NBER WORKING PAPER SERIES

TECHNOLOGY TRANSFER AND EARLY INDUSTRIAL DEVELOPMENT: EVIDENCE FROM THE SINO-SOVIET ALLIANCE

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Working Paper 29455
http://www.nber.org/papers/w29455

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2021

We thank David Atkin, Bruno Caprettini, Dora Costa, Michele Di Maio (discussant), Alvaro Garcia, Jiandong Ju, Naomi Lamoreaux, Nicholas Li, Ernest Liu, Kalina Manova (discussant), Nathan Nunn, Luigi Pascali, Nancy Qian, Xuan Tian, John Van Reneen, Eric Verhoogen, Guo Xu, and Elira Kuka, Jared Rubin, and Danila Serra through the Adopt-a-Paper program. We also thank seminar and conference participants at Harvard, UCLA, Yale University, University of British Columbia, University of Michigan, George Washington University, Auburn University, University of Oxford, LUISS, Université di Padova, University of Melbourne, Tsinghua University, the NBER Summer Institute on on Productivity, Development and Entrepreneurship, the Cliometrics Conference, the Second Women in International Economics (WIE) Conference, the CEPR/LEAP Workshop in Development Economics, the Barcelona GSE Summer Forum on the Economics of Science and Innovation, the Pacific Conference for Development Economics, the Webinar Series in Finance and Development (WEFIDEV), the LSE Asia Economic History Seminar, the Online Economic History Workshop, and the Ridge Conference for helpful comments and discussion. We are also thankful to senior officials at Statistics China for declassifying the historical data for this research and to historians at the National Archives Administration of China for their help in accessing archival materials. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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JEL No. L2,M2,N34,N64,O32,O33

ABSTRACT

This paper studies the causal effect of technology and knowledge transfers on early industrial development. Between 1950 and 1957, the Soviet Union supported the "156 Projects" in China for the construction of technologically advanced, large-scale, capital-intensive industrial facilities. We exploit idiosyncratic delays in project completion and the unexpected end of the Sino-Soviet Alliance, due to which some projects received Soviet technology embedded in capital goods and know-how, while others were eventually realized by China alone using domestic technology. We find that receiving both Soviet technology and know-how had large, persistent effects on plant performance, while the effects of receiving only Soviet capital goods were short-lived. The intervention generated horizontal and vertical spillovers, as well as production reallocation from state-owned to privately owned companies since the late 1990s.

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1 Introduction

International technology and knowledge transfers are key drivers of economic development. Numerous works have shown that the adoption of foreign technologies may lead to a substantial boost in firm productivity in less-advanced economies (Pavcnik, 2002; Mel et al., 2008; Goldberg et al., 2009; Bloom et al., 2013; Hardy and Jamie, 2020). Consequently, technology transfer interventions have been widely used to promote industrialization in developing countries (Hoekman et al., 2004; Robinson, 2009), especially through the diffusion of state-of-the-art capital goods (Stokey, 2020). However, in their early stages of industrialization, countries lack not only modern capital goods but also industry-specific knowledge that allows pioneering firms to succeed (Mostafa and Klepper, 2018). Acquiring this knowledge is complex: several of its elements are "tacit" or embodied in workers and organizations and are often obtained through extensive on-the-job training from foreign companies (Chandra, 2006).

Despite the importance of technology and knowledge transfers, little is known about their causal impact on early industrialization, mostly due to lack of long-term data and natural variation in the delivery of such interventions. Moreover, it is empirically challenging to disentangle the effects of technology embedded in foreign capital goods from those of know-how diffusion and human capital training, as they often occur simultaneously.

This paper studies the causal effect of technology and knowledge transfers on early industrial development, using evidence from the Sino-Soviet Alliance. In the 1950s, to advance the industrialization of the newly formed People's Republic of China, the Soviet Union supported the development of the so-called 156 Projects, an array of technologically advanced, large-scale, capital-intensive industrial facilities.[1] These projects could be of two types: the "basic" ones involved the duplication of whole Soviet plants and the transfer of state-of-the-art Soviet machinery and equipment. The "advanced" ones, in addition to the "basic" component, also included the transfer of know-how to operate the new machinery and in-plant technical and management training for Chinese engineers and production supervisors. The Soviet transfer was considered a vital factor in Chinese development. Its investments, which accounted for 45% of Chinese GDP in 1949, allowed China to receive the best Soviet technology, which in the steel and iron industries was considered the best in the world (Lardy, 1995).

We use newly assembled data from historical archives on the 156 Projects signed between 1950 and 1957, which we matched with declassified data on their plant performance yearly until 2000 for the steel industry and in 1985 and between 1998 and 2013 for all the industries.

[1] We say "so-called" because 156 projects were originally contemplated and because the identifying label has persisted to this day in China. However, only 139 projects involving Soviet technology transfer were eventually signed and approved.

Our identification strategy relies on idiosyncratic delays in project completion due to Soviet constraints in providing capital goods and experts to train their Chinese counterparts. When the Sino-Soviet Split in 1960 ended the alliance between the two countries, projects that experienced fewer delays had already received the Soviet machinery (*basic treated* projects) or the Soviet machinery, know-how and training (*advanced treated* projects) as planned. By contrast, projects that experienced more delays ended up not receiving any Soviet capital goods (*basic comparison* projects) or any Soviet capital goods, know-how and training (*advanced comparison* projects), and were completed by China alone, following the original Soviet plans but using traditional domestic technology. Notably, advanced and basic treated projects had very similar observable characteristics compared to their comparison projects, were located in comparable geographical areas, and operated in the same industries. We also propose an IV strategy in which we instrument the probability of receiving the Soviet technology transfer with the delays that projects experienced. While the delays strongly predict whether a project received the planned basic or advanced Soviet transfer, 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 advanced transfer had large, persistent effects on the quantity and quality of a plant's output, while the impact of the basic transfer was positive but short-lived. For instance, productivity of advanced treated plants rose by 3.4% relative to advanced comparison plants within a year of the plant opening, then continued to increase for 40 years, with a cumulative impact of 51.6%. By contrast, the impact of a basic transfer took four years to materialize. After reaching a peak of 23.2% 15 years after the plant opening, the effects flattened out, then started decreasing and stopped being significant after 30 years.

Second, declassified firm-level data in 1985 and between 1998 and 2013 in all industries confirm the long-lasting effect of the advanced transfer and the short-lived impact of the basic transfer. Both sets of results are confirmed by the IV specifications, which show a magnitude similar to the OLS ones.

Third, we investigate why the effects of the advanced transfer persisted over years, while the effects of the basic transfer were short-lived. We document that, in the 1960s and 1970s, when China's interaction with foreign countries was extremely limited, only advanced treated plants were able to home-fabricate modern machineries and equipment, which ultimately replaced Soviet capital when it became obsolete. Moreover, once China began gradually opening to international trade in the early 1980s, advanced treated plants relied dramatically less on the import of foreign capital, and they systematically engaged more in trade due to producing better-quality output than advanced comparison plants. The development of new technologies and the comparative advantage in trade may explain the long-lasting effects of the advanced transfer, years after the Sino-Soviet cooperation. Conversely, we do not observe any differential development of new technologies between basic treated and comparison plants when China was a closed economy, nor differential imports of foreign capital and exports since the 1980s. Therefore, basic treated plants outperformed basic comparison firms given the better technology of Soviet capital as long as China was a closed economy. As soon as it was possible, both firms adopted similar more modern foreign machineries and their performance gap quickly narrowed. Finally, we do not find evidence that our results are driven by special ex-post government favors to treated plants, by better political connections, or by selection on unobservable plant characteristics.

The major goal of the Soviet technology transfer was to create large industrial facilities to push local industrial development. Was the program successful in doing so? We document that between plant openings and 1985, a higher number of plants were operating in the related industry of basic and advanced treated plants (same or upstream/downstream industries) located within 50 km, relative to their comparison plants. However, only spatial proximity to advanced treated plants generated positive productivity spillovers due to knowledge diffusion. In fact, firms located close to advanced treated plants (a) increased their productivity relative to firms at the same distance of advanced comparison plants, (b) adopted the same technology of the latter when China was a closed economy, and (c) followed their export patterns when China opened up to international trade. By contrast, these variables did not differentially change between firms located close to basic treated and comparison plants.

Starting in the 1990s, the Chinese government began progressing toward a market economy, allowing privatization of state-owned companies. We therefore investigate whether public or private firms were able to capture the gains from technology adoption. We find that, between 1998 and 2013, firms that became privately owned and were economically related to advanced treated plants had better performance and were more productive. We uncover two potential mechanisms behind these results. First, counties where advanced treated plants were located experienced a higher reallocation of production from state-owned to privately owned firms. Therefore, firms that become privately owned in such counties faced more competition, which likely forced them to adapt to the changing market conditions faster. Second, counties where advanced treated plants were located had a higher number of college graduates and high-skilled workers. Consequently, when private companies started competing for inputs in the local market, they could rely on higher workforce quality, with positive effects on their outcomes. By contrast, we do not find evidence of higher government investment in counties with treated plants.

Finally, we assess the contribution of the Soviet transfer to the Chinese aggregate growth rate between 1950 and 2008. First, we show that an additional treated project increased province-level output on average by 13.2% per year. We also compute the cross-sectional fiscal multiplier: for every additional technology transfer investment dollar per capita that a province received (compared to others), its GDP per capita increased by $0.85.[2] A back-of-the-envelope calculation shows that, without the Soviet transfer, Chinese real GDP per capita growth between 1953 and 1978 would have been halved, confirming the transfer's vital importance in Chinese industrialization.

The contribution of this paper is threefold. First, it contributes to the literature that studies the role of technology diffusion in developing countries (see Verhoogen, 2020 for a comprehensive review). Previous papers have documented the positive impact of technology diffusion on short-run performance of small and medium-sized firms (Pavcnik, 2002; Mel et al., 2008; Goldberg et al., 2010; Bloom et al., 2013; Bruhn et al., 2018; Hardy and Jamie, 2020) and the existence of substantial barriers to its adoption (Atkin et al., 2017; Bloom et al., 2020; Juhász et al., 2020). To the best of our knowledge, this paper is the first to use nonexperimental data to examine the effects of international technology transfer on large industrial facilities, following them from their foundation to recent times. Our context is China, which experienced the "the fastest sustained expansion in history" (Morrison, 2019).

Second, our paper relates to the literature on knowledge diffusion and on-the-job training by foreign firms and their role in industrial upgrading. Foreign seeding of industry knowledge can be an important catalyst for growth (Mostafa and Klepper, 2018), and multinational firms and joint ventures are a key source of knowledge transfer (Keller and Yeaple, 2013; Yeaple, 2013; Jiang et al., 2018; Giorcelli, 2019) Meanwhile, competition and language barriers impede knowledge sharing across firms (Hardy and Jamie, 2020; Guillouët et al., 2021). Our research shows that knowledge diffusion and on-the-job training are essential for ensuring persistent effects of industrial policies: they create industry-specific know-how, which allows for technology development and innovation in the long run.

Finally, this paper is related to the large literature on spillover effects. Existing research has shown sizable spillovers determined by the opening of large new plants (Javorcik et al., 2008; Greenstone et al., 2010; Alfaro-Urena et al., 2019), worker mobility (Stoyanov and Zubanov, 2012), managerial knowledge diffusion (Bloom et al., 2020; Bianchi and Giorcelli, 2020), and sectoral industrial policies (Liu, 2019; Heblich et al., 2020; Lane, 2021). Our setting allows us to disentangle the spillover effects of large firms that use foreign technology from those of large firms that employ domestic technology and from knowledge spillovers that follow know-how diffusion, and their interactions with major institutional changes.

The rest of this paper is organized as follows. Section 2 describes the Sino-Soviet Alliance. Section 3 describes the data. Section 4 discusses the empirical framework and the identification strategy. Section 5 studies the effects of the technology transfer on firm-level outcomes.

[2] All references to dollars in this paper are 2020 U.S. dollars unless noted otherwise.

Sections 6 and 7 examine the spillover and aggregate effects. 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. For both powers, a strategic alliance with China was crucially important (Lardy, 1995). Since 1927, China had been intermittently enmeshed in a civil war fought between the Kuomintang-led government of the Republic of China (ROC) and the Communist Party of China. The U.S. government supported the Kuomintang and the government of the ROC by providing military, economic, and political assistance,[3] but in 1949, the Communist Party emerged as victorious. China's war came to an end, and the People's Republic of China (PRC) was formed. Despite some initial Soviet distrust, the PRC's inspired principles and economic system provided the ideological basis for cooperation with the Soviet Union. On February 14, 1950, the two countries signed the "Sino-Soviet Treaty of Friendship, Alliance, and Mutual Assistance," which marked the start of large-scale economic and military cooperation and the Soviet Union's official recognition of the PRC as a strategic partner (Zhang et al., 2006). In response to the Sino-Soviet Alliance, the United States and its allies imposed economic sanctions against the PRC in the 1950s and stopped all trade activities with the country.

2.2 The Soviet Technology Transfer Setup

At the end of China's civil war, the country's economy was largely premodern. Almost two-thirds of output was agricultural, less than one-fifth industrial, and the few industrial factories built during 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, used traditional technologies. The newly formed government adopted a centralized, planned-economy model, based on state ownership of all economic activities and large collective units in agriculture (Perkins, 2014). Market forces were largely eliminated, and industrial inputs and outputs were allocated according to quotas established by subsequent Five-Year Plans. Wages were set by the government, which allocated skilled workers to jobs.

[3] On December 16, 1945, U.S. 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).

The First Five-Year Plan (1953–1957) declared that one of the new government's major goals was to build a modern industrial system. However, the country lacked technical knowledge and expertise to do so on its own. Several Chinese leaders admitted 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" (Ji, 2019). Therefore, PRC officials pressed hard for technology transfer from the Soviet Union (Zhang et al., 2006, p. 110). Between 1950 and 1957, the two countries signed various agreements for the construction of the 156 Projects. These projects focused on heavy industries, such as metallurgy, machinery, manufacturing, electricity, coal, petroleum, and chemical raw materials—the Chinese government was intending to mimic the development model of the Soviet Union in the 1930s. The total value of such investments amounted to $80 billion (in 2020 figures; $20.2 billion in 1955 RMB), equivalent to 45.7% of Chinese GDP in 1949 and 144.3% of its industrial output.[4]

The 156 Projects could be of two types. The "basic" ones involved the duplication of whole Soviet plants and widespread technology transfer. The Soviet Union provided state-of-the-art machinery and equipment, as well as help in surveying geological conditions, selecting plant sites, directing plant construction, and supplying blueprints. Through this transfer, China received the most advanced technology available in the Soviet Union, which in some industries was the best in the world. For instance, in the iron and steel industry, during the 1950s the Soviet Union built and operated the world's best blast furnaces—these were installed in Chinese plants in Anshan, Wuhan, and Paotou before even being employed in Soviet factories (Lardy, 1995, p. 178).

More than half the projects, in addition to the "basic" component, also had an "advanced" ones, via know-how and knowledge transfers. The Soviet experts taught the Chinese high-skilled technicians working in these plants how to operate the new machinery. They also offered in-plant technical and industrial management training to the engineers and production supervisors. The engineer training included classes in math, physics, and chemistry, as well as lectures in organizational, technological, and planning methods. The supervisor training, based on "scientific management" principles, included operational-planning classes, instructions on assigning workers to the most appropriate tasks, and the introduction of quality-control methods (Clark, 1973).[5] The Soviet experts spent on average three years

[4] The Soviet Union did not provide any aid in the form of grants; it lent China only $2.9 billion ($300 million in 1955 dollars) in response to a Chinese request for 10 times that amount. This loan shall be used to "repay the Soviet Union's delivery of machinery and 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" (Lardy, 1995). The prices of machinery, equipment, raw materials, and other commodities were calculated according to world market prices.

[5] Starting in the early 1930s, Soviet planners under Stalin selectively adopted the latest American management methods; they invited many Western companies, including the Ford Motor Company to invest in the Soviet Union (Hirata, 2018).

in Chinese plants, sharing engineering designs, product designs, and other technical data (Zhang et al., 2006).[6] According to historical records, the Soviet training and the 4,000 product designs they shared substantially improved technological innovations, increased equipment operation rates and product quality, and decreased both production costs and the amount of raw materials used (Zhang et al., 2006; Hirata, 2018; Ji, 2019).

The locations for the 156 Projects were chosen based on geological conditions and access to natural resources. For example, experts from the Soviet Ministry of Metallurgy explained that the nonferrous metal plants, such as the Guizhou Aluminum Company, "must be built on copper rich ore," and that "the copper content of the ore should be tested during the site selection." Beyond the geological conditions, Chinese leaders had a strong preference for choosing inner regions and mountain areas to protect these plants from potential military attacks (Lardy, 1995). For these reasons, the 156 Projects were concentrated in the northeastern regions (Heilongjiang, Jilin, Liaoning) and the inner regions (Shaanxi, Shanxi, Gansu, and Hubei, Figure 1).

Only 10 projects were built on sites where firms existed before 1949. These firms were almost completely destroyed during the Civil War and were no longer able to produce; therefore, they were rebuilt from scratch (Hirata, 2018). In this respect, the Soviet assistance shaped the geographical distribution of Chinese industrialization, since before 1952 the few existing firms were almost all located in the coastal areas (Lardy, 1995, p. 145).

2.3 Delays in the 156 Projects, and the Sino-Soviet Split

Despite the rosy picture of "Great Friendship" promulgated by the authorities, the 156 Projects suffered serious difficulties and delays. Machinery, equipment, and designs ordered from the Soviet Union almost always arrived or started operating later than planned, due to constraints on Soviet production capacity, lack of Soviet experts able to visit Chinese plants, and miscommunication between Soviet and Chinese experts (Filatov, 1975; Hirata, 2018).

For one thing, the Soviet Union did not have machinery and equipment in reserve, and by 1955 almost every Soviet industrial area had received orders for capital goods from China (Zhang et al., 2006) that proved difficult to deliver. Between 1955 and 1960, one-third of annual Soviet production of steel-rolling equipment was for China. Meanwhile, accidents on the Soviet side led to further substantial delays. For instance, the Benxi Iron and Steel Company, built to replicate the Red October (Krasny Oktyabr) factory in Volvograd, was expected to receive Soviet machinery and equipment in 1954. As this material was about

[6] Despite 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 were working in China between 1952 and 1959.

to be shipped, a fire destroyed critical equipment in the Red October factory, which then blocked the shipment to Benxi, ensuring that it would produce it later, after its plant operations could resume (Filatov, 1975).

The Soviets also lacked sufficient numbers of experts to help oversee plant construction and installation of new machinery and equipment. For example, Soviet experts who were supposed to visit the Fushun Aluminum Plant in 1959 never did so—they were retained to deal with an unexpected breakdown in the Volkhov Aluminum Plant, which in turn delayed the machinery installation in Fushun (Filatov, 1980).

Similarly, the language barriers between Soviet and Chinese teams required the constant presence of translators, but this, too, proved problematic. Soviet experts expected to visit the Changchun First Automotive Plant in 1955 had to wait until their translators learned Chinese, which prevented the Chinese plant from starting its operations on schedule (Borisov and Koloskov, 1980). Long-distance bilingual communication fostered additional problems. When Soviet experts arrived at the Jilin Daheishan Molybdenum Mine Plant, they realized their designs did not fit, as the initial written communication was misunderstood and letters requesting additional clarifications went lost (Kiselev, 1960).

In light of these delays, it would have been profitable for China to prioritize the most promising projects, but the country faced many challenges in doing so. In fact, each project was unique, aimed at replicating a specific Soviet plant, which made it impossible to reallocate machinery or equipment across the 156 Projects (Filatov, 1975). And unfortunately, the Soviet experts who did arrive in China were proficient only in the use of specific machinery and their translators had been trained in project-specific terminology, which limited their employment to the projects they were initially allocated to (Borisov and Koloskov, 1980).

Further complicating matters, the Sino-Soviet Alliance descended into turmoil in the late 1950s over political and ideological disputes. Despite attempting to maintain a bilateral relationship in the early 1960s, the two countries couldn't reach an agreement, and the formal end of their cooperation in 1963 became known as the Sino-Soviet Split. Long before that, the156 Projects had already been dramatically reduced in scope and number. In 1960, the Soviet Union suddenly withdrew its experts from China and stopped providing machinery and equipment. At that point, the finished projects would retain the Soviet-designed machinery and equipment, while unfinished projects would no longer receive any Soviet transfers and had to be completed by China on its own. Completing these projects without Soviet cooperation was difficult. China still lacked the experience and human capital needed to replicate the Soviet plants and capital goods (Zeitz, 2011). The country's limited access to the foreign technology market after 1950 forced it to rely solely on its own resources until at least 1978. The unfinished projects were completed following the Soviet plans, but employing traditional domestic technology (Clark, 1973).

In the end, all 139 projects were completed,[7] either with or without the Soviet assistance and despite the start of the Great Leap Forward, the Chinese government's campaign to organize its vast population in rural communes for agricultural and industrial production, begun in 1958 and abandoned in 1961 (Lardy, 1995).

3 Data

We collected and digitized different types of historical and administrative data from primary sources. In this section, we document our data-collection process and describe the data collected. Additional details and definitions of the variables appear in Appendix B.

3.1 The 156 Projects

We started our data collection by compiling a list of the 156 Projects envisioned under the Sino-Soviet Alliance, from the official agreements between the Soviet Union and the PRC stored at the National Archives Administration of China. As previously mentioned, while initial discussions between Chinese and Soviet leaders aimed at 156 Projects, the number of civil projects signed and approved between 1950 and 1957 was 139. For each project, we collected detailed information on its name and location, the name of the plant built, industry, size and capacity, whether the project involved a basic or an advanced technology transfer, and whether a plant existed on the same site before 1949.

Of the 139 approved projects, 80 (57.6%) were completed before the Sino-Soviet Split, and 59 (42.4%) were completed after the Split, therefore by China alone, without Soviet equipment, machinery, or technical assistance (Table 1, column 1). Eighty-three (59.7%) were supposed to receive an advanced transfer, and 56 (40.3%) a basic one. Most were located in China's northeastern and interior regions, for strategic reasons and for proximity to natural resources, and only 10 (7.1%) were built on the site of plants existing before 1949 and destroyed during the Civil War (Figure 1). The projects called for the construction of large industrial plants; each employing on average 37,690 workers, for a total of around 5 million workers—a mere 2.5% of China's total workforce, but 36.6% of the country's employment in the industrial sector in 1952. The projects were overwhelmingly concentrated in heavy industries. The electricity sector accounted for 23.0% projects, the machinery sector for 21.6%, the coal sector for 20.1%, and the steel and nonferrous metal industries for 14.4% and 10.1%, respectively (Figure A.1). Only two projects (1.4%) were in light industry. The average planned investment amounted to $579.4 million, and the projects' mean duration

[7] By contrast, out of 105 industrial projects that were under discussion for a second phase of technology transfer but that had not been formally approved at the time of the Split and for which location, industry, and type of equipment hadn't yet been discussed, only 20 were eventually completed (Zhang et al., 2006).

was expected to be 5.4 years (Table 1, column 1).

3.2 Firm-Level Data

We manually collected and digitized restricted, plant-level 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, utilization of inputs, capacity, the specific machinery in use, 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 receive the Soviet technology transfer with their outcomes in the Steel Association reports. Half the plants belong to projects that received the Soviet transfer; the other half were completed by China alone.

We also manually collected and digitized confidential, firm-level data from the Second Industrial Survey, conducted by Statistics China in 1985 and declassified for this project. This survey is the first and the most comprehensive dataset on Chinese industrial enterprises between 1949 and the early 1990s. It covers more than 40 industries within the industrial sector, containing firm-level data for the 7,592 largest firms operating in China in 1985. The survey gathered data on each firm's output, sales, profits, fixed assets, raw materials, total wages, number of employees, finished product inventory, main products, production equipment, and year of establishment. Using plant name, location, and province, we manually and uniquely matched all 139 plants that were supposed to receive the Soviet technology transfer to their performance in 1985. To the best of our knowledge, this paper is the first to systematically use Chinese steel-plant-level data and firm-level data from before the 1990s. From the Survey, we also collected and digitized county-level and prefecture-level industrial production data.[8]

Finally, we manually matched all 139 plants that were supposed to receive the Soviet technology transfer with their 1998–2013 performance from the China Industrial Enterprises database. This database, compiled yearly from 1998 to 2013, covers more than 1 million public and private industrial enterprises above a designated size in China.[9] It includes a rich set of information on firms: firm output, number of employees, and profits, as well as ownership structure and capital investment.

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

[9] The data include firms whose 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. These data confirm that the PRC was little industrialized in 1950. The average share per province of firms in the agricultural sector was 85%, accounting for 80% of total provincial output. By contrast, the share of provincial output in heavy industries was less than 18%. Between 1952 and 1985, the situation gradually changed. Heavy industries uniformly increased their shares of production, at the expense of light industries (Figure A.2, Panel A).

As China adopted a planned-economy model, government control over industry dramatically increased. In 1952, 48.7% of the firms were privately owned, while state-owned corporations comprised only 20.2%. By 1965, more than 90% of firms were state-owned (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 shifted from the coastal regions to the country's interior (Figure A.3, Panel B)—consistent with the fact that most of the 156 Projects were located in the interior regions for strategic reasons and for proximity to natural resources.

4 Identification Strategy

The identification strategy of this paper relies on the delays in completion of the 156 Projects that arose after their start. When in 1960 the Soviet Union canceled the program, projects with fewer delays had already received either a basic or an advanced transfer, as planned (basic or advanced treated projects). By contrast, projects with more delays received no Soviet capital, know-how or training, and were eventually completed by China alone, following the Soviet plans but employing traditional domestic technology (basic or advanced comparison projects).

We estimate the effects of the Soviet technology transfer via the following equation:

$$\text{outcome}_{ispt} = \sum_{j=1}^{2} \delta_j \cdot \text{Type Transfer}_j \cdot \text{Treatment}_i + \sum_{j=1}^{2} \beta_j \cdot \text{Type Transfer}_j + \beta \cdot X_i + \theta_{spt} + \epsilon_{ispt} \quad (1)$$

where outcome_{isct} is one of several key performance metrics, such as logged output, TFP,[10], and workers of firm i in industry s in province p at time t; Type Transfer_j is an indicator for firms supposed to receive a basic transfer if $j = 1$ or an advanced transfer if $j = 2$; Treatment_i is an indi-

[10] Specifically, we compute either TFPQ or TFPR based on the possibility of measuring firm physical output or only revenues. Details about their estimation can be found in Appendix C.

cator that equals one for plants that eventually received a Soviet transfer; $\mathbf{X_i}$ is a vector of baseline project characteristics,[11] and θ_{spt} are industry-province-year fixed effects. For firms operating in the steel industry, we observe yearly outcomes from the time the plants started operating through 2000, and in the estimating equation 1 we replace the industry-province-year fixed effects θ_{st} with province-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 method to solve the "small number of clusters" issue (Cameron et al., 2008). Figure A.5 provides robustness to different fixed effects. Appendix D.3 provides robustness to alternative clustering levels.

Under the identification assumption that the delays in project completion—defined as the difference between the actual and the planned year of project completion—were orthogonal to their characteristics or their potential success, and therefore create a natural variation in eventually receiving the Soviet transfer, the coefficient δ_j measures the effects of receiving either a basic or an advanced transfer on plant outcomes relative to their comparison group. The remainder of this section provides evidence in support of this identification assumption.

We start our analysis by testing whether basic or advanced treated projects were systematically different than basic or advanced comparison projects when they were signed and approved. For instance, treated projects may have been approved or started earlier and therefore more likely to have been finished before the Split. However, a mean comparison between approval and start dates of both basic treated and comparison projects and advanced treated and comparison projects fails to reject the null hypothesis of equality among groups (Table 1, columns 5–10). Comparison projects may have been more complex and therefore harder to complete before the Spit. The planned investment, the value of equipment supposed to be received from Soviet Union, the expected project length, the planned number of workers, and the expected capacity are statistically indistinguishable between basic treated and comparison projects and their comparison projects, which seems to exclude this hypothesis. Treated projects may have been located in areas with a stronger preexisting industrial development, which may have helped the setup of new plants. While only 7% of projects were built on the site of firms destroyed during the Sino-Japanese war, this share is substantially the same between basic and advanced treated and basic and advanced comparison projects.

We also test whether basic or advanced treated projects were comparable when they started their operation. The actual investment and number of workers, as well as their qualifications, are very close in magnitude and never statistically significant between treated and comparison groups.

Finally, we test whether basic or advanced treated projects may have located in more accessible areas than the comparison projects. The difference in distance from national and provincial borders, the coast and treated ports where most economic activities were concentrated, and railroads and roads is statistically insignificant between treated and comparison projects. These results are fully consistent with the historical records that explain how project delays were caused by constraints on Soviet production capacity, limited supply of Soviet experts and translators, and miscommunication

[11] These characteristics are plant capacity, actual investment, approval and start year, distance from province and coastal borders, and whether the plant was built on the site of a previously existing firm.

between the two countries' experts, but were not related to project-specific characteristics (Filatov, 1975; Hirata, 2018).

Despite the similarity in their observable characteristics, treated projects may have been concentrated in industries particularly important for Chinese economic development or the more-developed Soviet Union. We therefore estimate a multinomial logit where the dependent variable that takes different values for projects treated with a basic transfer, projects treated with an advanced transfer, comparison projects supposed to receive an advanced transfer, and comparison projects supposed to receive a basic transfer (the baseline) is regressed on a full set of industry fixed effects. None of the estimated coefficients is statistically significant (Figure 2, Panel A), indicating that industry fails to predict which projects eventually received the Soviet planned transfer.

Similarly, treated projects may have been located in more developed regions, whose firms would have grown more regardless of the Soviet technology transfer. This is an unlikely scenario because, when the transfer started, Chinese industrialization was nascent, and concentrated along the coast, while the 156 Projects were located in the interior regions (Figure 1). However, to further investigate this potential issue, we provide two pieces of evidence. First, we estimate the same multinomial logit as above, replacing industry fixed effects with province fixed effects. None of the estimated coefficients is significantly different from zero (Figure 2, Panel B), suggesting that project location is not correlated with the probability of eventually being treated. We find similar results at the prefecture and county levels (Figure A.4, Panels A and B).

Next, we show that the share of treated basic and advanced transfer projects in each province is not correlated with its outcomes and pretransfer trends. GDP, population, number of workers, number of firms, industrial output, and other government investments between 1949 and 1951 do not predict the share of basic and advanced treated projects a province eventually received (Table A.1, columns 1–3). Moreover, the share of basic and advanced treated projects appears to be independent from the province time trend in the three years before the start of the Soviet transfer. The 22 estimated coefficients on the interaction between a linear pretrend and the share of basic treated projects or advanced treated projects are never significantly different from zero (Table A.2, columns 3 and 5). Similarly, we always fail to reject the null hypothesis that the coefficients on the share of basic and advanced treated projects are significant, thus corroborating the lack of correlation with province characteristics (Table A.2, columns 2 and 4).

Finally, a potential threat to our identification strategy arises if the Chinese government reallocated the Soviet machinery or workers moved from treated to comparison projects before or after the Split. However, since each project was aimed at replicating specific Soviet plants, China could not reallocate the Soviet machinery, equipment, experts, or translators to the most promising projects before the Split (Filatov, 1975). After the Split, the records on capital owned by plants indicate that treated plants did indeed retain the Soviet equipment. It would have been unprofitable for the government to temporarily shut down treated plants and replace brand-new machines, especially in light of the difficulties the country was facing in manufacturing capital goods on its own (Zeitz, 2011; Ji, 2019). Regarding the workforce, individual records to trace worker movement do not exist, to the best of our knowledge, but the historical records indicate that engineers in treated plants were employed to train other engineers, but only from nearby factories (Zhang et al., 2006; Hirata, 2018). Moreover, migration in China at that time was highly restricted thanks to the household registration (*hukou*) system, which made worker movements from treated to comparison plants extremely rare.

4.1 IV Estimation

Since the probability of eventually participating in the Soviet transfer hinged on project delays, we also propose an IV approach in which we instrument the probability of receiving the treatment with such delays. The exclusion restriction implies that the delays affected plant outcomes only through the treatment itself. While this hypothesis is not directly testable, we show that the delays in completion of both basic and advanced transfer projects are not predicted by their characteristics (Table A.3).

However, delays *do* predict the probability of receiving the Soviet technology transfer. For basic transfer projects, an additional year of delays decreases the probability of receiving the Soviet transfer by 16.7% (and by 19.2% according to the estimation of the marginal effects of a probit model; Table A.4, columns 1 and 4). Similarly, for advanced transfer projects, an additional year of delays decreases the probability of receiving the Soviet transfer by 18.8%, a result confirmed by the probit estimation, which indicates a 20.8% probability reduction (Table A.4, columns 5 and 8).

Taken together, the results presented in this section indicate lack of correlation between project and province characteristics and the probability of receiving the treatment, which, however, is strongly and negatively correlated with project delays.

5 Effects of Technology Transfer on Firm Performance

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

5.1 Plant-Level Results in the Steel Industry

The results of estimating equation 1 on plants in the steel industry indicate that the advanced transfer had large and persistent effects on plant outcomes, while the impact of the basic transfer was positive but short-lived. Output of advanced treated plants rose by 3.9% relative to output of advanced comparison plants within a year of plant opening, and by 20.9% within five years. The gap between the two groups of plants continued to increase up to 40 years after the program, reaching a cumulative effect of 54.6% (Figure 3, Panel A). By contrast, the impact of a basic transfer took four years to materialize. After reaching a peak of 23.2% 15 years after the plant opening, the effects flattened out, then started decreasing and stopped being significant after 30 years (Figure 3, Panel A).

The use of state-of-the-art Soviet capital also affected the quality of steel. Relative to to basic comparison plants that were using domestic blast furnaces, the introduction of open-hearth furnaces in basic treated plants increased the production of crude steel (considered the best-quality steel) while reducing the quantities of pig iron (considered of lower quality given its higher carbon content) up to 20 years, the estimated life-cycle of Soviet machineries (Table 2, columns 1–2).[12] Conversely, the increase of crude steel and reduction in pig iron in advanced treated plants remained systematically higher than in advanced comparison plants. This outcome was likely due to the adoption of better production methods, that became embedded in firm organizations (Zhang et al., 2006). For instance, the adoption of Soviet methods of analysis that systematically sampled hot metals reduced the time to determine their chemical composition from 50 minutes to 2 minutes. This allowed necessary adjustments to be made more quickly, and led in turn to higher output quantity and quality in the short and in the long run (Clark, 1973).

We next investigate the effects of Soviet transfer on productivity. Specifically, we estimate $\log \text{TFPQ}$=logTFPR-log $\widetilde{p}$, where $\widetilde{p}$ is the revenue-share weighted average of the prices of plant products and TFPR is calculated using (Gandhi et al., 2020)'s method. The dynamic of productivity follows a similar pattern as output. Specifically, TFPQ of advanced treated plants rose between 3.4% one year after plant opening to 51.6% at the end of our sample, relative to advanced comparison plants (Figure 3, Panel B). TFPQ of basic treated plants increased from four years after plant opening up to 20 years, ranging between 6.0% and 22.2%, and is no longer significant after 30 years (Figure 3, Panel B).

We further explore the increase in productivity by focusing on the different components of the production function. The increase in TFPQ appears to be driven largely by output growth, since treated and comparison plants employed similar numbers of workers and used not-significantly-different quantities of inputs (coke and iron, Table 2, columns 3–5).

A caveat in interpreting the productivity results is that the Chinese economy was a noncompetitive environment until at least the late 1980s. Consequently, all firms in a given industry faced the same prices in a given year. On one hand, this implies that TFPQ does not suffer any bias due to plant-specific variation in output or input prices. On the other hand, Chinese prices may not be reliable indicators of underlying product quality, which may generate the so-called "quality bias." For instance, treated plants may have used the same quantity of better-quality inputs as comparison plants.

We test for the possibility of quality bias as follows. First, we aggregate output and inputs using their average annual prices as reported by the American Iron and Steel Institute, and we compute TFPR and TFPQ with these values. The estimates using Chinese and U.S. prices are very similar in magnitude (Figure C.1). Consistent with these results, the historical records indicate that Chinese prices indeed reflected quality differences. In 1985, for instance, Statistics China set the crude

[12] Specifically, open-hearth furnaces facilitate the control of carbon content, by allowing period sampling and interim analysis of the heat, which is not possible with blast furnaces.

steel price at 320RMB (US$199.22 in 2020 figures) per ton, compared to 249RMB (US$154.95 in 2020 figures) per ton for pig iron. Second, following de Roux et al. (2020), who show that the transmission bias and the quality bias offset when the production function is estimated with naive OLS, we estimate TFPR and TFPQ with the OLS factor shares. The results are nearly identical to those that use our baseline estimation (Figure C.1). Finally, we replace physical quantities of steel with their sales, and we replace input quantities with their expenditures. While the increase in steel and crude steel sales and the decrease of pig iron sales are larger than the corresponding quantity estimates, input expenditures are not statistically different between treated and comparison plants, in line with our main results (Table A.5).

Our findings are robust to a variety of modifications to the baseline specification. Specifically, our results hold if we replace province-year fixed effects with prefecture-year fixed effects (Figure A.5, Panels A and B). We also propose different levels of standard-error clustering, that, in all cases, confirm the significance level of our main specification (Figure A.5, Panels C and D). Finally, we instrument the probability of receiving the Soviet transfer with the delays that projects experienced. The results are very close to the baseline OLS estimates, which confirms that receiving the Soviet technology transfer was due to the extent of delays experienced by the different projects, rather than on their characteristics (Figure A.5, Panels E and F).

Finally, two things are worth noting about our results. First, because a potential challenge to our estimations is the 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., 2013). In all cases, these tests, described in Appendix D, confirm the significance level of our main specification (Table D.1). Second, a potential concern in interpreting these findings is that the firm supervisors or the local government may have had incentives to misreport some data, for instance to meet the goals of the Great Leap Forward. To attenuate this concern, we assert three points. First, the Steel Association Reports were highly monitored and checked by industry peers, which strongly limited the possibility of manipulation. Second, after the Sino-Soviet Split, the Chinese government wanted to tie up loose ends with the Soviet Union as quickly as possible.[13] Therefore, if any manipulation occurred, it should have aimed at underestimating rather than overestimating the impact of the Soviet technology transfer, especially in the long run. This would go against us finding results.[14] Third, we cross-check our data with several sources, as described in Appendix C, and they appear accurate and fully consistent. In particular, we use the estimates independently made by Clark (1973) and (Zhang et al., 2006) that assessed the minimum and maximum possible levels of steel production, based on the capital in use in each steel plant. Using these values instead of those from the Steel Association Reports leads to comparable results (Figure B.1). Moreover, both studies conclude that the data from the Steel Association Reports, our main source, appear credible.

[13] For instance, China rushed to repay Soviet loans immediately, even though it could have done so over ten years (Zhang et al., 2006).

[14] For instance, during the Great Leap Forward, the Chinese government wanted to show the efficacy of labor-intensive methods of industrialization, which would emphasize manpower rather than machines and capital expenditure, in stark contrast with the goals of the Soviet transfer (Clark, 1973; Lardy, 1995).

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

For 1985 and between 1998 and 2013, the availability of large-scale 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 these samples corroborates our finding on the steel industry that the advanced transfer had large and persistent effects on firm performance.

In 1985 and between 1998 and 2013, the value added of advanced treated firms was, respectively, 52.3% and 54.7% higher than that of advanced comparison firms, and TFPR was 49.5% and 51.6% higher (Table 3, Panel A, columns 1–2 and 5–6). By contrast, while the value added and TFPR of basic treated firms were still higher than basic comparison firms in 1985, they were no longer significantly different between 1998 and 2013 (Table 3, Panel B, columns 1–2 and 5–6). In both cases, the numbers of workers and inputs used are not statistically different between treated and comparison plants (Table 3, Panels A and B, columns 3–4). The magnitude of the estimates on the full sample are remarkably similar to those obtained from the steel-plant sample, which indicates that the Soviet technology transfer results apply beyond the steel industry.

5.3 Development of New Technologies

Why did the effects of advanced transfer persist over time, while the effects of basic transfer were short-lived? In this section, we examine potential mechanisms.

Between 1960 and 1978, due to the Soviet Split and the embargo of Western countries, Chinese firms could rely only on their own resources to operate and innovate. Advanced treated firms were able to domestically develop new technologies during this period. Specifically, in the 1960s the basic oxygen steelmaking converters, that blew oxygen through molten pig iron and lower the carbon content of the alloy, became predominant (Clark, 1973). Data on firm capital adoption from the Steel Association Reports indicate that advanced treated plants were the only ones able to home-fabricate such converters, and sell them to other plants (Fruehan et al., 1997). Consequently, advanced treated plants were 65% more likely to use the basic oxygen steelmaking than advanced comparison plants (Table 4, column 1).

The Soviet capital that was state-of-the-art in the 1950s and 1960s became obsolete in the 1970s and 1980s, due to the development of continuous casting furnaces. Once again, data on capital adoption indicate that only advanced treated plants home-fabricated the continuous casting furnaces that were used to replace Soviet open-hearth ones. As a result, advanced treated plants were 78% more likely to use this type of furnaces than advanced comparison plants, while this difference is not significant between basic treated and comparison plants (Table 4, column 2). This technological development may have offset the diminishing return of Soviet capital and may explain why the advanced transfer effects were persistent.

In the late 1970s, the China began gradually opening to international trade, especially with the Western world, allowing the country to import machines from the United States and Western Europe. In light of the domestic development of new technologies, advanced treated plants relied dramatically less than advanced comparison plants on the import of foreign capital. Nevertheless, they exported 45.5% more steel and produced 51.1% more steel above the international standards than advanced comparison plants (Table 4, columns 3–5). This finding indicates that the quality of steel produced by advanced comparison plants was recognized not only in China, but also by the international steel market.

By contrast, we do not observe any differential development of new technologies between basic treated and comparison plants when China was a closed economy, nor differential imports of foreign capital and exports when the country lifted its restrictions to international trade (Table 4, columns 1-5). Data on capital adoption indicates that basic treated and comparison plants kept almost the same capital between between their opening and the early 1980s and adopted similar more modern machineries after that. This finding may explain why the basic transfer effects did not persist. As long as firms were stuck with their original technology, basic treated plants were more productive than basic comparison firms given the better technology of Soviet capital. When both plants could import foreign machineries, their performance gap quickly narrowed.

Another potential mechanism for long-run persistence may be the composition of plant human capital. Though China was a planned economy, treated and comparison plants, given their large size, were given some autonomy in the local labor market in terms of hiring (Hirata, 2018; Liu, 2019). The composition of human capital in the two types of plants was similar at time of opening, as we've shown shown in our balancing tests. However, over time, advanced treated plants increased the number of engineers and high-skilled technicians and reduced the number of unskilled workers (Table 5, columns 1–3). According to the historical records, given the low level of Chinese human capital at the time of plant opening, many engineers and high-skilled technicians were trained within the firms and were directly involved in developing new technologies and improving production methods (Zeitz, 2011; Ji, 2019). This may help explain the persistence of the advanced transfer, even many years after the Soviet intervention. Conversely, the human capital composition did not differentially change between basic treated and comparison plants.

5.4 Alternative Explanations for the Technology Transfer Effects

Even if project delays represent a natural variation in the probability of receiving the Soviet transfer, it still may be the case that in subsequent years treated plants received special favors from the government that, in turn, allowed their performance to flourish. For instance, the government may have allocated more funds to treated plants or may have invested more in counties were treated plants were located.

To investigate this potential issue, we first examine whether basic or advanced treated plants received any special funding from the government. We find that loans and transfers that the government allocated are not statistically different between basic or advanced treated plants and their comparison plants, neither in the short run nor in the long run (Table A.6, Panel A, columns 1–2).[15]

[15] While we can observe yearly loans and transfers only for plants in the steel industry, looking at these variables in all 139 plants in 1985 and between 1998 and 2013 confirms the lack of differential loans and

Moreover, we check whether treated plants became more accessible than comparison plants after the Soviet transfer, which may have contributed to their success. We find that the distance from railroads and roads, statistically indistinguishable at the time of the transfer, did not differentially change in the following decades (Table A.6, Panel A, columns 3–4).

Treated plants may have also become more politically connected than comparison plants over time, or perhaps better politicians were allocated to their administrative areas. To test this hypothesis, we collected data from the People's Daily Online database, which includes names, city and year of birth, and education of both the secretaries of the Municipal Party Committee and the mayors at the prefecture-city level from 1949 to 2018. The secretaries of the Municipal Party Committee were directly linked with the central government and were responsible for Party affairs within the city area and for strengthening the Party's leadership. In accordance with the instructions of the higher-level Party committee, they carried out the work of Party agenda in the region, and they set up political and legal committees, the Party Committee's organization department, and other departments. The mayors represented the local government and coordinated the work of the Municipal People's Congress, the municipal government, and the provincial government. We therefore test whether secretaries and mayors that worked where treated plants were located were more likely to be born or have studied locally or whether they were more educated than those who worked where treated plants were located. Having studied in the same areas where where treated plants were located may reflect stronger links with local firm management, while we use years of education as a proxy for politician quality. None of these four measures is statistically different between treated and comparison plants in the 40 years after the Soviet transfer (Table A.7, columns 1–6), which suggests that political connections and politician quality remained comparable over time.

Next, we check whether counties in which treated plants were located received more transfers from the government than counties where comparison plants were located. We find that total investments, as well as investments in industries both related and unrelated to the 156 Projects, are not statistically different between the two types of counties (Table A.8, columns 1–3). Similarly, the number of other industrial projects sponsored by the Chinese government after the Sino-Soviet Split and the overall length of railroads and roads are the same between treated and comparison counties (Table A.8, columns 4–5).[16] Taken together, these results demonstrate that the government did not favor plants that received the Soviet transfer or the counties where they were located. It is worth noting that if we compare advanced and basic comparison plants with the steel plants built under these projects, the former, in spite of eventually not receiving any Soviet transfer, performed better and were larger than the latter (Table A.9, columns 1-3). These results do not have any causal interpretation, but may indicate that, even if advanced and basic comparison projects were completed by the Chinese government alone, Soviet help in their initial planning was beneficial.

transfers between treated and comparison plants (Table A.6, Panel B).

[16] Other industrial projects sponsored by the Chinese government after the Split include the Construction of the Third Front (TF), a massive yet short-lived industrialization campaign in China's underdeveloped hinterland between 1964 and 1972. Fan and Zou (2021) document that the TF had long-run positive aggregate effects on the local economy, regardless of the initial development level of the regions.

In Section 4, we showed that basic and advanced treated plants exhibited similar observable characteristics compared to their comparison plants. However, a potential concern to our identification may be selection on unobservable characteristics. To address this issue, we use the methodology proposed by Oster (2019), which assumes that the correlation between treatment and unobservables is equal to the correlation between treatment and observables multiplied by a factor δ. A treatment effect is robust to selection on unobservables if it does not change sign at $\delta = 1$. This value of δ means that the degree of selection on observed variables is the same as that on unobserved variables.[17] In Table A.10, we show that our estimates change little relative to our main results as we move from $\delta = 0.1$ to $\delta = 1$ (columns 2–6). In order to have our treatment effects no longer significant, the degree of selection on unobserved variables should be between 6 and 18 times larger than selection on observed variables, values that are implausible (Table A.10, column 7). Therefore, our results do not appear driven by selection on unobservables.

6 Spillover Effects

One goal of the Soviet technology transfer was to create large industrial facilities to push local industrial development. In this section, we examine whether the transfer was successful in doing so, as well as the types of short-run and long-run spillovers it generated.

6.1 Agglomeration Effects

We start our analysis of spillover effects by investigating whether on the extensive margin firms that started their operations between the 156 Projects' opening and 1985 were more likely to locate close to treated plants, relative to comparison plants. Of the 7,592 firms operating in China in 1985, when the Second Industrial Survey was conducted, 6,134 (80.8%) were founded after 1952, when the Soviet technology transfer started.[18]

Between the 156 Projects' opening and 1985, a higher number of new firms located near treated plants relative to comparison plants. Specifically, 19.5% more new firms located within 50 km of a basic treated plant, with respect to basic comparison plants, and 18.5% more located within 50 km of an advanced treated plant (Table A.12, Panel A, column 1). By contrast, there is no differential firm entry between 50 and 100 km (Table A.12, Panel A, column 2).

These findings are almost totally driven by the entry of firms in related industries, i.e., firms operating in the same industry or in upstream/downstream industries of treated and comparison plants, while there is not a higher concentration of new firms operating in unrelated industries

[17] Specifically, Oster (2019) shows that a treatment effect is robust if it does not change sign at $\delta = 1$ and $R_{max} = 1.3 \cdot \tilde{R}$, where R_{max} is the R squared of a hypothetical regression of the outcome on both observables and unobservables. $\tilde{R}$ is the R squared of a regression of the outcome on just the observables. Table A.11 shows sensitivity to R_{max}.

[18] We have no data on firm performance other than for the steel industry back then, but the 1985 Second Industrial Survey contains data on firm location and foundation year, which we use to perform such analysis.

(Table A.12, Panel A, columns 3 and 5). This result seems to indicate that the agglomeration effects were related to the presence of treated plants, and not by other local factors that may have simultaneously affected firm location and treated plant performance. Repeating the same analysis on the 20 plants that belong to the steel industry leads to similar results, despite the small sample size (Table A.12, Panel B).

6.2 Horizontal Spillovers

After absorbing the content of the Soviet training, advanced treated firms could have experienced additional improvements by transmitting new acquired knowledge to nearby firms. To capture these effects, we estimate equation 1 on steel firms established within 50 km of treated or comparison steel plants between their opening and 1985. The results support the existence of positive horizontal spillovers, mostly related to the advanced transfer. While steel plants located close to basic treated plants did not exhibit better performance than those close to basic comparison plants, steel plants close to advanced treated plants increased their production of steel by 12.9% and were 12.4% more productive than steel plants close to advanced comparison plants (Table 6, columns 1–2). These results are likely driven by the adoption of technologies developed by advanced treated plants. As indicated by the historical records (Lardy, 1995; Ji, 2019), Soviet-trained engineers were employed to diffuse knowledge to nearby firms and helped them to adopt new technologies and better production methods. Consistently, we find that plants close to advanced treated plants were more likely to use basic oxygen converters and continuous-casting furnaces than plants close to advanced comparison plants, and, when China opened up to trade, they exported significantly more and produced a higher quantity of steel above the international standards (Table 6, columns 3–6).[19]

6.3 Vertical Spillovers

The Soviet technology transfer may have generated spillovers on firms in the supply chain of treated plants. To estimate these effects, first we identify steel-industry firms in the supply chain of treated and comparison plants by using the input-output matrix provided by the National Bureau of Statistics of China (NBS; see Appendix B.4). Second, we estimate equation 6 on steel firms located within 50 km of treated and comparison plants in nonsteel sectors.

Being a steel plant close to a nonsteel basic treated plant is associated with higher production relative to being close to a nonsteel basic comparison plant. Compared to the latter, in the former the quantity of steel produced is 12.9% higher (Table 7, column 1). These findings are fully consistent with the increased production of treated plants, which in turn may have affected their supply chain. However, only firms close to advanced treated plants experience a productivity increase, estimated to be 14.1% (Table 7, column 2). These companies are also the only ones to register

[19] Similarly, we find that in 1985, firms located within 50 km of advanced treated plants and operating in the same sector had higher value added and TFPR than firms located close to advanced comparison plants, with no differences for basic treated and comparison plants (Table A.13, columns 1–2). These estimates are close in magnitude to those estimated in the steel industry only.

an increase in the probability of using basic oxygen converters and continuous casting furnaces and that systematically engaged more in trade and produced more steel above the international standards (Table 7, columns 3–6).[20] The higher quality of supplied inputs may have in turn helped the differential performance of advanced treated plants to persist over time.

Overall, the spillover analysis presented so far is consistent with the findings in Greenstone et al. (2010), who show that productivity spillovers generated by the Million Dollar Plants are related mainly to workers rather than to input and output flows. By contrast, competition spillovers appear limited. This is not surprising, given the booming Chinese demand for steel and the country's large labor supply, which could be easily reallocated from the agricultural sector to the industrial sector (Lardy, 1995).

6.4 The Role of Institutional Reforms

Starting in the 1990s, the Chinese government undertook a number of market-liberalization reforms and began privatizing state-owned companies. We therefore investigate whether public or private firms were able to capture the gains from industry-specific know-how created by the Soviet transfer.

Looking at spillover effects between 1998 and 2013, we document that firms spatially close to advanced treated plants performed better in terms of value added and TFPR than firms spatially close to advanced comparison plants, only if they were economically horizontally or vertically related to them and became privately owned (Table 8, Panel A, columns 1–4). Those firms were also able to gain more from market liberalization, because they systematically engaged more in exporting (Table 8, Panel A, columns 7–8). The gains do not appear for private firms close to plants that got a basic transfer. We find similar effects for privately owned firms in the supply chain of treated and comparison plants (Table 8, Panel B, columns 1–12). Finally, firms close but not related to treated plants did not have better outcomes than firms close but not related to comparison plants (Table 8, Panel C).

Taken together, our results indicate that in the long run, being located close to advanced treated plants gave a competitive advantage to firms only if they were privately owned and only if they were economically related to treated plants. Therefore, the Soviet transfer may have created some local, industry-specific know-how that interacted with the transition from a planned economy to a market economy.[21] This interpretation is consistent with Liu (2019), who shows that sectoral interventions might generate positive aggregate effects. We next explore the channels through which these effects operated.

Competition. We start by examining whether counties in which treated plants were located

[20] In 1985, firms close to basic treated plants had higher value added but were not more productive; only firms close to advanced treated plants *also* had a TFPR increase (Table A.13, columns 1–2). Notably, the estimates in 1985 are close in magnitude to the estimates in the steel industry.

[21] Our estimates are based on a comparison between firms or counties that hosted the 156 Projects and either ended up or did not end up receiving the Soviet transfer due to the delays they experienced. In this respect, our spillover results differ from Heblich et al. (2020), that compare counties where the 156 Projects were located with counties suitable to host them but that were not selected and find that in the 1990s the significant productivity advantage of the former fully eroded due to overspecialization.

(*treated counties*) were exposed to more market competition than counties in which comparison plants were located (*comparison counties*). In Section 6.1, we showed that a larger number of firms in related industries were established close to treated plants relative to comparison plants. Between 2005 and 2013, the agglomeration effects persisted. Specifically, basic and advanced treated counties had around 25% more firms in related industries than basic and advanced comparison counties (Table A.14, Panel A, columns 1–2). However, in advanced treated counties there was a higher reallocation of production from state-owned to privately owned firms (Table A.14, Panel A, columns 4–5). This is likely due to their better performance, as firms that were privatized during this period were those with higher labor or capital productivity (Hsieh and Song, 2015). In turn, privately owned firms in advanced 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.

Human Capital. Next, we test whether treated counties had a higher concentration of human capital. We find that the number of college graduates and high-skilled workers is higher in advanced treated counties relative to advanced comparison counties, while there are no statistically significant differences between basic treated and comparison counties (Table A.14, Panel B, columns 1–6). The fact engineers and high-skilled workers of advanced treated plants were used to train workers in nearby firms may have contributed to form a more educated local laborforce. When firms started competing for inputs in the local market, companies that became privately owned may have been able to hire these workers, with positive effects on their performance.

Government Investments. Finally, the government may have invested more resources in treated counties, allowing firms located there to perform better, despite the technology transfer. In Section 5.4, we showed that total investments, and investments in related and unrelated industries of the 156 Projects, were not statistically different between treated and comparison counties (Table A.8, columns 1–3), which suggests that this potential channel is not driving our results.

7 Soviet Transfer and the Chinese Growth Miracle

In the past 80 years, China has experienced "the fastest sustained expansion by a major economy in history" (Morrison, 2019). To what extent did the Soviet technology transfer contribute to such outstanding economic growth?

First, we estimate the effects of the technology transfer projects on the long-run development of provinces in which they were located, by regressing province outcomes on the province share of treated projects interacted with an indicator for years after 1952, when the Soviet transfer started. A 1% increase in the share of treated projects increases the province average logged industrial output by 1.2% per year. Considering that the average number of treated projects per province is 8.6, having an additional treated project increases the logged industrial output by 13.2% per year (Table A.16, Panel A, column 1). Similarly, an additional treated project is associated with 4.9% higher employment in the industrial sector and 17.6% higher GDP per capita (Table A.16, Panel A, columns 2–3). By contrast, the share of treated projects is unrelated to government investments and the number of other industrial projects that were discussed but not approved under the Sino-Soviet Alliance (Table A.16, Panel A, columns 4–5).

Second, we estimate the cross-sectional fiscal multiplier of the technology transfer investments on provincial real GDP, via the following 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 ΔGDP per capita$_{pt}$ is the change in real GDP per capita in province p between year t and year t-1 with $t \in [1953, 2008]$; $\frac{\text{Investment TT}_p}{\text{Population}_{p,1949}}$ is the amount of investments per capita in technology transfer projects completed by the 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 treated projects with the average province-level delays. The exclusion restriction requires that the average province-level delay affects province-level outcomes only through its effect on the share of treated projects. While the exclusion restriction is not directly testable, the average province-level delay does not predict any province-level characteristics between 1949 and 1951 (Table A.1, columns 4–6).

A province that got \$1 per capita more in the Soviet transfer 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 \$0.61 to \$0.68 between 1953 and 2008 (Table A.16, Panel B).

Next, we use our cross-sectional fiscal multiplier to assess the impact of the Soviet technology transfer on 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 inflation after the Chinese Civil War was one of the primary goals of the newly formed government (Lardy, 1995, p. 118).[22] 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.[23] We then perform a back-of-

[22] As explained in Chodorow-Reich (2019) and Guren et al. (2020), a potential concern in using a cross-sectional multiplier to assess aggregate effects is that the cross-sectional multiplier measures outcomes in the treated area relative to the "contaminated" untreated area, violating the micro no-interference Stable Unit Treatment Value Assumption (SUTVA-micro). However, Chodorow-Reich (2019) shows that "in practical settings with geographic units of the size of U.S. states or smaller and demand shocks that do not induce factor mobility, SUTVA-micro violations should have minimal impact on general equilibrium effects and usually may be safely ignored" (p. 2). These conditions are likely to hold in our setting, as Chinese provinces are comparable to U.S. states, and labor and capital could not be freely moved across the country.

[23] Our calculation: 0.20=0.85×0.24, where 0.85 is our estimated medium-run cross-sectional multiplier (Table A.16, 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 A.16, column 4).

the-envelope calculation of the effects of the Soviet transfer on the national Chinese real GDP per capita growth rate. Specifically, we compute the effect of the Soviet transfer 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 ($46.16 billion in 2020 figures) and Y is the Chinese GDP in 1952 ($268.92 billion in 2020 figures). Therefore, without the Soviet transfer, the Chinese national real GDP growth rate would have been 3.4 percentage points lower in the medium run and 2.6 percentage points lower in the long run. Considering an average annual real GDP per capita growth rate of 7% between 1953 and 1978 and of 11.9% between 1953 and 2008, without the transfer such growth rates would have been 3.6% between 1953 and 1978 (51% lower) and 9.3% between 1953 and 2008 (21.8% lower). While these findings are fairly large, they are consistent with the historical evidence that considers the Soviet transfer as vital in Chinese early industrial development (Lardy, 1995; Zhang et al., 2006).

Moreover, we compute the return on investment of the Soviet transfer 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 Soviet transfer accounted for a average annual increase in nominal GDP of $9.2 billion (in 2020 figures) during these 25 years. We compute the direct costs of the transfer as the sum of the total value of the technology-transfer-treated projects ($46.16 billion in 2020 figures) and the loan China received from Soviet Union and paid back in 10 years at an interest rate of 1% ($2.93 billion in 2020 figures). However, when the Chinese leaders decided to push industrial development, they did so at the expense 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 transfer as the crowding out of the agricultural sector. Specifically, between 1952 and 1978, the agriculture sector's share of GDP decreased from 51% to 28.2%, which corresponds to an average annual reduction of $2.6 billion (in 2020 figures). Therefore, the benefits of the Soviet transfer were two times higher than the costs.

Finally, we compare the Soviet transfer in China to similar U.S. interventions in Western Europe. Specifically, the Marshall Plan's Productivity Program (1952–1958) provided technologically advanced U.S. capital goods and know-how to European firms that were a generation behind the U.S. firms (Silberman et al., 1996). In both cases, the human-capital component of such interventions was strongly linked to persistent results on firm outcomes (Bjarnar and Kipping, 2002; Giorcelli, 2019). In other words, human capital was the crucial ingredient for firms no matter the political situation they faced.

However, spillover effects of the Productivity Program were limited, in contrast with the substantial spillover effects the Soviet transfer generated. This could be explained by the fact that the Productivity Program targeted existing small and medium-sized firms that faced domestic and international competition, which may have discouraged them from sharing know-how with potential competitors (Fauri, 2006; Giorcelli, 2019). Conversely, China was an agricultural country, with limited trade opportunities, that could rely uniquely on Soviet assistance to foster its early-stage industrialization. The size of the new industrial facilities allowed them to exploit economies of scale from Soviet technology and to push agglomeration and spillover effects. Such effects were facilitated by know-how diffusion, which could flow across noncompetitor, state-owned firms. Finally, the Productivity Program did not attempt to change the pattern of European development, whereas the 156 Projects were located mostly in remote areas that would not otherwise have had great chances to industrialize.

8 Conclusions

This paper studies the effects of technology transfer on early industrial development. We collected data on the 156 Projects sponsored by the Soviet Union for the construction of technologically advanced, capital-intensive industrial facilities in China. To identify the causal effect, we rely on idiosyncratic delays in project completion, due to which some received Soviet technology while others were eventually realized by China alone with traditional domestic technology. The Soviet technology transfer had large and persistent effects on plant performance, and know-how diffusion further boosted firm outcomes. Since the late 1990s, the intervention has generated horizontal and vertical spillovers, as well as production reallocation from state-owned to privately owned companies.

What are the policy implications of this paper? In 1949, China was an agricultural country comparable to various developing countries today, where technology and knowledge transfers often occur through foreign direct investment and joint ventures (Robinson, 2009; Jiang et al., 2018). Our work shows that the effects of foreign-imported technologies are hard to replicate using domestic capital goods in early stages of economic development. Moreover, our findings underscore the importance of foreign on-the-job training and know-how, not only for improving firm performance and technology development but also for propagating industry knowledge to other companies, with the subsequent creation of industry-specific high-skilled human capital in the long run.

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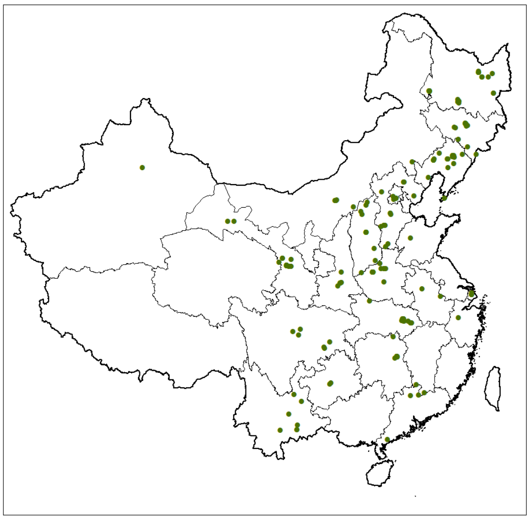
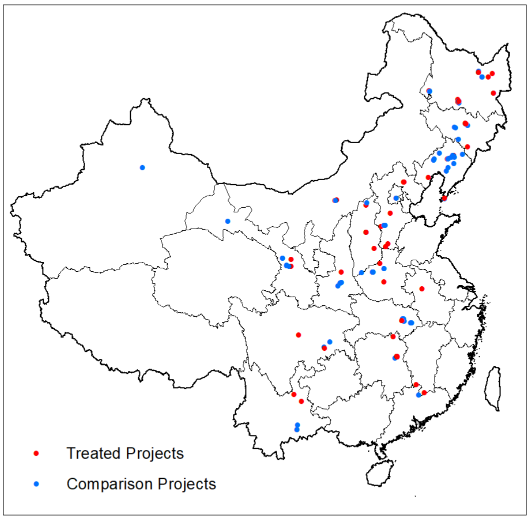
Figures and Tables

Figure 1: Distribution of the 156 Projects

Panel A: All Projects



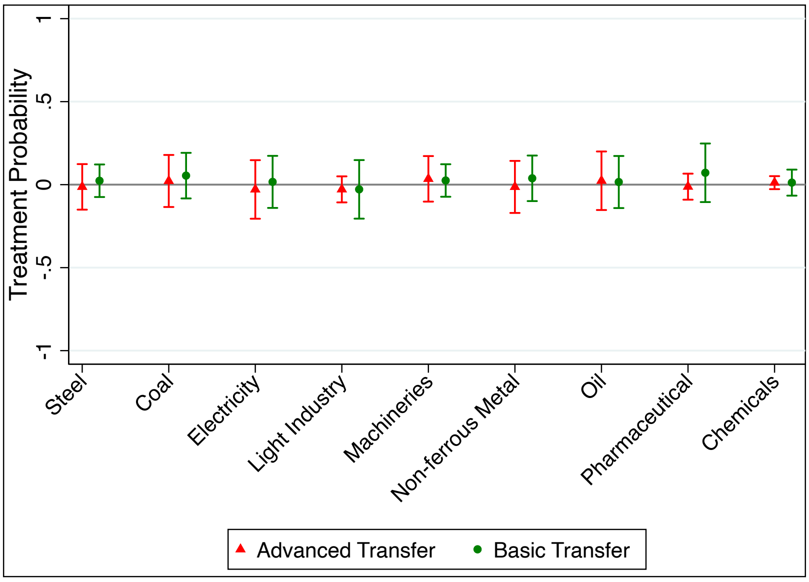
Panel B: Treated and Comparison Projects



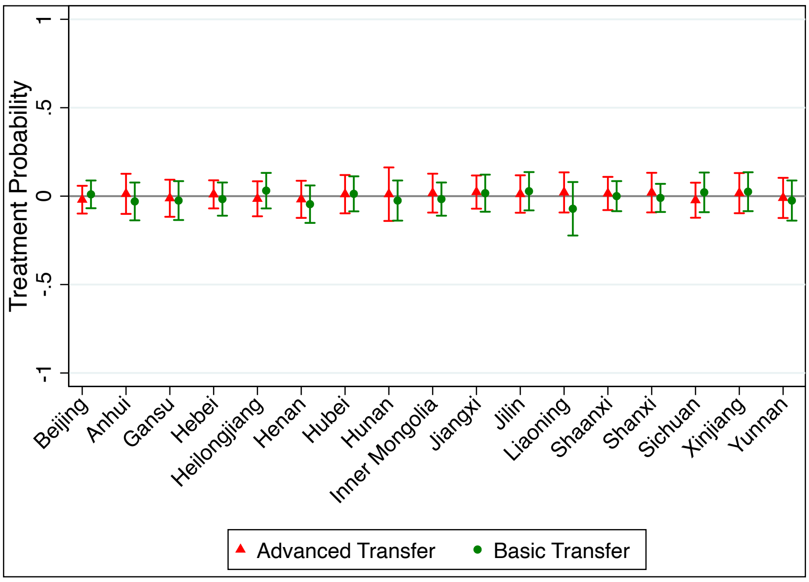
Notes. Panel A shows all the 139 approved projects between 1950 and 1957, although the iconic label 156 Projects refers to the number of projects initially contemplated. Panel B shows treated projects (completed with the Soviet technology) and comparison projects (completed by China alone using domestic traditional technology). Data are provided at the project level from the National Archives Administration of China.

Figure 2: Probability of Receiving the Soviet Technology Transfer, by Industries and Provinces

Panel A: Industry



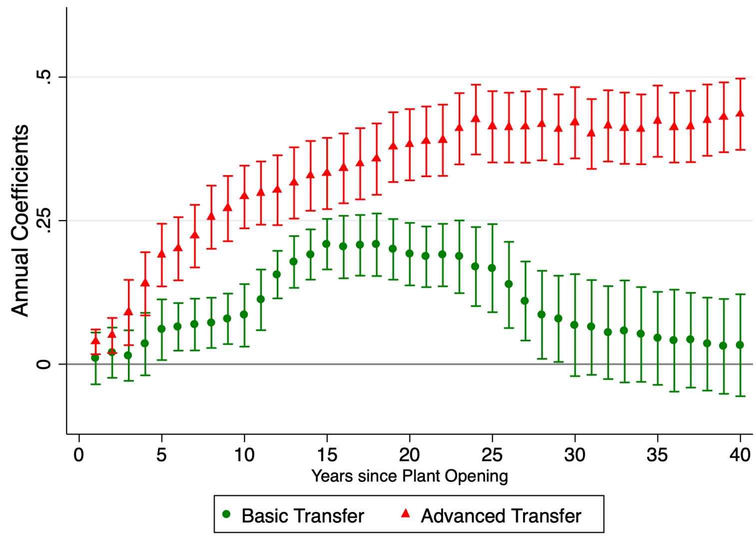
Panel B: Province



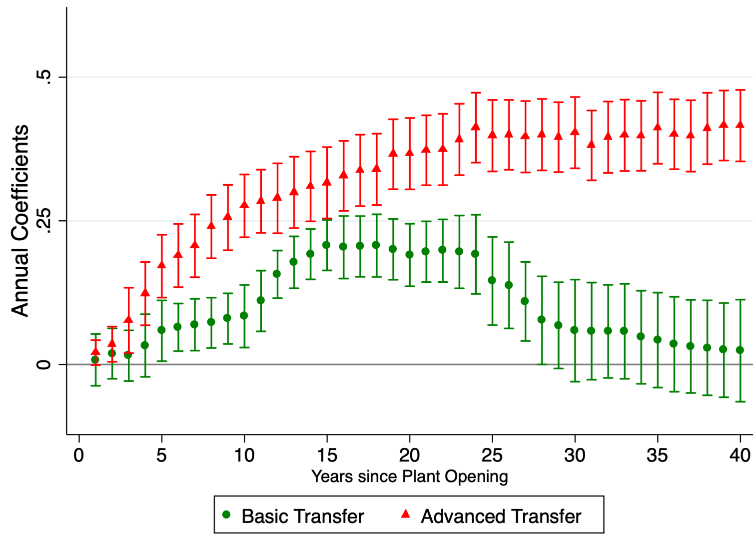
Notes. Coefficients and 95% confidence intervals from a multinominal logit estimating the probability of receiving a basic or an advanced transfer based on project industries (Panel A) and provinces (Panel B). The baseline category is comparison projects supposed to receive a basic transfer. Data are provided at the project level from the National Archives Administration of China.

Figure 3: Yearly Effects of the Technology Transfer on Plant Output and TFP

Panel A: Output



Panel B: TFPQ



Notes. Annual δ_j coefficients estimated from Equation 1 for plant output (Panel A) and TFPQ (Panel B). *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue-share weighted average of the prices of plant products, and TFPR is calculated using (Gandhi et al., 2020)'s method. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. Standard errors are wild-bootstrapped at the plant level (Cameron et al., 2008).

Table 1: The 156 Projects

	All Projects				Basic			Advanced		
	Mean	SD	Min	Max	Treated	Comparison	p-value	Treated	Comparison	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Project characteristics										
Approval Year	1953.21	1.21	1950	1957	1953.50	1953.21	0.346	1953.68	1954.24	0.412
Start Year	1955.49	1.32	1952	1957	1955.95	1955.41	0.795	1955.81	1955.85	0.837
Planned Investment (m)	579.40	213.2	80.03	1,813.20	576.81	577.09	0.773	581.55	582.16	0.895
Planned N. Workers (k)	37.70	20.30	12.80	70.61	37.41	37.95	0.654	37.78	37.43	0.621
Expected Equipment Value (m)	258.79	98.23	57.68	1,567.54	258.21	259.20	0.765	259.33	257.98	0.790
Expected Length	5.44	2.53	2	8	5.25	5.33	0.741	5.30	5.35	0.874
Expected Capacity (m tons)	1.58	7.54	0.40	7.33	1.55	1.62	0.664	1.65	1.52	0.690
Existing Firm	0.07	0.09	0	1	0.06	0.07	0.561	0.08	0.06	0.598
Plant characteristics t=0										
Actual Investment (m)	569.50	208.9	91.87	2,135.20	567.54	566.98	0.785	568.71	569.08	0.880
Actual N. Workers (k)	37.44	21.03	12.51	69.82	37.91	37.33	0.567	37.29	37.48	0.601
Engineers	1.68	2.89	0.55	2.98	1.56	1.71	0.783	1.78	1.45	0.802
High-Skilled Technicians	4.51	3.67	3.39	7.91	4.45	4.23	0.761	4.30	4.52	0.749
Unskilled Workers	31.78	8.67	29.39	35.91	31.58	31.93	0.748	31.33	31.59	0.732
Accessibility										
Distance Border (km)	343.60	224.57	0.30	873.63	342.90	344.51	0.765	345.67	342.10	0.709
Distance Province (km)	70.01	38.92	0.30	277.55	72.01	70.01	0.741	71.15	72.09	0.782
Distance Coast (km)	540.77	335.97	0.30	2,324.50	541.99	541.05	0.723	542.76	542.32	0.777
Distance Treated Ports (km)	567.11	350.98	0.30	2,368.92	561.01	560.03	0.765	562.38	563.45	0.760
Distance Highway (km)	42.00	59.71	0.42	208.395	40.94	41.43	0.665	41.20	40.87	0.691
Distance Railway (km)	66.64	183.22	0.16	1,611.88	65.89	63.40	0.732	64.12	65.33	0.765
Observations	139	139	139	139	34	22	56	37	46	83

Notes. Summary statistics for all the 139 approved projects between 1950 and 1957, although the iconic label 156 Projects refers to the number of projects initially contemplated. Data are provided at the project level from the National Archives Administration of China. *Advanced Transfer* is one for projects supposed to receive machinery, equipment, and technical assistance. *Basic Transfer* is one for projects supposed to receive machinery and equipment only. *Approval* and *Start Year* are the approval and start year of each project; *Expected Length* is expected project length in years; *Planned and Actual N. Workers* is number of plant planned and actual employees, in thousands; *Engineers* is the number of plant engineers; *High-Skilled Technicians* is the number of high-skilled technicians; *Unskilled Workers* is the number of unskilled workers; *Planned* and *Actual Investment* are, respectively, the investment planned at the approval time and the investment eventually realized, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Expected Equipment Value* is the value of the equipment a project was expecting to receive from Soviet Union, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Capacity* is in 10,000 tons per kilowatt; *Existing Firms* is one for firms built on the site of existing plants destroyed during the Chinese Civil War; *Distance Border, Province, Coast, Treated Ports, Highway* and *Railway* is the distance in km to the nation border, province border, coast, Treated Ports, highway, and railway as in 1952. *Delay* is the difference in years between the expected and actual length of each project. *p-value* is the p-value of testing equality between treated and comparison projects.

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

	Log Crude Steel (1)	Log Pig Iron	Log Workers (2)	Log Coke (3)	Log Iron (4)
Treatment * Basic * Year 1	0.032***	-0.028***	-0.009	0.005	-0.008
	(0.011)	(0.010)	(0.008)	(0.007)	(0.012)
Treatment * Basic * Year 5	0.056***	-0.069***	0.005	0.004	-0.002
	(0.015)	(0.017)	(0.006)	(0.006)	(0.005)
Treatment * Basic * Year 10	0.123***	-0.159***	-0.003	0.003	0.004
	(0.021)	(0.025)	(0.004)	(0.007)	(0.006)
Treatment * Basic * Year 20	0.178***	-0.203***	-0.008	0.006	-0.005
	(0.037)	(0.042)	(0.010)	(0.005)	(0.009)
Treatment * Basic * Year 30	0.048	-0.056	0.004	0.007	0.009
	(0.044)	(0.059)	(0.007)	(0.007)	(0.011)
Treatment * Basic * Year 40	0.041	-0.032	0.005	-0.005	0.003
	(0.035)	(0.030)	(0.007)	(0.006)	(0.004)
Treatment *Advanced*Year 1	0.055***	-0.058***	-0.006	-0.003	-0.002
	(0.015)	(0.012)	(0.008)	(0.005)	(0.003)
Treatment *Advanced*Year 5	0.078***	-0.091***	0.002	-0.002	-0.003
	(0.026)	(0.014)	(0.003)	(0.004)	(0.007)
Treatment *Advanced*Year 10	0.177***	-0.152***	-0.001	0.004	-0.005
	(0.039)	(0.028)	(0.003)	(0.006)	(0.008)
Treatment *Advanced*Year 20	0.203***	-0.198***	-0.008	-0.002	0.007
	(0.037)	(0.035)	(0.011)	(0.011)	(0.012)
Treatment *Advanced*Year 30	0.258***	-0.203***	0.005	0.003	-0.002
	(0.041)	(0.037)	(0.007)	(0.004)	(0.003)
Treatment *Advanced*Year 40	0.298***	-0.215***	0.008	0.006	-0.004
	(0.040)	(0.043)	(0.010)	(0.009)	(0.005)
Province-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	957	957	957	957	957

Notes. *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *Log Crude Steel, Pig Iron, Coke, Iron* are logged quantities (in tons) of crude steel, pig iron, coke, iron; *Log Workers* is logged total number of plant employees. 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 with 200 replications (Cameron et al., 2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Effects of the Soviet Technology Transfer in 1985 and 1998–2013

	Log Value Added		Log Workers		Log TFPR	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 1985						
Treatment * Basic	0.155***	0.167***	0.006	0.008	0.138***	0.147***
	(0.055)	(0.059)	(0.008)	(0.016)	(0.031)	(0.04)
Treatment * Advanced	0.421***	0.433***	0.003	0.009	0.402***	0.414***
	(0.067)	(0.072)	(0.005)	(0.010)	(0.071)	(0.077)
Model	OLS	IV	OLS	IV	OLS	IV
Sector-Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	139	139	139	139	139	139
Panel B: 1998-2013						
Treatment * Basic	0.031	0.038	0.001	0.004	0.029	0.032
	(0.032)	(0.035)	(0.002)	(0.006)	(0.034)	(0.038)
Treatment * Advanced	0.436***	0.445***	-0.002	-0.007	0.416***	0.422***
	(0.061)	(0.068)	(0.006)	(0.009)	(0.063)	(0.064)
Model	OLS	IV	OLS	IV	OLS	IV
Sector-Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,925	1,925	1,925	1,925	1,925	1,925

Notes. *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only).*Log Value Added* is measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log Workers* is logged total number of workers; *Log TFPR* is logged total factor productivity revenue computed with the Gandhi et al. (2020)'s method. Data are provided at the firm level from the Second Annual Survey in 1985 (Panel A) and from the China Industrial Enterprises database between 1998 and 2013 (Panel B). Standard errors are clustered at the firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Effects of Soviet Transfer on Technology Development

	Prob. Oxy. (1)	Prob. Cast. (2)	Log Import Capital (3)	Log Exports (4)	Log Int. St. (5)
Treatment * Basic	-0.009	0.007			
	(0.010)	(0.011)			
Treatment * Advanced	0.651***	0.784***			
	(0.151)	(0.143)			
Treatment * Basic	0.005	0.003	0.009	0.020	-0.040
* Post 1978	(0.006)	(0.009)	(0.011)	(0.030)	(0.041)
Treatment * Advanced	0.008	0.055***	-0.178***	0.375***	0.413***
* Post 1978	(0.009)	(0.018)	(0.061)	(0.041)	(0.072)
Sector-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	957	957	957	957	957

Notes. *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *Post 1978* is an indicator equal to one in years after 1985. *Prob. Oxy* and *Prob. Cast.* are indicators for plants using the basic oxygen converters and the continuous casting furnaces. *Log Import Capital, Exports* and *Int. St.* are logged values of foreign imported capital, firm exports, and quantity of steel that meet international standards. 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 with 200 replications (Cameron et al., 2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Effects of the Soviet Technology Transfer on Steel Plants, OLS

	% Engineers	% Techn.	% Unskilled
	(1)	(2)	(3)
Treatment * Basic * Year 1	0.005	-0.003	-0.002
	(0.007)	(0.005)	(0.004)
Treatment * Basic * Year 5	0.006	0.003	-0.009
	(0.008)	(0.005)	(0.014)
Treatment * Basic * Year 10	0.012	0.015	-0.022
	(0.018)	(0.020)	(0.024)
Treatment * Basic * Year 20	0.014	0.011	-0.026
	(0.015)	(0.010)	(0.027)
Treatment * Basic * Year 30	0.009	0.005	-0.013
	(0.010)	(0.008)	(0.016)
Treatment * Basic * Year 40	0.004	0.005	-0.010
	(0.011)	(0.012)	(0.014)
Treatment *Advanced * Year 1	0.003	-0.005	0.002
	(0.007)	(0.005)	(0.004)
Treatment *Advanced * Year 5	0.015***	0.013***	-0.022***
	(0.007)	(0.005)	(0.004)
Treatment *Advanced * Year 10	0.026***	0.028***	-0.045***
	(0.007)	(0.005)	(0.004)
Treatment *Advanced * Year 20	0.043***	0.038***	-0.080***
	(0.007)	(0.005)	(0.004)
Treatment *Advanced * Year 30	0.063***	0.045***	-0.101***
	(0.007)	(0.007)	(0.004)
Treatment *Advanced * Year 40	0.085***	0.058***	-0.133***
	(0.007)	(0.007)	(0.009)
Province-Year FE	Yes	Yes	Yes
Observations	957	957	957

Notes. *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *% Engineers*, *% Techn.*, and *% Unskilled* are the fraction of engineers, high-skilled technicians, and unskilled workers over plant total number of workers. 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 with 200 replications (Cameron et al., 2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: Horizontal Spillovers in the Steel Industry

	Log Output	Log TFPQ	Prob. Oxy.	Prob. Cast.	Log Exports	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment * Basic	-0.018	-0.016	-0.009	0.007		
	(0.042)	(0.038)	(0.010)	(0.011)		
Treatment *Advanced	0.122***	0.117***	0.308***	0.319***		
	(0.017)	(0.015)	(0.111)	(0.123)		
Treatment * Basic			0.002	-0.004	-0.015	0.022
*Post 1978			(0.004)	(0.006)	(0.020)	(0.021)
Treatment *Advanced			0.006	0.011	0.187***	0.201***
*Post 1978			(0.008)	(0.015)	(0.051)	(0.065)
County-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,400	1,400	1,400	1,400	1,400	1,400

Notes. *Treatment* is an indicator equal to one for firms located within 50 km of a treated plant and to zero for firms located within 50 km of a comparison plant and operating in the same industry. *Advanced* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive a basic transfer (machinery and equipment only). *Log Output* is logged quantities (in tons) of steel. *Log TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using the (Gandhi et al., 2020)'s method. *Prob. Oxy* and *Prob. Cast.* are indicators for plants using the basic oxygen converters and the continuous casting furnaces. *Log Import Capital, Exports* and *Int. St.* are logged values of foreign imported capital, firm exports and quantity of steel that meet international standards. 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 with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table 7: Vertical Spillover Effects in the Steel Industry

	Log Output	Log TFPQ	Prob. Oxy.	Prob. Cast.	Log Exports	Log Int. St.
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment * Basic	0.121***	0.022	0.001	0.003		
	(0.022)	(0.026)	(0.007)	(0.006)		
Treatment * Advanced	0.142***	0.132***	0.106***	0.100***		
	(0.035)	(0.039)	(0.031)	(0.025)		
Treatment * Basic			-0.004	0.002	-0.009	-0.011
* Post 1978			(0.005)	(0.008)	(0.010)	(0.025)
Treatment *Advanced			0.003	-0.005	0.145***	0.138***
*Post 1978			(0.005)	(0.006)	(0.032)	(0.031)
County-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,100	2,100	2,100	2,100	2,100	2,100

Notes. *Treatment* is an indicator equal to one for firms located within 50 km of a treated plant and to zero for firms located within 50 km of a comparison plant and operating in an upstream or a downstream industry. *Advanced* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive a basic transfer (machinery and equipment only). *Log Output* is logged quantities (in tons) of steel. *Log TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using (Gandhi et al., 2020)'s method. *Prob. Oxy* and *Prob. Cast.* are indicators for plants using the basic oxygen converters and the continuous casting furnaces. *Log Import Capital, Exports* and *Int. St.* are logged values of foreign imported capital, firm exports, and quantity of steel that meet international standards. 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 with 200 replications (Cameron et al., 2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8: Spillover Effects, 1998–2013

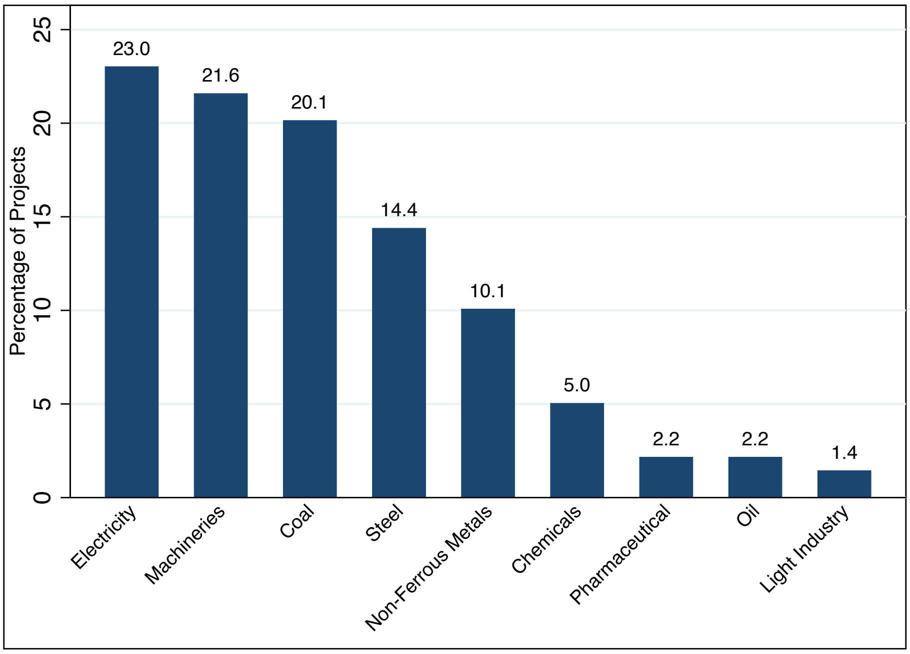
	Log Value Added		Log TFPR		Log Exports	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Related Firms						
Treatment*Basic	0.013	0.010	-0.005	-0.003	-0.012	-0.010
	(0.025)	(0.020)	(0.018)	(0.009)	(0.015)	(0.012)
Treatment*Advanced	0.011	-0.009	0.003	0.004	0.008	-0.015
	(0.020)	(0.012)	(0.008)	(0.004)	(0.007)	(0.018)
Treatment*Basic*Private	0.022	0.020	0.025	0.021	0.008	0.004
	(0.031)	(0.029)	(0.028)	(0.0283)	(0.013)	(0.003)
Treatment*Advanced	0.215***	0.206***	0.209***	0.200***	0.134***	0.124***
*Private	(0.031)	(0.044)	(0.045)	(0.041)	(0.033)	(0.028)
Treatment*Basic*Private*New	0.015	0.011	0.019	0.021	0.023	0.016
	(0.018)	(0.017)	(0.026)	(0.024)	(0.022)	(0.021)
Treatment*Advanced	0.033***	0.030***	0.031***	0.025***	0.050***	0.044***
Private*New	(0.011)	(0.009)	(0.006)	(0.005)	(0.012)	(0.010)
Model	OLS	IV	OLS	IV	OLS	IV
Sector-Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	560,123	560,123	560,123	560,123	560,123	560,123
Panel B: Not Related Firms						
Treatment*Basic	0.012	-0.004	-0.003	-0.015	-0.005	-0.004
	(0.015)	(0.011)	(0.018)	(0.016)	(0.012)	(0.009)
Treatment*Advanced	0.004	-0.003	0.004	0.003	0.003	-0.002
	(0.006)	(0.006)	(0.008)	(0.007)	(0.005)	(0.004)
Treatment*Basic*Private	0.005	-0.004	-0.004	0.008	-0.005	-0.003
	(0.005)	(0.012)	(0.007)	(0.011)	(0.008)	(0.005)
Treatment*Advanced	0.002	0.005	0.003	-0.004	0.001	0.007
*Private	(0.006)	(0.010)	(0.004)	(0.005)	(0.002)	(0.008)
Treatment*Basic*Private*New	0.002	0.005	-0.002	-0.003	0.003	0.001
Treatment*Advanced	(0.006)	(0.008)	(0.005)	(0.009)	(0.005)	(0.003)
Private*New	-0.008	-0.003	0.005	-0.006	0.006	0.003
	(0.010)	(0.004)	(0.005)	(0.009)	(0.009)	(0.038)
Model	OLS	IV	OLS	IV	OLS	IV
Sector-Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	324,762	324,762	324,762	324,762	324,762	324,762

Notes. *Treatment* is an indicator equal to one for firms located within 50 km of a treated plant and to zero for firms located within 50 km of a comparison plant. *Advanced* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive a basic transfer (machinery and equipment only). *Private* is an indicator equal to one for firms that became private between 1998 and 2013. *New* is an indicator equal to one for firms that entered the market between 1998 and 2013. *Log Value Added* and *Exports* are measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020*; Log TFPR* is logged total factor productivity revenue computed with Gandhi et al. (2020) method. Data are provided at the firm level from the China Industrial Enterprises database between 1998 and 2013. Standard errors are clustered at the firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Online Appendix — Not for Publication

Additional Figures and Tables

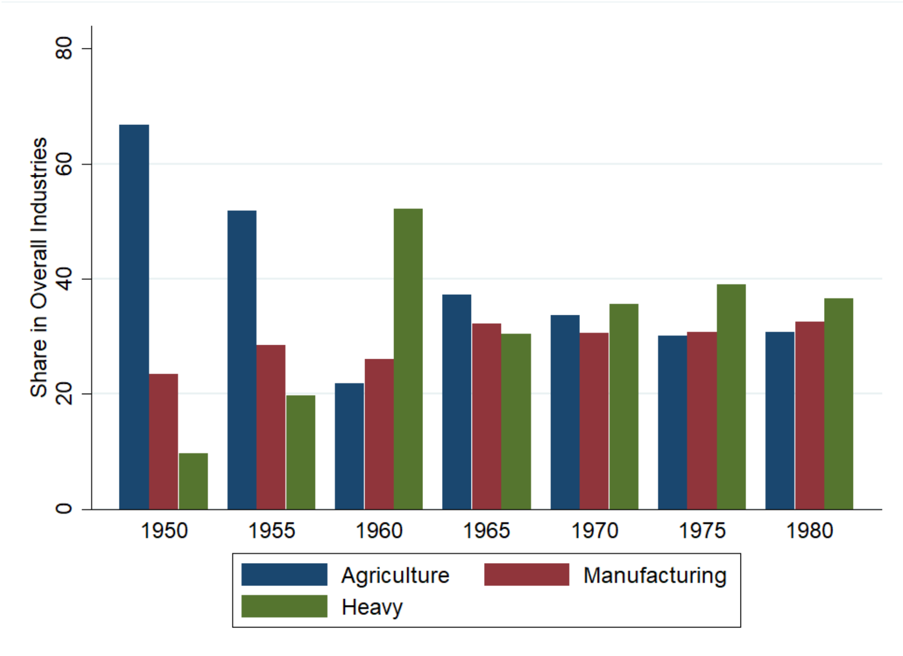
Figure A.1: The 156 Projects by Industry



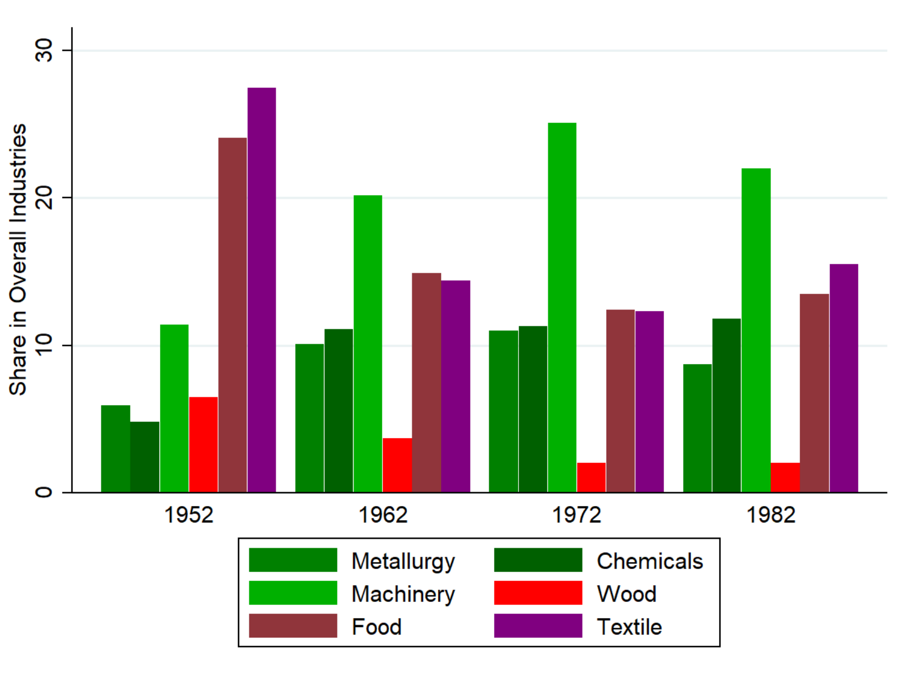
Notes. Distribution of the 139 approved technology transfer projects by industry, although 156 projects were initially contemplated. Data are provided at the project level from the National Archives Administration of China.

Figure A.2: Industry Dynamics

Panel A: By Sector



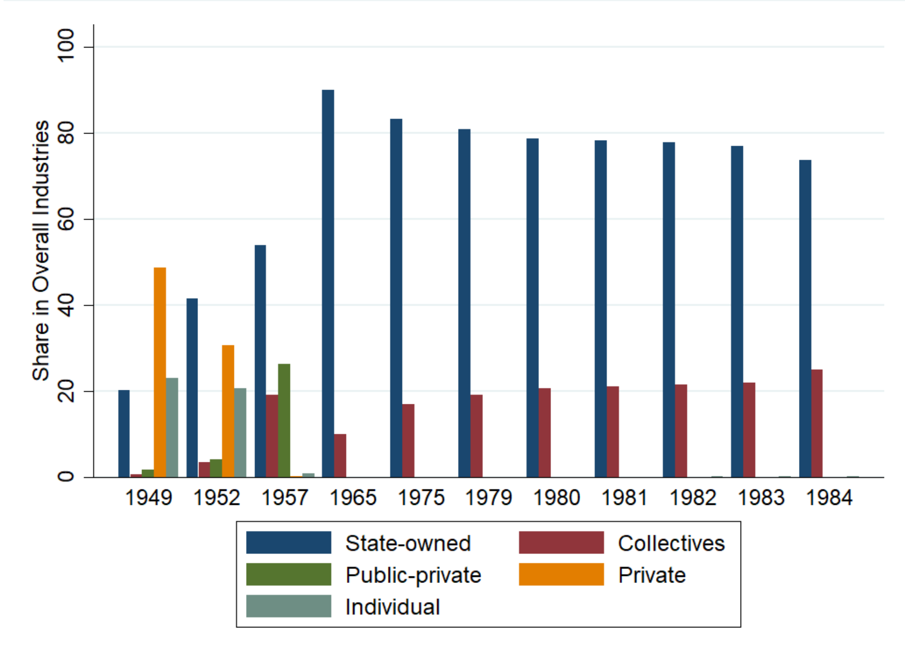
Panel B: By Industry



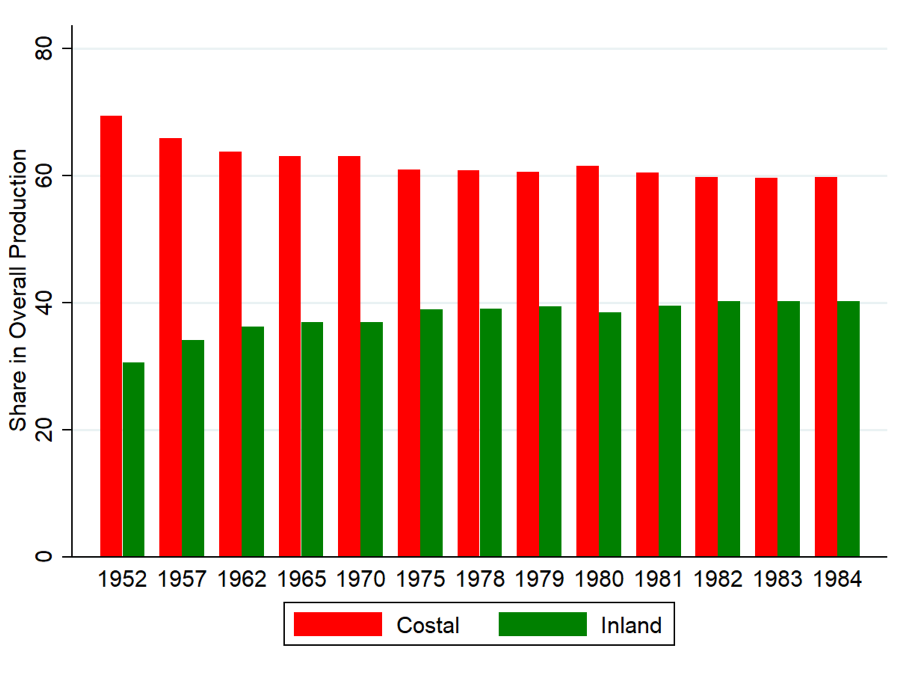
Notes. Panel A shows the percentage of firms in the agriculture, manufacturing, and heavy industries, respectively, from 1949 to 1985. Panel B shows the detailed industry distribution in heavy industries (metallurgy, chemicals, and machinery), and manufacturing-related industries (wood, textile, food). 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



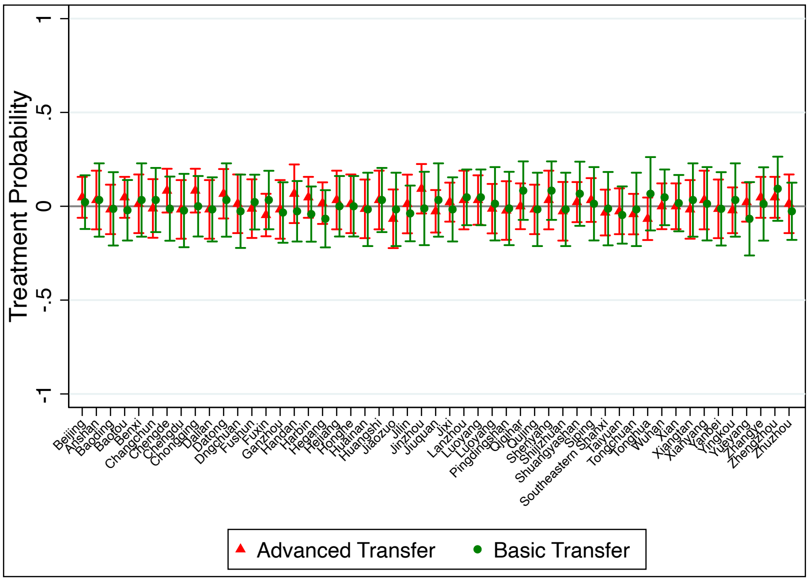
Panel B: Regional Allocation



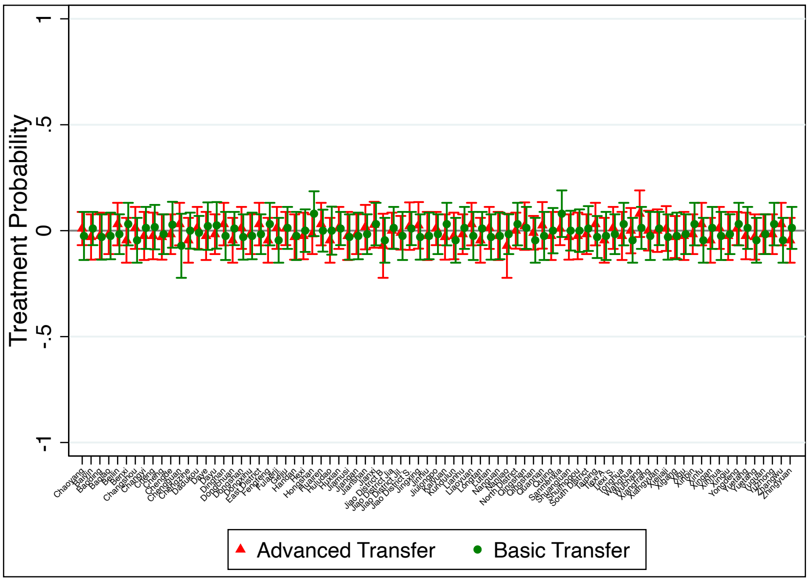
Notes. Panel A shows changes in the percentage of firms operating as state-owned, collective, public-private, private, and individual firms, respectively, from 1949 to 1985. Panel B displays the production allocation between coastal regions and inland regions. Data are provided at the province level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

Figure A.4: Probability of Receiving the Soviet Technology Transfer by Prefectures and Counties

Panel A: Prefectures

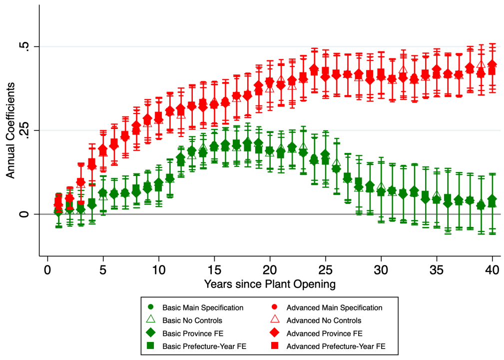


Panel B: Counties

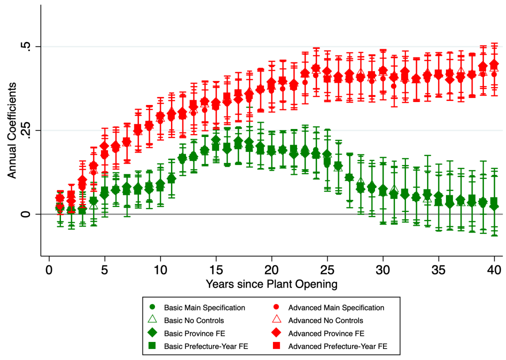


Notes. Coefficients and 95% confidence intervals from a multinomial logit estimating the probability of receiving a basic or an advanced transfer based on project prefectures (Panel A) and counties (Panel B). The baseline category is comparison projects supposed to receive a basic transfer. Data are provided at the project-level from the National Archives Administration of China.

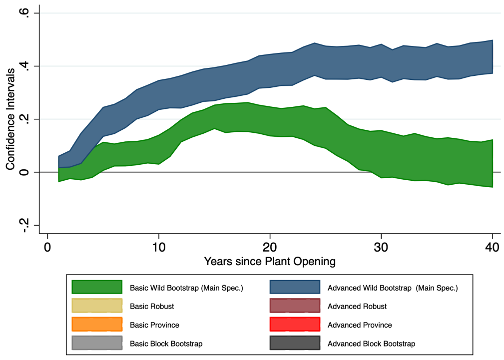
Figure A.5: Robustness Checks



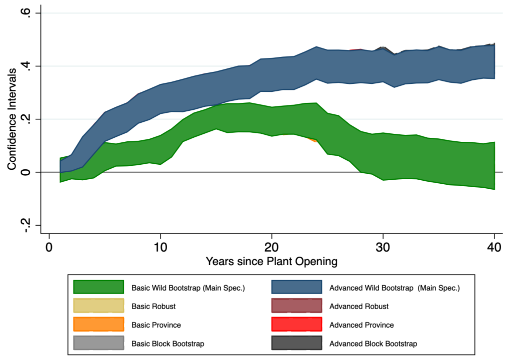
Panel A: Output, Alternative Fixed Effects



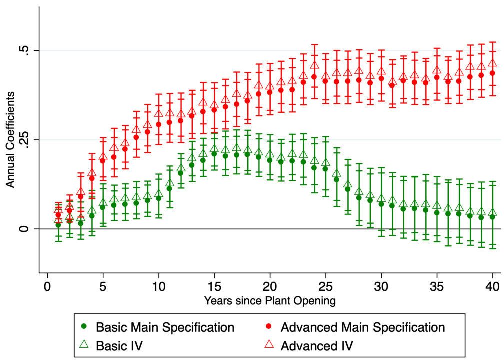
Panel B: TFPQ Alternative Fixed Effects



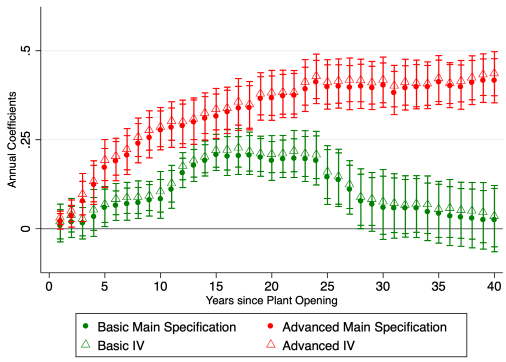
Panel C: Output, Alternative Clustering



Panel D: TFPQ, Alternative Clustering



Panel E: Output, IV



Panel F: TFPQ, IV

Notes. Annual δ_j coefficients estimated from the equation 1 for plant output and TFPQ. *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using the (Gandhi et al., 2020)'s method. Panels A and B control for alternative fixed effects. Panels C and D control for alternative clustering. Panels E and F show the results of the IV specification where the probability of receiving the Soviet training is instrumented by project delays. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. Standard errors are wild-bootstrapped at the plant level (Cameron et al., 2008).

Table A.1: Province-Level Balancing Tests

	Share Basic Treated Projects			Share Advanced Treated Projects		
	(1)	(2)	(3)	(4)	(5)	(6)
Log GRP	0.008	0.003	0.003	-0.030	-0.094	-0.094
	(0.009)	(0.004)	(0.003)	(0.137)	(0.155)	(0.146)
Log GRP Primary	0.009	0.009	0.009	0.249	0.025	0.025
	(0.010)	(0.011)	(0.015)	(0.173)	(0.184)	(0.183)
Log GRP Secondary	0.023	0.027	0.027	0.094	0.127	0.127
	(0.037)	(0.033)	(0.031)	(0.096)	(0.099)	(0.086)
Log Population	-0.009	-0.006	-0.006	-0.237	-0.145	-0.145
	(0.006)	(0.008)	(0.009)	(0.152)	(0.154)	(0.157)
Log Population Density	-0.013	-0.018	-0.022	-0.058	-0.055	-0.061
	(0.022)	(0.029)	(0.021)	(0.098)	(0.101)	(0.111)
Log Workers	-0.006	-0.009	-0.009	-0.007	-0.003	-0.003
	(0.012)	(0.011)	(0.010)	(0.056)	(0.063)	(0.064)
Log Number of Firms	-0.005	-0.006	-0.006	0.071	0.101	0.101
	(0.018)	(0.019)	(0.010)	(0.071)	(0.081)	(0.081)
Log Industrial Output	-0.009	0.009	0.009	0.005	-0.047	-0.047
	(0.013)	(0.015)	(0.012)	(0.016)	(0.014)	(0.012)
Log Total Investment	0.008	0.005	0.005	-0.060	-0.068	-0.068
	(0.008)	(0.007)	(0.005)	(0.054)	(0.060)	(0.055)
Log Capital Productivity	-0.009	-0.008	-0.008	-0.023	0.014	0.014
	(0.014)	(0.013)	(0.011)	(0.178)	(0.199)	(0.164)
Log Labor Productivity	-0.002	-0.001	-0.001	-0.032	-0.027	-0.027
	(0.003)	(0.005)	(0.002)	(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. *Share Treated Projects* is the share of treated projects out of all approved projects per province. *Average Province Delays* is the average years of delay between the expected length and the actual length of the approved technology transfer projects. *Log GRP, GRP Primary, GRP Secondary, Population, Population Density, Workers, Number of Firms, Industrial Output, Total Investment, Capital Productivity*, and *Labor Productivity* are logged real province product, real gross province product from the primary sector, real gross province product from the secondary sector, total population, total population/province square miles, number of workers, number of firms, real industrial output, capital productivity defined as real industrial output over capital, and labor productivity defined as real industrial output over workers. Data are provided at the province level from the Statistical Yearbooks between 1949 and 1951. Robust standard errors are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.2: Test for Pretrends

	Linear Pretrend	Share Basic	Pretrend * Share Basic	Share Advanced	Pretrend * Share Advanced
	(1)	(2)	(3)	(4)	(5)
Log GRP	0.066	0.051	0.015	0.021	-0.012
	(0.060)	(0.068)	(0.014)	(0.028)	(0.024)
Log GRP Primary	0.006	0.089	-0.005	0.017	-0.015
	(0.014)	(0.086)	(0.009)	(0.026)	(0.020)
Log GRP Secondary	0.023	0.015	-0.046	-0.023	0.016
	(0.055)	(0.088)	(0.272)	(0.028)	(0.022)
Log Population	0.035	-0.073	-0.009	0.031	0.011
	(0.283)	(0.070)	(0.495)	(0.042)	(0.016)
Log Population Density	0.015	-0.022	-0.020	0.033	0.021
	(0.013)	(0.029)	(0.023)	(0.045)	(0.027)
Log Workers	0.019	-0.046	-0.005	0.027	-0.011
	(0.102)	(0.084)	(0.178)	(0.034)	(0.018)
Log Number of Firms	-0.062	-0.016	0.036	0.020	-0.015
	(0.130)	(0.049)	(0.227)	(0.023)	(0.029)
Log Industrial Output	0.013	0.013	-0.011	0.013	0.019
	(0.019)	(0.019)	(0.333)	(0.015)	(0.022)
Log Total Investment	0.011	0.009	-0.005	-0.017	0.013
	(0.092)	(0.049)	(0.006)	(0.025)	(0.019)
Log Capital Productivity	-0.016	-0.010	-0.008	-0.024	0.013
	(0.066)	(0.009)	(0.008)	(0.028)	(0.016)
Log Labor Productivity	-0.042	-0.036	0.007	0.018	-0.013
	(0.121)	(0.058)	(0.012)	(0.020)	(0.018)
Observations	51	51	51	51	51

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

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

	Delays							
	Panel A: Basic Transfer				Panel B: Advanced Transfer			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Approval Year	-0.002	-0.002	-0.000	-0.002	0.015	0.013	0.013	-0.002
	(0.002)	(0.003)	(0.004)	(0.002)	(0.008)	(0.018)	(0.012)	(0.002)
Start Year	-0.001	-0.002	0.001	-0.000	-0.005	-0.008	-0.011	-0.000
	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)	(0.004)	(0.014)	(0.002)
Expected Length	-0.002	0.001	-0.002	0.001	0.002	-0.003	0.002	0.001
	(0.005)	(0.002)	(0.004)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)
Number of Workers	-0.003	0.002	-0.002	0.003	-0.004	-0.002	-0.005	0.003
	(0.006)	(0.005)	(0.002)	(0.004)	(0.005)	(0.003)	(0.006)	(0.004)
Engineers		0.001				0.003		
		(0.002)				(0.004)		
High-skilled Technicians		0.005				0.002		
		(0.008)				(0.003)		
Existing Firm	-0.001	-0.001	0.002	-0.002	0.009	0.007		-0.002
	(0.002)	(0.003)	(0.003)	(0.003)	(0.010)	(0.009)		(0.003)
Planned Investment	-0.003	-0.002	-0.004	-0.003	0.002			-0.001
	(0.008)	(0.005)	(0.005)	(0.006)	(0.003)			(0.002)
Actual Investment		-0.004				-0.008		
		(0.008)				(0.007)		
Capacity	0.000	0.002	0.001	-0.002	-0.004	-0.002	0.002	0.003
	(0.000)	(0.004)	(0.006)	(0.004)	(0.005)	(0.003)	(0.004)	(0.003)
Distance Prov. Border (km)		0.003				0.002		
		(0.004)				(0.003)		
Distance Treated Ports (km)		-0.002				-0.001		
		(0.006)				(0.001)		
Distance Highway (km)		0.003				0.003		
		(0.004)				(0.005)		
Distance Railway (km)		-0.005				-0.002		
		(0.006)				(0.003)		
Province FE	No	No	Yes	No	No	No	Yes	No
Sector FE	No	No	No	Yes	No	No	No	Yes
Observations	56	56	56	56	83	83	83	83

Notes. Panel A includes 56 projects supposed to receive a basic transfer (machinery and equipment only). Panel B includes 83 projects supposed to receive an advanced transfer (machinery, equipment and technical assistance). *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Delays* is the difference between the planned length and the actual length of each project; *Approval Year* and *Start Year* are the approval and start years of each project; *Expected Length* is expected project length in years; *Number of Workers* is the total number of plant employees; *Engineers* is the number of plant engineers; *High-Skilled Technicians* is the number of high-skilled technicians; *Planned Investment* and *Actual Investment* are measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Capacity* is measured in 10,000 tons per kilowatt; *Existing Firms* equals 1 for firms built on the site of an existing plant destroyed during the Chinese Civil War; *Distance Prov. Border, Treated Ports, Highway* and *Railway* is the distance in km between the plant and the province border, Treated Ports, highway and railway as in 1952. Data are provided at the project level from the National Archives Administration of China. Robust standard errors are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

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

	Treatment							
	Panel A: Basic Transfer				Panel B: Advanced Transfer			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Delays	-0.167***	-0.167***	-0.165***	-0.192***	-0.188***	-0.187***	-0.188***	-0.208***
	(0.017)	(0.017)	(0.018)	(0.012)	(0.055)	(0.057)	(0.055)	(0.044)
Approval Year	0.002	0.008	0.002	0.005	0.004	0.002	0.007	0.009
	(0.007)	(0.012)	(0.004)	(0.011)	(0.008)	(0.004)	(0.011)	(0.010)
Start Year	-0.006	0.001	-0.002	0.002	0.001	0.002	-0.004	-0.002
	(0.010)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.006)	(0.005)
Expected Length	-0.001	-0.011	-0.012	-0.014	0.002	0.002	0.009	0.011
	(0.004)	(0.010)	(0.014)	(0.019)	(0.004)	(0.005)	(0.012)	(0.014)
Number of Workers	0.005			0.005	-0.007	-0.008	-0.002	-0.005
	(0.011)			(0.015)	(0.011)	(0.012)	(0.005)	(0.012)
Engineers	-0.012				-0.007	-0.011		
	(0.019)				(0.009)	(0.016)		
High-skilled Technicians	-0.008				-0.001	-0.004		
	(0.010)				(0.002)	(0.003)		
Existing Firm	0.005	-0.001	0.004	0.003	0.003	0.004	-0.002	0.005
	(0.007)	(0.003)	(0.008)	(0.012)	(0.004)	(0.019)	(0.006)	(0.011)
Planned Investment	0.005	0.015	0.011	0.005	0.011	0.009	0.008	0.010
	(0.012)	(0.022)	(0.013)	(0.007)	(0.014)	(0.010)	(0.011)	(0.012)
Capacity	-0.001	-0.004	0.007	0.006	-0.002	0.003	-0.004	-0.003
	(0.015)	(0.007)	(0.008)	(0.006)	(0.004)	(0.005)	(0.005)	(0.005)
Distance Prov. Border (km)	0.005				0.005			
	(0.009)				(0.006)			
Distance Treated Ports (km)	0.014				0.099			
	(0.016)				(0.012)			
Distance Highway (km)	0.011				0.003			
	(0.025)				(0.004)			
Distance Railway (km)	-0.015				0.009			
	(0.016)				(0.015)			
Model	OLS	OLS	OLS	Probit	OLS	OLS	OLS	Probit
Province FE	No	Yes	No	No	No	Yes	No	No
Sector FE	No	No	Yes	No	No	No	Yes	No
Observations	56	56	56	56	83	83	83	83

Notes. Panel A includes 56 projects supposed to receive a basic transfer (machinery and equipment only). Panel B includes 83 projects supposed to receive an advanced transfer (machinery, equipment and technology transfer). *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Delays* is the difference between the planned length and the actual length of each project; *Expected Length* is expected project length in years; *Number of Workers* is the total number of plant employees; *Engineers* is the number of plant engineers; *High-Skilled Technicians* is the number of high-skilled technicians; *Capacity* is measured in 10,000 tons per kilowatt*; Approval Year* and *Start Year* are the approval and start years of each project; *Planned Investment* is measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. *Existing Firms* equals 1 for firms built on the site of an existing plant destroyed during the Chinese Civil War; *Distance Prov. Border, Treated Ports, Highway* and *Railway* is the distance in km between the plant and the province border, Treated Ports, highway, and railway in 1952. Data are provided at the project level from the National Archives Administration of China. Robust standard errors are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.5: Effects of the Soviet Technology Transfer on Sales and Input Expenditures

	Log Steel	Log Crude Steel	Log Pig Iron	Log Coke	Log Iron
	(1)	(2)	(3)	(4)	(5)
Treatment * Basic * Year 1	0.012	0.017	-0.018	0.004	-0.004
	(0.016)	(0.015)	(0.011)	(0.006)	(0.008)
Treatment * Basic * Year 5	0.068***	0.061***	-0.069***	0.003	-0.001
	(0.015)	(0.012)	(0.019)	(0.005)	(0.003)
Treatment * Basic * Year 10	0.093***	0.129***	-0.159***	-0.002	0.005
	(0.033)	(0.028)	(0.027)	(0.005)	(0.008)
Treatment * Basic * Year 20	0.195***	0.185***	-0.203***	-0.003	-0.004
	(0.033)	(0.041)	(0.044)	(0.004)	(0.006)
Treatment * Basic * Year 30	0.091**	0.103**	-0.077**	0.006	0.008
	(0.042)	(0.052)	(0.038)	(0.005)	(0.012)
Treatment * Basic * Year 40	0.050	0.051	-0.032	-0.002	0.005
	(0.051)	(0.054)	(0.034)	(0.003)	(0.006)
Treatment *Advanced*Year 1	0.041***	0.065***	-0.058***	-0.004	-0.003
	(0.011)	(0.013)	(0.014)	(0.006)	(0.005)
Treatment *Advanced*Year 5	0.209***	0.084***	-0.091***	-0.001	-0.002
	(0.033)	(0.025)	(0.017)	(0.002)	(0.006)
Treatment *Advanced*Year 10	0.311***	0.188***	-0.152***	0.005	-0.002
	(0.044)	(0.033)	(0.031)	(0.008)	(0.003)
Treatment *Advanced*Year 20	0.410***	0.212***	-0.198***	-0.001	0.002
	(0.040)	(0.038)	(0.039)	(0.003)	(0.002)
Treatment *Advanced*Year 30	0.435***	0.265***	-0.203***	0.004	-0.005
	(0.045)	(0.047)	(0.041)	(0.005)	(0.006)
Treatment *Advanced*Year 40	0.465***	0.303***	-0.215***	0.003	-0.007
	(0.048)	(0.045)	(0.045)	(0.008)	(0.008)
Province-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	957	957	957	957	957

Notes. *Treatment* is an indicator equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *Log Crude Steel, Pig Iron, Coke, Iron* are values of crude steel, pig iron, coke, iron, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. 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 with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

Table A.6: Government Loans, Political Connections, and Accessibility

Panel A	Log Loans	Log Transfers	Log Distance Road	Log Distance Railroad
	(1)	(2)	(3)	(4)
Treatment * Basic * Year 1	0.004	-0.009	-0.003	-0.005
	(0.006)	(0.010)	(0.006)	(0.007)
Treatment * Basic * Year 5	0.005	-0.006	-0.002	0.009
	(0.009)	(0.009)	(0.004)	(0.013)
Treatment * Basic * Year 10	-0.003	-0.008	-0.004	-0.003
	(0.004)	(0.008)	(0.006)	(0.005)
Treatment *Basic * Year 20	-0.007	0.004	-0.005	-0.003
	(0.013)	(0.006)	(0.008)	(0.007)
Treatment * Basic * Year 30	0.005	-0.009	-0.003	-0.009
	(0.008)	(0.012)	(0.008)	(0.011)
Treatment * Basic * Year 40	-0.012	0.002	-0.003	0.009
	(0.011)	(0.004)	(0.004)	(0.017)
Treatment *Advanced*Year 1	-0.008	-0.005	-0.007	-0.010
	(0.013)	(0.011)	(0.010)	(0.012)
Treatment *Advanced*Year 5	-0.009	0.008	-0.004	0.004
	(0.011)	(0.015)	(0.005)	(0.008)
Treatment *Advanced*Year 10	0.002	-0.009	-0.005	-0.005
	(0.004)	(0.013)	(0.008)	(0.010)
Treatment *Advanced*Year 20	0.003	-0.007	-0.004	-0.005
	(0.004)	(0.017)	(0.006)	(0.012)
Treatment *Advanced*Year 30	-0.012	0.002	-0.003	-0.003
	(0.015)	(0.007)	(0.005)	(0.007)
Treatment *Advanced*Year 40	-0.007	0.006	-0.009	0.004
	(0.008)	(0.015)	(0.011)	(0.006)
Province-Year FE	Yes	Yes	Yes	Yes
Steel Industry Only	Yes	Yes	No	No
All Industries	No	No	Yes	Yes
Observations	957	957	5,512	5,512

Panel B	Log Loans		Log Transfers	
	(1)	(2)	(3)	(4)
Treatment * Basic	-0.022	-0.025	-0.018	-0.016
	(0.038)	(0.043)	(0.020)	(0.018)
Treatment * Advanced	-0.017	-0.019	-0.022	-0.021
	(0.021)	(0.022)	(0.030)	(0.024)
County-Year FE	No	Yes	No	Yes
Years	1985	1998-2013	1985	1998-2013
Observations	139	1,925	139	1,925

Notes. *Treatment* is equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *Log Loans* and *Log Transfers* are, respectively, logged loans and free transfers that the government granted to treated and comparison plants and are measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020 in steel industry in Panel A and in all industries in Panel B. *Roads* and *Railroads* measure the logged distance in km from the closest roads and railroads for all treated and comparison plants. Data are provided at the plant level from the Steel Association Reports between 1949 and 2000 and at the firm level from the Second Annual Survey in 1985 and from the China Industrial Enterprises database between 1998 and 2013. 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.7: Government Loans, Political Connections, and Accessibility

	Secretaries			Mayors		
	Born City	University City	Years Education	Born City	University City	Years Education
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment * Basic * Year 1	-0.004	-0.004	-0.005	-0.007	-0.008	-0.009
	(0.006)	(0.008)	(0.005)	(0.009)	(0.009)	(0.012)
Treatment * Basic * Year 5	-0.003	-0.001	-0.006	-0.008	-0.010	-0.007
	(0.005)	(0.003)	(0.007)	(0.011)	(0.011)	(0.013)
Treatment * Basic * Year 10	-0.002	-0.005	-0.004	-0.006	-0.006	-0.006
	(0.005)	(0.008)	(0.003)	(0.007)	(0.007)	(0.009)
Treatment *Basic * Year 20	-0.003	-0.004	-0.005	-0.005	-0.008	-0.004
	(0.004)	(0.006)	(0.004)	(0.007)	(0.011)	(0.006)
Treatment * Basic * Year 30	-0.006	-0.008	-0.006	-0.009	-0.010	-0.008
	(0.005)	(0.012)	(0.005)	(0.012)	(0.010)	(0.010)
Treatment * Basic * Year 40	-0.002	-0.005	-0.010	-0.008	-0.008	-0.009
	(0.003)	(0.006)	(0.011)	(0.010)	(0.011)	(0.012)
Treatment *Advanced*Year 1	-0.004	-0.003	-0.014	-0.009	-0.009	-0.008
	(0.006)	(0.005)	(0.012)	(0.014)	(0.010)	(0.009)
Treatment *Advanced*Year 5	-0.001	-0.002	-0.010	-0.011	-0.008	-0.012
	(0.002)	(0.006)	(0.011)	(0.012)	(0.011)	(0.015)
Treatment *Advanced*Year 10	0.005	-0.002	-0.015	0.013	-0.011	-0.011
	(0.008)	(0.003)	(0.017)	(0.015)	(0.014)	(0.010)
Treatment *Advanced*Year 20	-0.001	-0.002	-0.012	-0.009	-0.009	-0.013
	(0.003)	(0.002)	(0.016)	(0.010)	(0.008)	(0.013)
Treatment *Advanced*Year 30	-0.004	-0.005	-0.011	-0.007	-0.007	-0.012
	(0.005)	(0.006)	(0.013)	(0.009)	(0.009)	(0.016)
Treatment *Advanced*Year 40	-0.003	-0.007	-0.010	-0.010	-0.011	-0.009
	(0.008)	(0.008)	(0.012)	(0.012)	(0.013)	(0.013)
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
All Industries	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,512	5,512	5,512	5,512	5,512	5,512

Notes. *Treatment* is equal to one for projects completed with the Soviet technology transfer and to zero for projects completed by China alone. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *Born City* and *University City* are indicators for secretaries of the Municipal Party Committee (columns 1–2) and mayors (columns 4–5) assigned to a prefecture city they were born in or studied in. *Years Education* is the logged number of secretaries' (column 3) and mayors' (column 6) years of education. Data are provided at the prefecture city level from the People's Daily Online database between 1949 and 2018. 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.8: County-Level Government Investments

	Log Investment			Log Other Projects	Log Infrastructure
	All	Related Industries	Unrelated Industries		
	(1)	(2)	(3)	(4)	(5)
Treatment * Basic	-0.019	-0.011	0.015	-0.014	0.021
	(0.025)	(0.044)	(0.028)	(0.015)	(0.038)
Treatment *Advanced	-0.022	0.009	-0.005	0.012	0.014
	(0.023)	(0.003)	(0.010)	(0.011)	(0.020)
County-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	2,250	2,250	2,250	2,250	2,250

Notes. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). *Log Investment* is logged government investment in all industries, in industries related to the 156 Projects and in unrelated industries. *Log Other Projects* is logged number of industrial projects financed by the Chinese government to promote industrialization after the end of the Sino-Soviet Alliance. *Log Infrastructure* is logged government investment in infrastructure. Data are provided at the province level from the Statistical Yearbooks between 1949 and 2008. 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 A.9: Correlation between Comparison Plants and Other Steel Plants

	Log Output	Log TFPQ	Log Workers
	(1)	(2)	(3)
Basic * Year 1	0.022	0.011	0.010
	(0.015)	(0.010)	(0.008)
Basic * Year 5	0.029***	0.012***	0.015***
	(0.010)	(0.004)	(0.005)
Basic * Year 10	0.033***	0.014***	0.020***
	(0.011)	(0.005)	(0.006)
Basic * Year 20	0.035***	0.015***	0.022***
	(0.007)	(0.005)	(0.007)
Basic * Year 30	0.039***	0.014***	0.023***
	(0.010)	(0.004)	(0.006)
Basic * Year 40	0.035***	0.010***	0.020***
	(0.007)	(0.003)	(0.005)
Advanced*Year 1	0.020	0.009	0.012
	(0.018)	(0.009)	(0.010)
Advanced*Year 5	0.030***	0.015***	0.014***
	(0.011)	(0.005)	(0.004)
Advanced*Year 10	0.035***	0.015***	0.018***
	(0.012)	(0.006)	(0.005)
Advanced*Year 20	0.038***	0.012***	0.024***
	(0.012)	(0.004)	(0.006)
Advanced*Year 30	0.040***	0.013***	0.025***
	(0.015)	(0.004)	(0.006)
Advanced*Year 40	0.037***	0.012***	0.022***
	(0.011)	(0.003)	(0.004)
Province-Year FE	Yes	Yes	Yes
Observations	2,342	2,342	2,342

Notes. The sample includes advanced and basic steel comparison plants and steel plants built by the Chinese government under industrial projects started after the Sino-Soviet Split. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance) that were eventually completed by China alone. *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only) that were eventually completed by China alone. *Log Output* is logged quantities (in tons) of steel. *Log TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using Gandhi et al. (2020)'s method. *Log Workers* is logged number of workers. 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 with 200 replications (Cameron et al., 2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.10: Bounding Based on Correlation Between Observables and Unobservables

	Main Results	$\delta = 0.1$	$\delta = 0.2$	$\delta = 0.4$	$\delta = 0.6$	$\delta = 0.8$	$\delta = 1$	δ for $\beta = 0$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Output								
Treatment * Basic * Year 1	0.010	0.009	0.009	0.008	0.007	0.006	0.005	
Treatment * Basic * Year 5	0.061	0.059	0.057	0.055	0.053	0.051	0.049	6.33
Treatment * Basic * Year 10	0.085	0.084	0.082	0.081	0.080	0.078	0.075	6.41
Treatment * Basic * Year 20	0.191	0.190	0.188	0.186	0.185	0.182	0.178	7.66
Treatment * Basic * Year 30	0.064	0.063	0.061	0.059	0.056	0.054	0.051	
Treatment * Basic * Year 40	0.033	0.031	0.030	0.029	0.027	0.025	0.022	
Treatment *Advanced*Year 1	0.039	0.037	0.035	0.033	0.031	0.029	0.026	10.15
Treatment *Advanced*Year 5	0.190	0.187	0.185	0.182	0.179	0.175	0.171	11.98
Treatment *Advanced*Year 10	0.291	0.290	0.288	0.285	0.282	0.280	0.277	12.44
Treatment *Advanced*Year 20	0.382	0.380	0.377	0.375	0.371	0.367	0.363	13.98
Treatment *Advanced*Year 30	0.420	0.418	0.415	0.411	0.408	0.405	0.400	15.32
Treatment *Advanced*Year 40	0.435	0.432	0.430	0.428	0.425	0.421	0.417	18.90
Panel B: TFPQ								
Treatment * Basic * Year 1	0.008	0.007	0.006	0.005	0.005	0.004	0.003	
Treatment * Basic * Year 5	0.059	0.058	0.056	0.054	0.053	0.051	0.048	6.78
Treatment * Basic * Year 10	0.083	0.081	0.080	0.078	0.075	0.073	0.070	6.90
Treatment * Basic * Year 20	0.191	0.190	0.188	0.185	0.182	0.180	0.177	8.01
Treatment * Basic * Year 30	0.059	0.057	0.055	0.053	0.050	0.048	0.045	
Treatment * Basic * Year 40	0.024	0.022	0.020	0.018	0.015	0.013	0.010	
Treatment *Advanced*Year 1	0.021	0.020	0.018	0.017	0.016	0.014	0.013	11.22
Treatment *Advanced*Year 5	0.189	0.188	0.185	0.183	0.181	0.178	0.175	12.39
Treatment *Advanced*Year 10	0.276	0.275	0.271	0.269	0.266	0.263	0.260	13.76
Treatment *Advanced*Year 20	0.367	0.365	0.362	0.360	0.358	0.355	0.350	14.51
Treatment *Advanced*Year 30	0.403	0.401	0.398	0.396	0.394	0.391	0.388	15.91
Treatment *Advanced*Year 40	0.416	0.415	0.412	0.410	0.408	0.404	0.399	18.61

Notes. The table shows how different hypotheses on the degree of correlation between observables and unobservables affect the main coefficients. The notation follows Oster (2019). The coefficient δ is the relative degree of selection on observed and unobserved variables. R_{max} is the hypothetical R squared in a regression that includes both observables and unobservables. $\tilde{R}$ is the R squared in the regression that includes only observables (Figure 3). Oster (2019) finds that $R_{max} = 1.3$ and $\delta = 1$ are appropriate bounds to calculate bias-adjusted treatment effects. *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\tilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using the (Gandhi et al., 2020)'s method. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only).

Table A.11: Bounding Based on Correlation Between Observables and Unobservables

Panel A: Output	Main Results	$\delta = 1$					
		$R_{max} = 1.10\tilde{R}$	$R_{max} = 1.20\tilde{R}$	$R_{max} = 1.30\tilde{R}$	$R_{max} = 1.40\tilde{R}$	$R_{max} = 1.50\tilde{R}$	$R_{max} = 2\tilde{R}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment * Basic * Year 1	0.010	0.003	0.004	0.005	0.006	0.006	0.007
Treatment * Basic * Year 5	0.061	0.047	0.048	0.049	0.051	0.053	0.055
Treatment * Basic * Year 10	0.085	0.071	0.072	0.075	0.077	0.078	0.080
Treatment * Basic * Year 20	0.191	0.173	0.175	0.178	0.179	0.181	0.183
Treatment * Basic * Year 30	0.064	0.047	0.049	0.051	0.055	0.058	0.061
Treatment * Basic * Year 40	0.033	0.018	0.021	0.022	0.023	0.026	0.029
Treatment *Advanced*Year 1	0.039	0.020	0.022	0.026	0.029	0.030	0.031
Treatment *Advanced*Year 5	0.190	0.167	0.169	0.171	0.162	0.165	0.169
Treatment *Advanced*Year 10	0.291	0.270	0.273	0.277	0.280	0.282	0.285
Treatment *Advanced*Year 20	0.382	0.358	0.361	0.363	0.365	0.369	0.373
Treatment *Advanced*Year 30	0.420	0.396	0.399	0.400	0.403	0.406	0.412
Treatment *Advanced*Year 40	0.435	0.413	0.415	0.417	0.420	0.422	0.428
Panel B: TFPQ							
Treatment * Basic * Year 1	0.008	0.002	0.002	0.003	0.005	0.006	0.007
Treatment * Basic * Year 5	0.059	0.042	0.046	0.048	0.052	0.055	0.058
Treatment * Basic * Year 10	0.083	0.066	0.069	0.070	0.073	0.076	0.079
Treatment * Basic * Year 20	0.191	0.173	0.176	0.177	0.181	0.185	0.187
Treatment * Basic * Year 30	0.059	0.041	0.044	0.045	0.048	0.052	0.055
Treatment * Basic * Year 40	0.024	0.008	0.008	0.010	0.012	0.015	0.019
Treatment *Advanced*Year 1	0.021	0.010	0.011	0.013	0.015	0.017	0.020
Treatment *Advanced*Year 5	0.189	0.170	0.172	0.175	0.179	0.182	0.186
Treatment *Advanced*Year 10	0.276	0.255	0.258	0.260	0.263	0.267	0.269
Treatment *Advanced*Year 20	0.367	0.340	0.345	0.350	0.354	0.358	0.361
Treatment *Advanced*Year 30	0.403	0.383	0.395	0.388	0.391	0.394	0.396
Treatment *Advanced*Year 40	0.416	0.394	0.398	0.399	0.403	0.406	0.410

Notes. The table shows how different hypotheses on R_{max} affect the main coefficients. The notation follows Oster (2019). The coefficient δ is the relative degree of selection on observed and unobserved variables. R_{max} is the hypothetical R squared in a regression that includes both observables and unobservables. $\tilde{R}$ is the R squared in the regression that includes only observables (Figure 3). Oster (2019) finds that $R_{max} = 1.3$ and $\delta = 1$ are appropriate bounds to calculate bias-adjusted treatment effects. *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using the (Gandhi et al., 2020)'s method. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only).

Table A.12: Entry of New Firms Spatially Close to Treated and Comparison Plants

	All Firms (1–2)		Related Sectors (3–4)		Unrelated Sectors (5–6)	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All Firms						
Treatment * Basic	0.195***	-0.007	0.193***	-0.006	0.018	-0.004
	(0.043)	(0.046)	(0.044)	(0.047)	(0.013)	(0.020)
Treatment * Advanced	0.185***	-0.003	0.178***	-0.002	0.012	-0.001
	(0.015)	(0.042)	(0.012)	(0.042)	(0.012)	(0.019)
Sector-County FE	Yes	Yes	Yes	Yes	Yes	Yes
Distance (km)	0–50	50–100	0–50	50–100	0–50	50–100
Observations	139	139	139	139	139	139
Panel B: Steel Industry						
Treatment * Basic	0.183***	-0.025	0.175***	-0.020	0.025	0.055
	(0.029)	(0.105)	(0.137)	(0.105)	(0.044)	(0.064)
Treatment * Advanced	0.179***	-0.033	0.171***	-0.013	0.011	0.008
	(0.007)	(0.106)	(0.011)	(0.019)	(0.045)	(0.015)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Distance (km)	0–50	50–100	0–50	50–100	0–50	50–100
Observations	20	20	20	20	20	20

Notes. *Number of New Firms* is the logged number of new firms that located within 10 km, between 10 and 25 km, between 25 and 50 km, and between 50 and 100 km of treated and comparison plants between 1952 and 1985. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). In Panel A, *distance* is the distance in kilometers between new firms and any treated and comparison plants; in Panel B, *distance* is the distance in kilometers between new firms and any treated and comparison plants in the 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. Data are provided at the firm level from the Second Industrial Survey of 1985. Standard errors are wild-bootstrapped at the county level with 200 replications. ***p<0.01, **p<0.05, *p<0.1.

Table A.13: Spillover Effects in 1985

	Horizontal Spillovers		Vertical Spillovers	
	Log Value Added	Log TFPR	Log Value Added	Log TFPR
	(1)	(2)	(3)	(4)
Treatment * Basic	0.026	0.029	0.124***	0.012
	(0.051)	(0.025)	(0.023)	(0.022)
Treatment * Advanced	0.116***	0.109***	0.140***	0.131***
	(0.030)	(0.029)	(0.028)	(0.015)
Model	OLS	OLS	OLS	OLS
County FE	Yes	Yes	Yes	Yes
Observations	2,250	2,250	2,100	2,100

Notes. *Treatment* is an indicator equal to one for firms located within 50 km of a treated plant and to zero for firms located within 50 km of a comparison plant, operating in the same industry (columns 1–2) or operating in an upstream or a downstream industry (columns 3–4). *Advanced* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms within 50 km of a treated or a comparison plant supposed to receive a basic transfer (machinery and equipment only). *Log Value Added* is measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Log TFPR* is logged total factor productivity revenue computed with the Gandhi et al. (2020)'s method. Data are provided at the firm level from the Second Annual Survey in 1985. Standard errors are clustered at the firm level. ***p<0.01, **p<0.05, *p<0.1.

Table A.14: Channels of Persistence of the Soviet Technology Transfer

Panel A: Competition

	Log Number of Firms			Fraction Privately Owned Firms		
	All	Related	Unrelated	All	Related	Unrelated
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment * Basic	0.243***	0.242***	0.006	0.015	0.012	0.018
	(0.038)	(0.035)	(0.011)	(0.021)	(0.027)	(0.009)
Treatment * Advanced	0.251***	0.240***	-0.007	0.166***	0.161***	-0.003
	(0.034)	(0.022)	(0.012)	(0.020)	(0.015)	(0.005)
County-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 * Basic	0.015	0.010	0.009	0.007	0.003	-0.005
	(0.021)	(0.017)	(0.014)	(0.011)	(0.004)	(0.006)
Treatment * Advanced	0.198***	0.238***	0.155***	0.072***	0.113***	-0.005
	(0.030)	(0.037)	(0.044)	(0.015)	(0.032)	(0.006)
County-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,250	2,250	2,250	2,250	2,250	2,250

Notes. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located; *Advanced* is an indicator equal to one for counties with treated or comparison projects supposed to receive an advanced transfer; *Basic* is an indicator equal to one for counties with treated or comparison projects supposed to receive a basic transfer. *Log Number of Firms* is the logged number of firms per county; *Fraction Privately Owned Firms* is the per county fraction of firms that became private after 2005; *College Graduates* and *High-Skilled Workers* are the logged number of college graduates and senior technicians per county; *Log Government Investments* is measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Related Industries* includes firms in the same, upstream, or downstream industry of treated and comparison plants; *Unrelated Industries* includes firms not in the same, upstream, or downstream industry of treated and comparison plants. Data are provided at the county level from the Statistical Yearbooks from 2005 to 2013. 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 A.15: 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. *Share Treated Projects* is the share of treated projects out of all approved projects per province. *Average Project Delays* is the average delay in years between the expected length and the actual length of the approved 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. Data are provided at the province level from the Statistical Yearbooks in 1949. Robust standard errors in are parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table A.16: Aggregate Effects of the Soviet Technology Transfer

Panel A: Province-Level Outcomes

	Log Ind. Output	Log Ind. Employment	Log GDP Capita
	(1)	(2)	(3)
Share Projects * Post 1952	1.213***	0.445***	1.603***
	(0.426)	(0.157)	(0.107)
Observations	963	963	963
Province FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Panel B: Cross-Sectional Multiplier

	ΔGDP capita					
	Medium Term (1953–1978)			Long Term (1953-–2008)		
	(1)	(2)	(3)	(4)	(5)	(6)
Treated Projects per 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. *Share Projects* is the share of projects completed by the Soviet Union out of all projects approved under the Sino-Soviet Alliance. *Post 1952* is an indicator equal to one for years after 1952. *Log Ind. Output, Ind. Employment, GDP Capita,* are the province-level logged industrial output, industrial employment, and GDP per capita. *Treated Projects per 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 $t \in [1953, 2008]$. Data are provided at the province level from the Statistical Yearbooks between 1949 and 2008. Standard errors are wild-bootstrapped at the province level with 200 replications (Cameron et al., 2008). ***p<0.01, **p<0.05, *p<0.1.

B Data Collection and Dataset Construction

In this Appendix, we provide a detailed description of our primary data sources and how we constructed the dataset, as well as a list of all the variables we use 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 variables' construction.

B.1 Description of Primary Sources

Our data collection targeted the 156 Projects approved under the Sino-Soviet Alliance between 1950 and 1957. To retrieve the list of such projects, we relied on the official signed agreements between the 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 the plant built, industry, size and capacity, whether the project involved a complete or a partial technology transfer, and whether it was completed with 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 the PRC's economic development between 1949 and 1957, including detailed summaries of the 156 Projects. A comparison of these summaries with the official agreements reveals that the former contain no additional projects or project information beyond that found in the latter. We also compared our digitized list of projects against two historical studies in Chinese on the Sino-Soviet technology transfer program that independently collected the 156 technology transfer projects from the National Archives Administration of China as well (Zhang et al., 2003; Dong and Wu, 2004). Specifically, we checked for any differences or additional information on project name, start and completion years, and location, as well as project industry, size, and capacity, and whether the project involved a complete or a partial technology transfer. Neither (Zhang et al., 2003) nor (Dong and Wu, 2004) provide any additional or different project information, for any of the projects, beyond that contained in our data.We then constructed a panel dataset of plant performance and county/province outcomes, gathering data from four different sources.

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

Second Industrial Survey (1985). In the early 1980s, the Chinese government began implementing several reforms on market liberalization. Until then, stretching back to the RPC's founding in 1949, there had been a lack of systematic data on firm and industry structure. This survey, conducted by Statistics China in 1985, 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 constituted a guide for subsequent policies and reforms. As such, the survey covered more than 40 industries within the secondary sector. It is considered the most comprehensive dataset on industrial enterprises from the founding of the PRC through to the early 1990s.[1] The firm-level-data portion of the survey, though still confidential today, has been declassified for this project; it 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, which 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 (which is stored internally at Statistics China, in Beijing).

China Industrial Enterprises Database (1998–2013). This database, compiled by Statistics China yearly between 1998 and 2013 to compute GDP, covers more than 1 million publicly listed and private industrial enterprises whose asset value exceeded 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, as well as their accounting and financial information. Statistics China implemented strict double-checking standards 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 statistical yearbooks compiled by Statistics China between 1949 and 2000. This dataset contains province-level information on GDP,

[1] The First Industrial Survey was conducted in 1950, right after the PRC was founded. Its goal was estimating the "lay of the land" regarding the national industrial and mining enterprises, a basis for the recovery from the Civil War and subsequent development. However, this survey contains no firm-level data, and it predates the construction of treated and comparison plants. For this reason, we cannot employ it 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 for inclusion in the survey itself. We computed that the surveyed companies comprised only 1.74% of total Chinese firms but produced 62.46% of the industrial output in 1985.

population, capital, investment, and number of workers.

Data Validation. A potential concern with this data is that either the local governments or the firms may have misreported their production information to the central government to show better-than-actual performance. We therefore cross-checked our data against different sources, as follows.

First, we turned to Clark (1973) and Zhang et al. (2003), who independently studied the Chinese steel industry, by collecting data on steel plants with a capacity of at least 100,000 tons, respectively between 1949 and 1972 and 1972 and 2000. Specifically, for each plant, they estimated the minimum and the maximum yearly steel production based on the capital in use, concluding that the data from the Steel Association annual reports, our main source, appear credible. We repeat our main analysis using Clark (1973) and Zhang et al. (2003)'s data and find that our estimated coefficients using the annual reports are between the coefficients obtained using their minimum and maximum estimates (Figure B.1, Panels A and B). Even assuming that treated plants produced at the minimum and comparison plants at the maximum level estimated by Clark (1973) and Zhang et al. (2003), we would still find a persistent effect of the advanced transfer and a short-lived effect of the basic transfer, in line with our main results.

Second, for the Ansteel Company in Anshan, we were able to collect the plant's own production data, which it stored in its historical records (Ji, 2019). These data were intended for internal use and were not shared with the central government. When we compared this data with the data from the Steel Association Reports, we found that they are remarkably similar, with a correlation of 0.981.

Third, we summarized the industrial output of firms in the Second Industrial Survey by counties and prefectures, comparing this data with the county-level and prefecture-level industrial output data reported in the survey. The two sets of data are also remarkably similar, with a correlation of 0.989.

Fourth, we summarized the industrial output of firms in the Second Industrial Survey by provinces, comparing it with total province-level industrial output from the Statistical Yearbook of China in 1985. The two sets of data are comparable, with a correlation of 0.974.

Fifth, we validated the province-level industrial output from the Statistical Yearbook of China with province-level data on industrial production collected by Statistics China only for the years 1952, 1957, 1965, 1970, 1978, and 1984. The two sets of data are fully consistent, with a correlation of 0.986.

Finally, it is worth noting that, after the Sino-Soviet split, the Chinese government wanted to tie up loose ends with the Soviet Union as quickly as possible. As such, data manipulation should have aimed at lowering the performance of Soviet-treated plants, which would go against us finding a positive effect of the Soviet transfer.

Data Digitization. Between August 2019 and November 2020, we employed 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 ensure that all the data were correctly digitized. Bo Li also personally checked the accuracy of 70% of the data entries.

B.2 Matching Across Different Data Sources

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

B.3 Geolocalization of Treated and Comparison Plants

The Second Industrial Survey records each firm's address in 1984. To geolocalize the firms, we searched the 1984 address of each firm on Gaode Map, an online GPS browser that provides a 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 3,426 of the 7,592 firms covered by the Second Industrial Survey (45%), their 1984 addresses cannot be found, because 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 changed 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 searched firms by their name in Tianyancha, a comprehensive database on all registered Chinese firms, which provides the firms' current address. We obtained all firms' addresses and used Gaode Map's geocoding API to transfer the addresses to geographic locations, based on latitudes and longitudes.

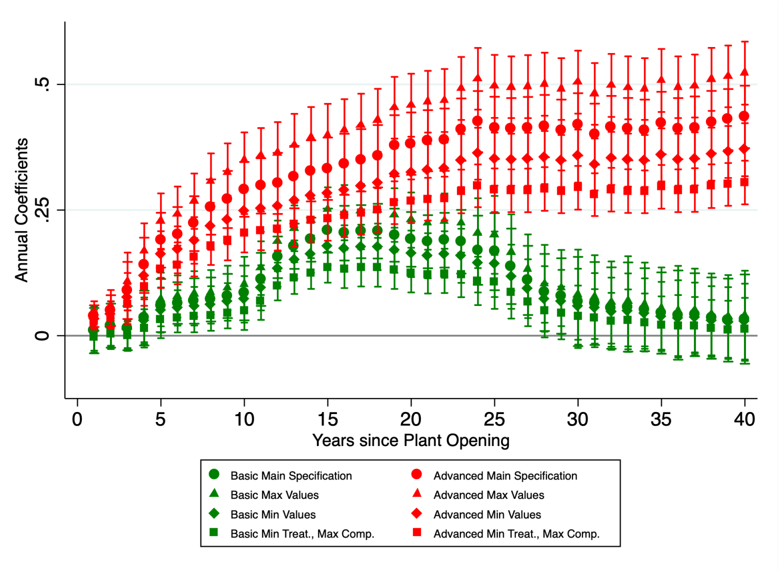
[3] From 1990 to 2013, Chinese prefecture cities were subject to some jurisdictional changes. However, because we retrieve firm latitude and longitude, these changes do not affect firm geolocalization.

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

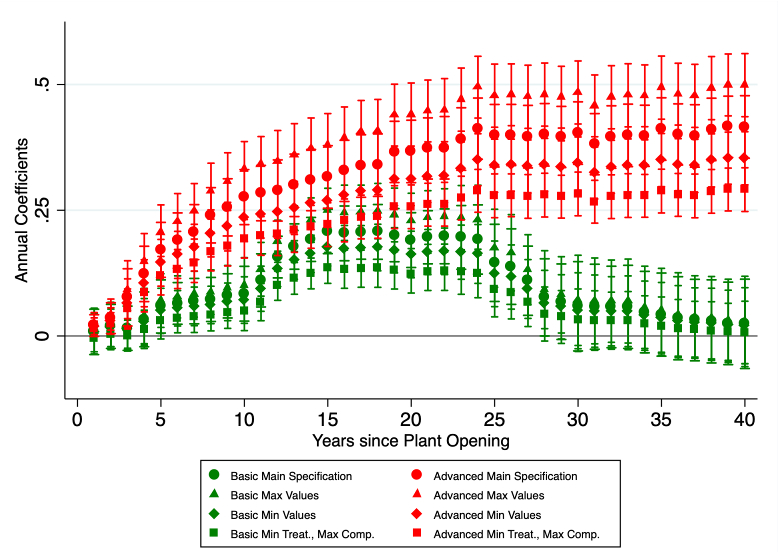
We constructed a list of firms economically related to treated and comparison plants as follows. We retrieved each firm's two-digit industry code from the Steel Association Reports or the Second Industrial Survey, from which we observe the firm products. If firms had the same two-digit industry code 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 or downstream, relative to the products of the treated and comparison plants. If products were neither upstream nor downstream, we consider firms not economically related to treated and comparison plants. After the National Bureau of Statistics of China (NBS) began compiling its Input-Output Tables in 1987, every five years (in the years ending with 2 and 7) it conducts the national input-output survey and compiles the benchmark input-output tables of the corresponding year. We therefore used the 1987 Input-Output Tables (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).

Figure B.1: Effects of the Soviet Technology Transfer on Steel Plants Using Data from Clark (1973) and Zhang et al. (2006)

Panel A: Output



Panel B: TFPQ



Notes. Data are provided at the plant level from Clark (1973) and (Zhang et al., 2003), using the minimum, production estimates, the maximum production estimates, and the minimum production estimates for treated plants and the maximum production estimates for comparison plants. *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using the method devised by (Gandhi et al., 2020). *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). 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 B.1: List of Variables, With Their Definitions and Sources

Variable	Definition	Level, Source and Years of Coverage
Log Steel	Logged tons of steel produced	Plant-year, Steel Association, 1949–2000
Log 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
Log Value Added	Difference between firm gross income and intermediate inputs	Firm-year, Second Industrial Survey, 1985; China Industrial Enterprises, 1998–2013
Log Fixed Assets	Logged value of land, buildings, and machines owned by the firm	Plant-year, Steel Association, 1949–2000
		Firm-year, Second Industrial Survey, 1985; China Industrial Enterprises, 1998–2013
Log Capital Stock	Calculated from gross fixed assets using the Perpetual Inventory Method (PIM),	Plant-year, Steel Association, 1949–2000
	see table notes.	Firm-year, Second Industrial Survey, 1985; China Industrial Enterprises, 1998–2013
Log TFPR	Total Factor Productivity Revenue; for estimation see Appendix C.	Firm-year, Second Industrial Survey, 1985; China Industrial Enterprises, 1998–2013
Log Revenues	Operating revenues	Firm-year, Second Industrial Survey, 1985; China Industrial Enterprises, 1998–2013
Log Costs	Logged 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

Notes. 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.

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 stock, L_{it} is total employment, M_{it} is materials, and A_{it} is the Hicksian-neutral productivity. These variables are defined in Table B.1. 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 lowercase letters refer to natural logarithms and β_0 measures the mean efficiency level across plants and over time.

We estimate equation C.2 using the methodology proposed by Gandhi et al. (2020) (GNR), who developed a nonparametric identification and estimation of gross-output production functions that employ a "proxy variable" in a similar vein as prior work by Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003) (LP).

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 and of materials used (coke and iron), via the formula log TFPQ=logTFPR-log $\widetilde{p}$, where $\widetilde{p}$ is the value added share weighted average of the prices of plant products, and TFPR (total factor productivity revenue) is calculated using the GNR method. For plants in all the industries, we estimate TFPR, where output is proxied by firm revenues, with the GNR method. All the nominal variables are deflated using the year-industry-specific deflator provided by Statistics China, with 1980 as the base year. A potential problem with 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: China was a planned economy, meaning that the output and input prices were set yearly by the government and were the same for all firms in the same industry. As a result, our estimates suffer no bias due to plant-specific variation in output or input prices.

Appendix Table C.1 reports the coefficients on labor, capital, and materials estimated with the GNR method. For robustness, we also report the labor, capital, and materials coefficients estimated with the OP and LP methodologies, OLS, and the factor shares (Solow's residuals). All the coefficients are remarkably similar to the OLS ones, indicating that the correlation between factor elasticities and productivity shocks is negligible and that firms, probably given their large size, were not very responsive to productivity shocks.

Because the country had a planned economy until at least the 1980s, two potential concerns arise in estimating TFP of Chinese firms. First, the average Chinese firm had limited decision-making power on inputs and output markets. However, as Hirata (2018) and Ji (2019) noted, treated and comparison plants, given their large size, were given substantial freedom in terms of inputs, labor choices, and output production decisions.[4] Because firms were price-takers—in the sense that they could not affect output and input market prices with their production decisions as prices were set yearly by the government—and managers were rewarded based on profits, we can assume that these firms were choosing inputs and quantities to maximize profits and apply the proposed TFP estimation methodology. Second, Chinese prices did not necessarily reflect a market equilibrium, so a potential "quality bias" may arise if treated plants had used the same quantity of better-quality inputs than comparison plants. We solve this issue, testing for the possibility of a quality bias, as follows. First, we aggregated output and inputs using their average annual prices as reported by the American Iron and Steel Institute, computing TFPR and TFPQ with these values. Second, following de Roux et al. (2020), who show that the transmission bias and the quality bias offset when the production function is estimated with naive OLS, we use TFPR and then TFPQ with the OLS-estimated factor shares. The results are nearly identical to those that use our baseline TFP estimation (Figure C.1), thus corroborating the similarities between the OLS and the GNR factor shares estimation.

[4] The situation was radically different in small firms and agricultural communities, where the government strictly controlled inputs and outputs.

Table C.1: Estimation of the Production Function

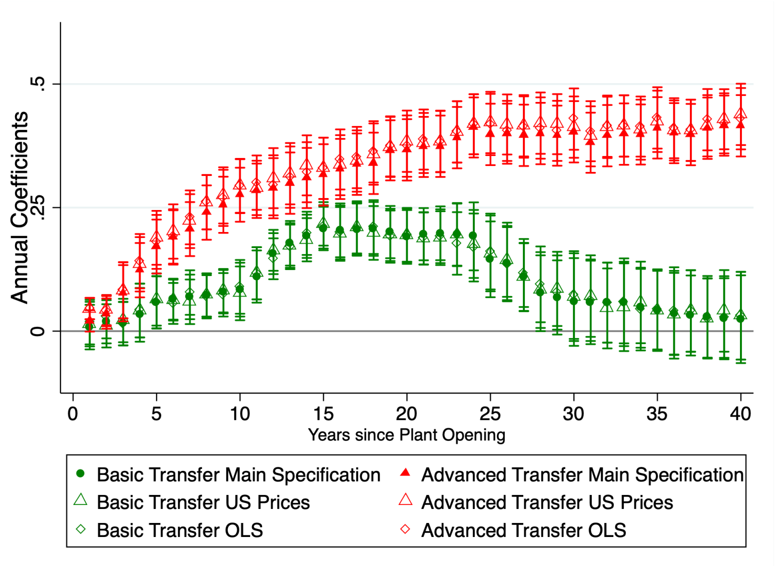
	I. Steel			II. Electricity			III.Machinery			IV. Coal		
	β_l	β_k	β_m	β_l	β_k	β_m	β_l	β_k	β_m	β_l	β_k	β_m
GNR	0.25***	0.24***	0.52***	0.21***	0.26***	0.51***	0.22***	0.19***	0.60***	0.22***	0.28***	0.51***
	(0.02)	(0.03)	(0.05)	(0.01)	(0.03)	(0.06)	(0.02)	(0.01)	(0.04)	(0.03)	(0.03)	(0.06)
LP	0.33***	0.22***	0.50***	0.21***	0.26***	0.52***	0.21***	0.18***	0.60***	0.22***	0.24***	0.51***
	(0.04)	(0.02)	(0.03)	(0.02)	(0.01)	(0.05)	(0.01)	(0.02)	(0.03)	(0.02)	(0.01)	(0.04)
OP	0.31***	0.20***	0.50***	0.20***	0.28***	0.53***	0.21***	0.19***	0.57***	0.22***	0.25***	0.50***
	(0.03)	(0.01)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.03)
OLS	0.21***	0.22***	0.52***	0.19***	0.30***	0.52***	0.22***	0.19***	0.59***	0.20***	0.25***	0.52***
	(0.01)	(0.02)	(0.05)	(0.03)	(0.02)	(0.06)	(0.02)	(0.01)	(0.05)	(0.02)	(0.03)	(0.06)
Factor Shares	0.24	0.26	0.50	0.20	0.26	0.51	0.20	0.22	0.60	0.21	0.26	0.51

	V. Nonferrous Metals			VI. Chemicals and Pharma			VII. Oil			VIII. Light Industry		
	β_l	β_k	β_m	β_l	β_k	β_m	β_l	β_k	β_m	β_l	β_k	β_m
GNR	0.31***	0.20***	0.52***	0.21***	0.19***	0.61***	0.21***	0.20***	0.63***	0.20***	0.21***	0.52***
	(0.02)	(0.04)	(0.03)	(0.01)	(0.02)	(0.04)	(0.01)	(0.02)	(0.05)	(0.03)	(0.04)	(0.05)
LP	0.32***	0.22***	0.50***	0.19***	0.20***	0.59***	0.20***	0.21***	0.59***	0.20***	0.20***	0.51***
	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.05)	(0.02)	(0.02)	(0.05)
OP	0.32***	0.21***	0.51***	0.22***	0.20***	0.60***	0.21***	0.25***	0.62***	0.19***	0.17***	0.52***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.01)	(0.06)	(0.03)	(0.02)	(0.06)	(0.03)	(0.02)	(0.04)
OLS	0.35***	0.20***	0.50***	0.20***	0.19***	0.61***	0.22***	0.21***	0.62***	0.20***	0.20***	0.52***
	(0.02)	(0.01)	(0.06)	(0.03)	(0.02)	(0.04)	(0.04)	(0.02)	(0.04)	(0.02)	(0.01)	(0.06)
Factor Shares	0.31	0.22	0.52	0.19	0.22	0.58	0.20	0.21	0.683	0.20	0.21	0.51

Notes. Coefficients on labor (β_l), capital (β_k), and intermediate goods (β_m) estimated with the methodology proposed by Gandhi et al. (2020) (GNR), Petrin et al. (2004) (LP), or Olley and Pakes (1996) (OP), OLS regressions, and factor shares by industry. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure C.1: TFP Robustness Checks

Panel A: All Projects



Notes. *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue share weighted average of the prices of plant products and TFPR is calculated using (Gandhi et al., 2020)'s method. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms supposed to receive a basic transfer (machinery and equipment only). Data are provided at the plant level from the 1949–2000 annual Steel Association Reports. Standard errors are wild-bootstrapped at the plant level with 200 replications (Cameron et al., 2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

D Small-Sample Tests

A potential challenge when estimating equation 1 in the steel industry is 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). In this section, we briefly describe these procedures and the required assumptions, and we show that our main analysis is robust to these tests. We also show that different levels of standard-error clustering do not affect 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 our 10 treatment plants. Once the 184,756 possible treatment assignments are computed,[5] the 0.5% and 99.5% 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%. Appendix Table D.1 columns 2 and 7 show the p-values of the permutation tests, which confirm in all cases the significance levels we observe in Figure 3.

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 other words, under the null hypothesis and conditional on 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 cases where the sample size is small. However, it is based on the assumption that changing the ordering of a sequence of random variables does not affect their joint distribution, which seems reasonable in our historical context.

[5] $184,756 = \frac{20!}{10!10!}$.

The randomization-inference-based test for the IV case is a generalization of the OLS case. Andrews and Marmer (2008) show 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.[6] Appendix Table D.1 columns 3 and 8 show the p-values of the permutation tests, which confirm in all cases the significance levels we observe in Figure 3.

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 each of the 20 steel plants over a 50-year span. We therefore employ the Ibragimov and Muller (2010) procedure, which 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 basic and advanced treated plants with the 10 coefficients estimated on the basic and advanced comparison plants, using a t-test for group mean equality.

The procedure requires that the coefficient estimates from each plant 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 the central-limit theorem.[7] 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 Table D.1, columns 4, 5, 9, and 10 show the p-values of the permutation tests, which confirm in all cases the significance levels we observe in Figure 3.

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

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

D.3 Different Levels of Standard-Error Clustering

Clustering standard errors at the plant level in equation 1 for the steel industry may create a "small number of clusters" problem: we have only 20 plants, while Monte Carlo simulations suggest having at least 42 clusters (Cameron et al., 2008; MacKinnon and Webb, 2018). However, the number of observations per cluster is "large"—we observe all 20 plants for 50 years each. We can therefore wild-bootstrap the standard errors—Cameron et al. (2008) show that this procedure works even in setting with as few as five clusters. Since, more recently, (Canay et al., 2021) have shown that the wild-bootstrap procedure has limited rejection probability if the number of clusters is "small" but the number of observations per cluster is "large," we test whether our results are robust to different clustering level in Figure A.5.

First, 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. 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, with the caveat that, as Bertrand et al. (2004) explain, this procedure does not perform well as the number of clusters declines (20 and fewer clusters; p. 269). Our significance levels are unchanged if we block-bootstrap the standard errors. Finally, we wild-cluster at the province level rather than at the firm level, obtaining comparable confidence intervals.

Overall, these results suggest that the preferred wild-bootstrap procedure is robust to other clustering methods or different levels of aggregation, as the significance level of our estimates never changes.

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

	Output					TFPQ				
	Main Spec.	Permutation		IM		Main Spec.	Permutation		IM	
		OLS	IV	OLS	IV		OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treatment * Basic * Year 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment * Basic * Year 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment * Basic * Year 10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment * Basic * Year 20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment * Basic * Year 30	0.047	0.045	0.048	0.049	0.043	0.031	0.033	0.035	0.036	0.038
Treatment * Basic * Year 40	0.234	0.241	0.253	0.261	0.291	0.344	0.371	0.302	0.374	0.325
Treatment *Advanced*Year 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment *Advanced*Year 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment *Advanced*Year 10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment *Advanced*Year 20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment *Advanced*Year 30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treatment *Advanced*Year 40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes. This table reports the p-values of the permutation tests and the Ibragimov-Mueller (IM) procedures for OLS and IV estimation of β coefficient in equation 1. *Output* is logged quantities (in tons) of steel. *TFPQ* is logged productivity, computed as $\log TFPQ = \log TFPR - \tilde{p}$, where $\widetilde{p}$ is the revenue-share-weighted average of the prices of plant products and TFPR is calculated using (Gandhi et al., 2020)'s method. *Treatment* is an indicator equal to one for counties where treated projects were located and to zero for counties where comparison projects were located. *Advanced* is an indicator for firms that were supposed to receive an advanced transfer (machinery, equipment, and technical assistance). *Basic* is an indicator for firms that were supposed to receive a basic transfer (machinery and equipment only). Data are provided at the plant level from the 1949–2000 annual Steel Association Reports.

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