] the 0.5 percent and 99.5 percent confidence intervals are computed as the 0.5% and the 99.5% percentiles of the treatment impact. A treatment outside these bounds is considered significant at 1 percent. Appendix Tables D.1, D.2, and D.3 show the p-values of the permutation tests, which confirm in all cases the significance levels we observe in Tables 3 and 4.

We use a similar approach to test the robustness of our IV estimation of equation 1. Following Greevy et al., 2004, we first calculate the Wei-Lachin statistic for the OLS case, computed as $T = \sum_{i=1}^{N} Z_i q_i = \sum_{i=1}^{N} Z_i \sum_{t=1}^{T} \sum_{j=1}^{N} q_{i,j,t}$, where Z_i is the binary random assignment variable for plant i, $q_{i,j,t} = \mathbb{1}(Z_i > Z_j)(\mathbb{1}(Y_{i,t} > Y_{j,t}) - \mathbb{1}(Y_{i,t} < Y_{j,t})$, and $\{Y_{i,t}\}_{t=1}^{T}$ is the vector of outcomes for plant i. Under the null hypothesis of no treatment effect, the treatment outcomes should not be systematically larger than the control outcomes. In order words, under the null hypothesis and conditional upon the order statistics, each possible candidate value of Wei-Lachin statistic T has an equal probability of occurring. For all the possible 184,756 treatment assignments we compute T. From the empirical distribution of T we obtain the appropriate quantile and reject the null hypothesis if T is greater than the quantile. Notably, this test does not rely on any asymptotic theory and so can be used in case of small sample size. However, it is based on the assumption that changing the ordering of a sequence of random variables

[7] $184,756 = \frac{20!}{10!10!}$.

does not affect their joint distribution, which seems reasonable in our historical context.

The randomization inference based test for the IV case is a generalization of the OLS case. Andrews and Marmer (2008) shows that in the IV case for a panel dataset the statistic T can be computed as $\widetilde{T} = \sum_{i=1}^{N} Z_i q_i = \sum_{i=1}^{N} Z_i \sum_{t=1}^{T} \sum_{j=1}^{N} \widetilde{q}_{i,j,t}$, where $\widetilde{q}_{i,j} = \mathbb{1}(Z_i > Z_j)(\mathbb{1}(\widetilde{Y}_{i,t} > \widetilde{Y}_{j,t}) - \mathbb{1}(\widetilde{Y}_{i,t} < \widetilde{Y}_{j,t})$, $\widetilde{Y_{i,t}} = Y_{i,t} - \beta_0 D + X_{it}' \hat{\delta}$, and $D = ZD_1 + (1-Z)D_0$. The instrument Z is the years of delay in plant completion, while X is a vector of plant and year indicators. The null hypothesis test is $H: \beta = \beta_0$ against the two-sided alternative. For each possible value of β, we compute $\{\widetilde{Y_{i,t}}\}_{t=1}^{T}$ and perform the permutation test, as for the OLS case. The set of values for which we cannot reject the null at 1% are used to construct an exact confidence interval for β.[8] Appendix Tables D.1, D.2, and D.3 show the p-values of the permutation tests, which confirm in all cases the significance levels we observe in Tables 3 and 4.

D.2 Ibragimov-Mueller Procedure

In our setting, while the cross-sectional sample size is small, the time dimension is fairly large, as we observe the 20 steel plants over a 50-year span each. We therefore employ the Ibragimov and Muller (2010) procedure, that is robust to heterogeneity across plants and autocorrelation across observations within plants. Specifically, we estimate the OLS and IV coefficients from equation 1 separately for each plant, obtaining 20 plant-specific estimates. Then, we compare the average of the 10 coefficients estimated on the treated plants with the 10 coefficients estimated on the comparison plants, using a t-test for group mean equality.

The procedure requires that the coefficient estimates from each plants are asymptotically independent and Gaussian distributed. In our case, it is reasonable to assume an asymptotic distribution in the T dimensions, as we have more than 50 observations per plant, meaning that we don't have to make any assumption on the structure of correlations between observations within a firm as long as the parameter estimators satisfy a central limit theorem.[9] The standard Gaussian plant-level distribution assumption can be relaxed, meaning that we can treat the plant-level estimates as drawn from independent normal distributions. Appendix Tables D.1, D.2, and D.3 show the p-values of the Ibragimov and Muller (2010) tests, which confirm in all cases the significance levels we observe in Tables 3 and 4.

[8] The Andrews and Marmer (2008) confidence intervals do not have to be single intervals, but in our case they always are.

[9] If the central limit theorem holds, the correlation across observations within a plant is unrestricted.

D.3 Different Levels of Standard Errors Clustering

Clustering standard errors at the plant level in equation 1 for the steel industry may create a "small number of clusters" problem, as we have have only 20 plants and Monte Carlo simulations suggest to have at least 42 clusters (Cameron et al., 2008; MacKinnon and Webb, 2018). However, the number of observation per cluster is "large", as we observe all the 20 plants for 50 years each. We can therefore wild bootstrap the standard errors, as Cameron et al. (2008) show that this procedure works even in setting with as few as five clusters. More recently, Canay et al. (2021) have shown that such procedure has limiting rejection probability if the number of clusters is "small", but the number of observations per cluster is "large". assumptions

For robustness, we compare the wild clustered standard errors with the robust ones (equivalent to cluster at the plant-year level). Notably, the standard errors are similar in magnitude and did not affect our significance level (Appendix Tables D.4, D.5, and D.6. We also block bootstrap the standard errors, a method that maintains the autocorrelation structure within groups (plants) by keeping observations that belong to the same group together in a "block" and sampling blocks instead of observations. As explained in Bertrand et al. (2004), this procedure does not perform well as the number of clusters declines (20 and fewer clusters, p.269). Consistently with their results, we find much smaller standard errors than with the wild cluster procedure. Finally, we wild cluster at county and province levels, obtaining smaller standard errors that in our preferred specification. In fact, Abadie et al. (2017) show that there many be harm in clustering at a level that is too aggregate.

Overall, these results suggest that the preferred wild bootstrap procedure is the most conservative and that clustering with other methods or at different level of aggregation never changes the significance level of our estimates.

Table D.1: Small Sample Robustness –
Effects of Technology Transfer Program on Steel Plants

Panel A: Plant Outputs, Inputs, and TFPQ

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Permutation, OLS	0.000	0.804	0.614	0.759	0.675	0.000
Permutation, IV	0.000	0.736	0.846	0.691	0.825	0.000
IM, OLS	0.000	0.514	0.477	0.423	0.527	0.000
IM, IV	0.000	0.403	0.805	0.574	0.645	0.000

Panel B: Quality of Products and Production Processes

	Log C. Steel	Log Pig Iron	Log Furn.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Permutation, OLS	0.000	0.000	0.000	0.000	0.000	0.002
Permutation, IV	0.000	0.000	0.000	0.000	0.000	0.003
IM, OLS	0.000	0.000	0.000	0.000	0.000	0.003
IM, IV	0.000	0.000	0.000	0.000	0.000	0.004

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log. Av. Wages	Log Total Wages
	(1)	(2)	(3)	(4)	(5)
Permutation, OLS	0.000	0.000	0.000	0.759	0.712
Permutation, IV	0.000	0.000	0.000	0.494	0.646
IM, OLS	0.000	0.000	0.000	0.677	0.709
IM, IV	0.000	0.000	0.000	0.558	0.822

Notes. The table reports the p-values of the permutation tests and the Ibragimov-Mueller procedures (IM) for OLS and IV estimation of β coefficient in equation 1. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages* and *Log Total Wages* are average and total wages.

Table D.2: Small Sample Robustness: β coefficient –
Effects of Complete and Partial Technology Transfer on Steel Plants

Panel A: Plant Performance

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Permutation, OLS	0.000	0.567	0.473	0.535	0.656	0.000
Permutation, IV	0.000	0.583	0.659	0.510	0.487	0.000
IM, OLS	0.000	0.601	0.742	0.787	0.588	0.000
IM, IV	0.000	0.643	0.604	0.769	0.742	0.000

Panel B: Quality of Products and Processes

	Log C. Steel	Log Pig Iron	Log. Fun.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Permutation, OLS	0.000	0.000	0.000	0.000	0.000	0.000
Permutation, IV	0.000	0.000	0.000	0.000	0.000	0.000
IM, OLS	0.000	0.000	0.000	0.000	0.000	0.000
IM, IV	0.000	0.000	0.000	0.000	0.000	0.000

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log Av. Wages	Log Tot. Wages
	(1)	(2)	(3)	(4)	(5)
Permutation, OLS	0.465	0.000	0.000	0.825	0.414
Permutation, IV	0.747	0.000	0.000	0.791	0.549
IM, OLS	0.483	0.000	0.000	0.543	0.476
IM, IV	0.751	0.000	0.000	0.611	0.534

Notes. The table reports the p-values of the permutation tests and the Ibragimov-Mueller procedures for OLS and IV estimation of β coefficient in equation 2. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages* and *Log Total Wages* are average and total wages.

Table D.3: Small Sample Robustness: γ coefficient –
Effects of Complete and Partial Technology Transfer on Steel Plants

Panel A: Plant Performance

	Log Steel (1)	Log Workers (2)	Log Fixed Assets (3)	Log Coke (4)	Log Iron (5)	Log TFPQ (6)
Permutation, OLS	0.000	0.414	0.712	0.701	0.546	0.000
Permutation, IV	0.000	0.508	0.763	0.476	0.745	0.000
IM, OLS	0.000	0.494	0.511	0.609	0.644	0.000
IM, IV	0.000	0.677	0.551	0.587	0.602	0.000

Panel B: Quality of Products and Processes

	Log C. Steel (1)	Log Pig Iron (2)	Log. Fun. (3)	Log Oxy. (4)	Log Cast. (5)	Log Int. St. (6)
Permutation, OLS	0.000	0.000	0.000	0.000	0.444	0.673
Permutation, IV	0.000	0.000	0.000	0.000	0.543	0.763
IM, OLS	0.000	0.000	0.000	0.000	0.479	0.548
IM, IV	0.000	0.000	0.000	0.000	0.521	0.677

Panel C: Human Capital

	% Engineers (1)	% Tech. (2)	% Unskilled (3)	Log Av. Wages (4)	Log Tot. Wages (5)
Permutation, OLS	0.000	0.526	0.000	0.498	0.573
Permutation, IV	0.000	0.591	0.000	0.874	0.649
IM, OLS	0.000	0.673	0.000	0.555	0.581
IM, IV	0.000	0.602	0.000	0.765	0.643

Notes. The table reports the p-values of the permutation tests and the Ibragimov-Mueller procedures for OLS and IV estimation of γ coefficient in equation 2. *Log Steel, Coke, Iron, C. Steel*, *Pig Iron, Furn., Oxy., Cast., Int.St.* are logged quantities (in tons) of steel, coke, iron, crude steel, pig iron, steel produced with the open heart furnace, basic oxygen, continuous casting available since 1985 and above international standards available since 1985; *Log Fixed Assets* is expressed in million 2020 USD, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPQ* is logged physical productivity; *% Engineers, % Techn.* and *% Unskilled* are the fraction of engineers, high-skilled technicians and unskilled workers over plant total number of workers; *Log Av. Wages* and *Log Total Wages* are average and total wages.

Table D.4: Robustness to Clustering the Standard Errors: β coefficient – Effects of Complete and Partial Technology Transfer on Steel Plants

Panel A: Plant Outputs, Inputs, and TFPQ

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Wild Bootstrap	(0.079)***	(0.059)	(0.025)	(0.009)	(0.055)	(0.086)***
Robust	(0.076)***	(0.058)	(0.024)	(0.010)	(0.053)	(0.085)***
Block Bootstrap	(0.076)***	(0.057)	(0.020)	(0.008)	(0.050)	(0.081)***
County	(0.070)***	(0.057)	(0.019)	(0.005)	(0.045)	(0.078)***
Province	(0.072)***	(0.058)	(0.021)	(0.007)	(0.040)	(0.080)***

Panel B: Quality of Products and Production Processes

	Log C. Steel	Log Pig Iron	Log Furn.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Wild Bootstrap	(0.086)***	(0.051)***	(0.060)***	(0.054)***	(0.039)***	(0.172)***
Robust	(0.085)***	(0.052)***	(0.058)***	(0.052)***	(0.036)***	(0.170)***
Block Bootstrap	(0.082)***	(0.047)***	(0.052)***	(0.045)***	(0.029)***	(0.161)***
County	(0.079)***	(0.045)***	(0.049)***	(0.046)***	(0.027)***	(0.158)***
Province	(0.075)***	(0.041)***	(0.045)***	(0.043)***	(0.026)***	(0.155)***

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log. Av. Wages	Log Total Wages
	(1)	(2)	(3)	(4)	(5)
Wild Bootstrap	(0.034)***	(0.016)***	(0.028)***	(0.031)	(0.067)
Robust	(0.031)***	(0.013)***	(0.025)***	(0.030)	(0.065)
Block Bootstrap	(0.028)***	(0.012)***	(0.025)***	(0.028)	(0.061)
County	(0.025)***	(0.011)***	(0.026)***	(0.027)	(0.059)
Province	(0.027)***	(0.012)***	(0.027)***	(0.025)	(0.055)

Notes. Standard errors are wild bootstrapped at the plant-level with 200 replications (row 1) following Cameron et al. (2008), robust (row 2), block bootstrapped with 200 replications (row 3) following Bertrand et al. (2004), and wild bootstrapped at the county- and province-levels (row 4 and 5). ***p<0.01, **p<0.05, *p<0.1.

Table D.5: Robustness to Clustering the Standard Errors: γ coefficient – Effects of Complete and Partial Technology Transfer on Steel Plants

Panel A: Plant Performance

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Wild Bootstrap	(0.075)***	(0.080)	(0.005)	(0.008)	(0.005)	(0.075)***
Robust	(0.074)***	(0.081)	(0.004)	(0.007)	(0.005)	(0.073)***
Block Bootstrap	(0.070)***	(0.075)	(0.004)	(0.006)	(0.004)	(0.070)***
County	(0.069)***	(0.074)	(0.004)	(0.006)	(0.004)	(0.067)***
Province	(0.068)***	(0.076)	(0.004)	(0.006)	(0.003)	(0.065)***

Panel B: Quality of Products and Processes

	Log C. Steel	Log Pig Iron	Log. Fun.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Wild Bootstrap	(0.011)***	(0.012)***	(0.070)***	(0.064)***	(0.043)***	(0.098)***
Robust	(0.010)***	(0.011)***	(0.065)***	(0.060)***	(0.040)***	(0.095)***
Block Bootstrap	(0.009)***	(0.008)***	(0.060)***	(0.055)***	(0.039)***	(0.092)***
County	(0.008)***	(0.007)***	(0.058)***	(0.053)***	(0.035)***	(0.089)***
Province	(0.006)***	(0.005)***	(0.052)***	(0.050)***	(0.031)***	(0.085)***

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log Av. Wages	Log Tot. Wages
	(1)	(2)	(3)	(4)	(5)
Wild Bootstrap	(0.034)	(0.013)***	(0.009)***	(0.035)	(0.030)
Robust	(0.032)	(0.011)***	(0.007)***	(0.034)	(0.029)
Block Bootstrap	(0.030)	(0.010)***	(0.005)***	(0.032)	(0.027)
County	(0.029)	(0.008)***	(0.006)***	(0.030)	(0.026)
Province	(0.028)	(0.006)***	(0.007)***	(0.029)	(0.025)

Notes. Standard errors are wild bootstrapped at the plant-level with 200 replications (row 1) following Cameron et al. (2008), robust (row 2), block bootstrapped with 200 replications (row 3) following Bertrand et al. (2004), and wild bootstrapped at the county- and province-levels (row 4 and 5). ***p<0.01, **p<0.05, *p<0.1.

Table D.6: Robustness to Clustering the Standard Errors –

Panel A: Plant Performance

	Log Steel	Log Workers	Log Fixed Assets	Log Coke	Log Iron	Log TFPQ
	(1)	(2)	(3)	(4)	(5)	(6)
Wild Bootstrap	(0.021)***	(0.009)	(0.005)	(0.003)	(0.005)	(0.019)***
Robust	(0.020)***	(0.009)	(0.004)	(0.003)	(0.004)	(0.016)***
Block Bootstrap	(0.018)***	(0.008)	(0.003)	(0.003)	(0.004)	(0.014)***
County	(0.017)***	(0.007)	(0.004)	(0.003)	(0.004)	(0.012)***
Province	(0.015)***	(0.008)	(0.003)	(0.003)	(0.004)	(0.009)***

Panel B: Quality of Products and Processes

	Log C. Steel	Log Pig Iron	Log. Fun.	Log Oxy.	Log Cast.	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Wild Bootstrap	(0.046)***	(0.039)***	(0.011)***	(0.012)***	(0.010)	(0.009)
Robust	(0.045)***	(0.037)***	(0.010)***	(0.010)***	(0.009)	(0.008)
Block Bootstrap	(0.040)***	(0.033)***	(0.008)***	(0.008)***	(0.008)	(0.006)
County	(0.041)***	(0.031)***	(0.007)***	(0.006)***	(0.008)	(0.005)
Province	(0.038)***	(0.030)***	(0.005)***	(0.005)***	(0.009)	(0.005)

Panel C: Human Capital

	% Engineers	% Tech.	% Unskilled	Log Av. Wages	Log Tot. Wages
	(1)	(2)	(3)	(4)	(5)
Wild Bootstrap	(0.020)***	(0.008)	(0.011)***	(0.007)	(0.009)
Robust	(0.018)***	(0.008)	(0.010)***	(0.006)	(0.008)
Block Bootstrap	(0.015)***	(0.007)	(0.009)***	(0.005)	(0.007)
County	(0.013)***	(0.007)	(0.008)***	(0.005)	(0.006)
Province	(0.010)***	(0.007)	(0.005)***	(0.005)	(0.006)

Notes. Standard errors are wild bootstrapped at the plant-level with 200 replications (row 1) following Cameron et al. (2008), robust (row 2), block bootstrapped with 200 replications (row 3) following Bertrand et al. (2004), and wild bootstrapped at the county- and province-levels (row 4 and 5). ***p<0.01, **p<0.05, *p<0.1.

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