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

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This paper studies the long-term effects of technology and know-how transfers on structural transformations. In the 1950s, the Soviet Union supported the construction of 156 Projects, large-scale capital-intensive industrial clusters in China, and sponsored a physical capital transfer providing state-of-the-art machinery and equipment; and a know-how transfer through training for engineers and production supervisors. We use newly-assembled data that follow these plants for over four decades, combined with natural variation in the transfers they eventually received. We find that know-how transfer had permanent effects on output quantity and quality, increased domestic technology development, and exports to the Western world when China engaged in international trade. By contrast, receiving only Soviet capital goods had smaller effects that faded out over time, especially after China's opening to trade. 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

Economic development has historically been associated to a process of structural transformation. As economic activity has moved from the agricultural to the nascent and more productive industrial sector, countries have grown rich (Gollin et al., 2013; Herrendorf and Schoellman, 2015; Porzio et al., 2021). In the last 80 years, it has become increasingly common for governments in less developed states to accelerate such economic transformations by promoting industrial policy interventions, that often takes the form of technology transfer from more advanced countries (Hoekman et al., 2004; Robinson, 2009). However, empirical evidence on the causal and long-run implications of these industrial policies remains limited. This is mainly due to the endogeneity of their delivery, as policymakers decide which firms and industries to target. Moreover, while the effects of such policies took several years to materialize, systematic data following the targeted units over time are rarely available. Finally, it is challenging to disentangle the impact of technology transfer from the role of know-how diffusion, as they generally occur simultaneously (Chandra, 2006; Mostafa and Klepper, 2018).

This paper studies the long-term effects of technology and know-how transfers on structural transformations, using evidence from the Sino-Soviet Alliance. In 1950s, to help the industrialization of the newly formed People's Republic of China, the Soviet Union supported the construction of the 156 Projects, large-scale capital-intensive industrial clusters in heavy industries – an investment equal to 45% of Chinese GDP in 1949. According to the initial agreements, all projects were supposed to duplicate specific Soviet plants and, after starting their operation with Chinese capital, receive two transfers: a *physical capital* transfer through the provision of Soviet state-of-the-art machinery and equipment; and a *know-how* transfer via the training of Chinese high-skilled technicians, engineers and production supervisors by Soviet experts. However, on the ground implementation of the 156 Projects encountered significant delays. As a consequence, when in 1960 the Sino-Soviet Split caused the sudden interruption of Soviet aid, some plants had already received both the physical capital and the know-how transfers, other plants had only gotten the physical capital transfer, while the remaining plants eventually didn't get any Soviet transfers. Nevertheless, this program is considered the most comprehensive technology transfer in modern industrial history and vital factor in Chinese development. It offered to the country the best technology available in Soviet Union, that in the steel and iron industries was among the best in the world (Lardy, 1995; Gangchalianke, 2002; Zhikai and Wu, 2002).

We collected and digitized different types of historical and administrative data from several primary sources. We first retrieved the list of the 156 Projects signed under the Sino-Soviet Alliance, that contain detailed information on the Soviet transfers received. Second, we

hand-collected annual reports for the steel industry, that allows us to track output quantity and quality, technology development and workforce composition of all the plants part of steel industrial clusters yearly from 1949 to 2000. Finally, we collected data on firm-level outcomes for all the industries, when available, namely in 1985 and between 1998 and 2013.

Our empirical strategy measures the impact of Soviet transfers by comparing plants that received both physical capital and know-how, to plants that only got physical capital and to plants that eventually didn't get any Soviet transfers, over a period of 40 years. We show that the three types of plants had statistically similar characteristics at baseline, were located in comparable geographical areas, and had similar access to natural resources and inputs. Furthermore, and more importantly for our difference-in-differences specification, they were on statistically indistinguishable performance trends before receiving the Soviet transfers, when they were all operating with Chinese capital.

The historical records explain that the differences in the transfers eventually received by Chinese plants depended on idiosyncratic accidents that Soviet physical capital assigned to them suffered and on delays in Soviet experts' trips to China (Lardy, 1995; Zhang et al., 2006; Hirata, 2018). These issues caused severe delays in the 156 Projects completion. For this reason, when the Split occurred, all the plants envisioned under the Sino-Soviet Alliance had already been built and started their operation, but only some had received one or both Soviet transfers. Consequently, we also propose an instrumental variable approach, instrumenting the probability of receiving the physical capital transfer with accidents that capital built for a specific Chinese plant suffered and the probability of also receiving the know-transfer with the delays in Soviet experts' arrival. Consistent with the historical narrative, we find lack of correlation between Chinese plant characteristics and physical capital's accidents and experts' delays on the Soviet side, which are, however, strongly and negatively correlated with the transfers eventually received by Chinese plants.

We find three key results. First, focusing on the steel industry, we show that plants that received Soviet physical capital had better performance relative to plants that did not receive any Soviet transfers in the short-run, but the effects disappeared over time. For example, output of the former differentially increased relative to that of the latter up to six years after receiving Soviet physical capital, reaching a 14.7 percent peak. After that, the effects started to decay and were no longer significant after 20 years, approximately when China opened up to international trade in 1978. Second and by contrast, plants that also received the know-how transfer showed an additional increase in outcomes compared to plants that received only the physical capital transfer, with a performance gap that widened over time and in particular after 1978. Specifically, output of such plants rose by 19.7 percent within 20 years of Soviet intervention, relative to that of plants that only got physical capital, and continued to grow, reaching a cumulative effect of 49.5 percent after 40 years. These plants

also produced better-quality steel and were systematically more productive, while employing similar inputs to the other plants. Third, our results are confirmed if we use data for firms in on all the industries, in 1985 and between 1998 and 2013.

We also show that repeating our analysis with the IV specification leads to very similar results to the OLS ones, confirming that the transfers eventually received by each plant largely depended on the accidents to the Soviet physical capital and on experts delays. Moreover, when China was a planned economy, the three types of plants did not receive differential quotas allocation. Even after the Spilt, they did not receive any special treatment by the central government and did not have systematically different access to infrastructure or exposure to political connections. Finally, they do not appear differentially affected by other major historical events, such as the Great Leap Forward or the Cultural Revolution.

We next investigate the mechanisms underlying our results, distinguishing between the pre- and post-1978 periods. In the 1960s and 1970s, when China's interaction with foreign countries was extremely limited, only plants that received the know-how transfer were able to domestically develop new production processes and modern machineries, which ultimately replaced Soviet capital when it became obsolete. Once China began gradually opening to international trade since 1978, such plants took more advantage of the new market opportunities. In fact, while they relied dramatically less on Western world physical capital, they imported more foreign equipment complementary to their machineries, and exported systematically more high-quality steel than plants that received Soviet physical capital. These results likely explains why their performance grew even more after 1978. Conversely, plants that only received Soviet physical capital did not import more foreign capital nor export more steel than plants which didn't get any Soviet transfer, suggesting that opening up to international trade contributed to erode the production advantages of these companies.

The major goal of the Soviet technology transfer was to create large industrial clusters to push local industrial development. Was the program successful in doing so? We document that steel plants horizontally or vertically related to plants that received the know-how transfer showed better performance and productivity, adopted the same technology when China was a closed economy, and followed their export patterns when China opened up to international trade, compared to plants related to plants that received physical capital transfer. Starting in the late 1990s, the Chinese government undertook a number of market liberalization reforms. We therefore test if the spillover effects persisted after this major institutional change. We find that, between 1998 and 2013, firms that became privately owned and were economically related to plants that received the know-how transfer had better performance and were more productive. At the county-level, these changes were associated to an increased share of industrial output produced by private firms. In fact, counties that hosted plants that received the know-how transfer had a higher concentration

of industry-specific human capital, which may have in turn helped firms to hire better educated workers when they started competing for inputs in the local labor market.

The contribution of this paper is threefold. First, our paper relates to the growing literature that examines the effects of industrial policies on structural transformations. Several works have shown the importance of investments in strategic industries to foster early stage economic development and their positive effects on local industrialization, targeted sectors, downstream users, and individual long-term outcomes (Wade, 1990; Liu, 2019; Mitrunen, 2020; Choi and Levchenko, 2021; Kim et al., 2021; Bianchi and Giorcelli, 2023; Lane, 2023). Our work complements prior findings by disentangling the effects of different components of industrial policy, namely the construction of large industrial clusters, the provision of technology transfer and the diffusion of industry-specific know-how. By showing that know-how diffusion is essential for ensuring persistent effects of government interventions, our paper also relates to the literature that documents the role of foreign firms in seeding industry-specific knowledge that can subsequently push the growth of a developing country's industry (Keller and Yeaple, 2013; Yeaple, 2013; Mostafa and Klepper, 2018). Our focus on China, the country that experienced the "the fastest sustained expansion by a major economy in history" (Morrison, 2019), speaks to the debate about the role of the state in achieving economic development (Evans, 1992; Besley and Persson, 2010; Dell et al., 2018).

Second, we contribute to the literature that studies the role of technology diffusion in developing countries (see Verhoogen, 2023 for a comprehensive review). Previous papers have documented the positive impact of capital and managerial technologies 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; Giorcelli, 2019; Hardy and Jamie, 2021) and the existence of substantial barriers to their 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 and know-how transfers on the largest industrial clusters of a country, following them from their foundation for over four decades.

Third, this work is related to the large literature on spillover effects. Existing research has focused on spillovers determined by foreign direct investments and the opening of large new plants (Javorcik, 2004; 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, 2022), and sectoral industrial policies (Liu, 2019; Fan and Zou, 2021; Lane, 2023). Our setting allows us to disentangle the spillover effects of technology transfer from knowledge spillovers that follow know-how diffusion, and their interactions with major institutional changes. In terms of context, a closely related paper is Heblich et al. (2020) compares counties that hosted the 156 Projects with similar

countries that did not from the 1980s, showing negative effects on productivity due to overspecialization. By contrast, our paper looks at differences within the 156 Projects, using enterprise-level data and assessing short-, medium-, and long-run direct effects and spillover effects of such industrial clusters.

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 and know-how transfers on plant outcomes. Section 6 examines the mechanisms, while Section 7 focuses on the spillover effects. Section 8 concludes.

2 The Sino-Soviet Alliance and the "156 Projects"

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,[1] 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 a massive 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 until 1978.

2.2 The "156 Projects"

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

[1] 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).

factories built during the Japanese occupation had been destroyed during the Civil War (Lardy, 1995, p. 144). 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 workers to jobs.

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 economic and technical assistance from the Soviet Union, that resulted in the signature of several agreements by the two countries between 1950 and 1957, known as the "156 Projects" (Zhang et al., 2006, p. 110). These projects consisted of the construction of large-scale capital-intensive industrial clusters in heavy industries, such as metallurgy, machinery, electricity, coal, petroleum, and chemical raw materials. 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.[2]

The locations for the 156 Projects were mostly chosen based on strategic reasons. While Soviet experts helped surveying geological conditions, selecting plant sites, and directing plant construction, 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).[3] In this respect, the 156 Projects shaped the geographical distribution of Chinese industrialization, since before 1952 the few existing firms were almost all located in the coastal areas (Lardy, 1995).

The 156 Projects were composed of multiple plants, supposed to duplicate whole Soviet plants and to receive both a *physical capital* transfer and a *know-how* transfer from Soviet Union. The physical capital transfer involved the provision of Soviet state-of-the-art

[2] 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.

[3] 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).

machinery, equipment, and blueprint, that "would enable China to have its own complete production line of an industrial sector, rather than become dependent on of the Soviet-centered industrial system" (Hirata, 2018, p. 170). The know-how transfer encompassed visits of Soviet experts to teach Chinese high-skilled technicians how to operate the new machineries, and to offer 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).[4] The Soviet experts were expected to spend on average three years in Chinese plants, sharing engineering designs, product designs, and other technical data (Zhang et al., 2006).[5]

This program is considered the most comprehensive technology transfer program in modern industrial history, still unmatched in scale and scope, and a vital factor in Chinese industrialization and economic development (Lardy, 1995; Zhang et al., 2006; Zhang, 2015). Through it, China received the best physical capital available in Soviet Union and moved from having an industrial technology a century behind that of developed industrial nations in 1949 to a comparable level in a mere ten years (Naughton, 2007).

2.3 Soviet Aid in Steel Industry

Chinese leaders, and in particular Chairman Mao Zedong, envisioned that Chinese industrial development would strongly rely on steel production. Not surprisingly, the steel industry accounted for 45 percent of the total investment in the 156 Projects and led to the construction of twenty out of the 156 industrial clusters. Each cluster was in turn composed of several plants, 304 in total. Notably, while all the plants within an industrial cluster were formally under a unique company, they operated as different firms, having each its own planning, financial, and labor departments (Angang Shizhi Bianzuan, 1991).

Soviet technology in steel and iron industry was considered among the best in the world (Clark, 1995; Gangchalianke, 2002). For instance, during the 1950s the Soviet Union built and operated the world's best blast furnaces—these were expected to be installed in Chinese plants in Anshan, Wuhan, and Baotou even before being employed in some Soviet factories (Lardy, 1995; Zhikai and Wu, 2002). The advancement of Soviet technology was recognized

[4] 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).

[5] 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.

from the US side as well. After studying the Soviet and Chinese industries for decades, Clark (1995) argued that Soviet steel technology transferred to China was comparable to that of the most developed Western economies. The Soviet experts were expected to show and teach their Chinese colleagues how to operate these state-of-the-art equipments, give lectures on how to increase steel production and quality, and disseminate the most recently developed Soviet organizational, technological, and management methods (Clark, 1973). The Soviet effort in promoting Chinese management of the 156 Projects impressed the Indian Prime Minister Nehru. While visiting the Anshan plant, he compared the Soviet transfer in China with the British and US one in India, concluding that in China "the entire process of production in the plant [was] being operated by Chinese experts," while in India the British and Americans "never allow[ed] Indians to manage the most important mechanism of the plants" (Zhikai and Wu, 2002; Hirata, 2018).

2.4 Delays in the 156 Projects and the Sino-Soviet Split

Despite the rosy picture of "Great Friendship" promulgated by the Soviet and Chinese authorities, the 156 Projects suffered severe difficulties on the ground, with the consequence that machinery, equipment, and experts almost always arrived later than planned. In fact, while China demanded too much too quickly, 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 that proved difficult to deliver (Zhang et al., 2006). Consequently, the Soviet and Chinese governments decided to start operations with available domestic capital goods and replace them with state-of-the-art Soviet machineries as soon as they were delivered. However, the pressure to produce beyond capacity caused several accidents on the Soviet side. Factory fires and floods and railway accidents destroyed critical equipment produced for China in multiple instances, causing severe delays in the delivery (Borisov and Koloskov, 1980). Moreover, Soviet experts, limited in number to begin with, had to learn how to operate the machineries, little employed even within the Soviet Union, before traveling to China and relied on translators, who often needed more time than expected to learn Chinese (Filatov, 1975; Hirata, 2018).

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, the 156 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.

These practical and political matters strongly affected the completion of the 156 Projects.

For instance, both the Bautou, Benxi and Wuhan industrial clusters were each supposed to have a plant duplicating the Red October (Krasny Oktyabr) blast furnace plant in Volgograd. While the completion of the three furnaces took almost a year longer than planned, soon after the furnaces for Bautou and Wuhan were shipped in 1957, a fire strongly damaged the one for Benxi. Soviet Union ensured that it would produce it as soon as its plant operations could resume, but due to the Split this never happened (Filatov, 1975). The fact that blast furnaces were brand new even in Soviet Union implied that Soviet experts had themselves learn how to operate them before leaving for China. The team, also delayed by a slow Chinese learning by translators, eventually left in 1958, but could only visit and train Chinese workers in Bautou, as they were forced to return to Soviet Union before heading to Wuhan due to the Split (Filatov, 1980).

As a result, despite being initially designed to be identical, the three plants ultimately were very different, as described by Clark during his visit in China in the early 1960s. The Bautou Blast Furnace Plant emerged as "an impressive modern, giant metallurgical complex, where the entire process of production in the plant employ[ed] systematic quality control methods, resulting in high-quality steel" (Clark, 1973, p.11). The Wuhan Blast Furnace Plant appeared as "a surprising state-of-the-art massive steel facility [...] whose workers were copying Soviet designs and products without thinking. As a consequence, the resulting products had many flaws and the scrapped output was enormous" (Clark, 1973, p.12). Finally, the Benxi Blast Furnace Plant was "of an impressive size for the eyes from a distance and apparently brand-new, but, as one walk[ed] in, production capital [was] a mixture of that of a Japanese and a Soviet factory of the 1930s, as the factory was employing the domestic capital, never replaced by Soviet furnaces" (Clark, 1973, p.12).

In light of these delays even before the Split, it would have been profitable for China to prioritize the most promising projects, but the country faced many challenges in doing so. First, it was too dependent on aid from the Soviet Union, that often did not even respond to the complaints of the PRC Ministry of Foreign Affairs (Zhang et al., 2006). Moreover, the fact that Chinese plants aimed at replicating a specific Soviet one made it impractical to re-allocate machinery or equipment across the 156 Projects (Filatov, 1975). And unfortunately, the Soviet experts who did arrive in China had just learnt how to operate specific machinery and their translators had been trained in project-specific terminology, which strongly limited the possibility of training across different projects (Borisov and Koloskov, 1980). Finally, China was facing an embargo from the Western world until at least 1978, which forced the country to rely on its own resources for about 20 years after the Split.

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 all the variables used in the analysis can be found in Appendix B.

3.1 The 156 Projects

We hand collected the 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. 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, that corresponded to the construction of an industrial cluster, we collected detailed information, such as name, location, industry, total investments, capacity, number of workers, and name and number of plants. For each plant, we also retrieved records indicating which Soviet transfer it received or if didn't receive any transfers.

As shown in Section 2.2, most projects were located in China's northeastern and interior regions, for strategic reasons and for proximity to natural resources (Figure 1). The projects were overwhelmingly concentrated in heavy industries. The electricity sector accounted for 23.0% of the 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, Panel A). Only two projects (1.4%) were in light industry. However, in terms of expenditures, the steel sector alone accounted for 45.1 percent of total investments in the 156 Projects, while the second larger recipient sector, electricity, for a mere 16.1 percent (Figure A.1, Panel B).

The construction of industrial clusters on average was planned to start in 1955 and span a duration of approximately 5.64 years (Table 1, column 1). The average cluster included 8.69 plants and should have employed 39,910 workers, for a total of around 5.5 million workers—only 3 percent of China's total workforce, but almost 40 percent of the country's employment in the industrial sector in 1952 (Table 1, Panel A, column 1). The twenty industrial clusters in steel industry were, on average, larger in terms of number of plants (15.2), expected length of their construction (6.12 years) and number of workers (46,670) than clusters in other industries, confirming their vital importance in the First Five-Year Plan (Table 1, Panel B, column 1). Such clusters were composed of 304 plants, which in turn aimed at duplicating 14 different Soviet plants.

We next hand-collected information on the accidents that Soviet physical capital built for

China suffered, as well as on the delays that Soviet experts' trips to China experienced, from the Russian State Archive of the Economy. The historical records contain precise information on the reasons of the accidents and the delays and on the Chinese plants to which physical capital was planned to be delivered and that Soviet experts were supposed to visit. Physical capital was exposed to 115 accidents of three types: fires (41.7%) and floods (26.1%) in Soviet factories where machinery and equipment for Chinese plants were built and trains derails (32.8%) while they were transported to China. Although these numbers may seem quite high, such accidents were extremely common in the Soviet Union and completely destroyed the physical capital for China (Borisov and Koloskov, 1980; Filatov, 1980). Considering the time needed to build steel machineries was at least two years, such issues dramatically slowed their delivery. 87 percent of the 109 planned trips of Soviet experts to China were delayed. In 42.1 percent of the cases, machineries they had to learn to use got destroyed and they needed to wait for them being rebuilt. Urgent matters in Soviet factories, such as unexpected breakdowns or repairs, that needed experts' immediate help, and translators' slow progress in learning Chinese were responsible for respectively 38.9 and 19.0 percent of the remaining delays. Matching accidents and delays on the Soviet side to the 304 Chinese steel plants indicate that 62 percent of them experienced accidents in the physical capital they were supposed to receive and 84 percent delays in experts' arrival. When the Split suddenly interrupted the delivery of the program, 98 steel plants had received both physical capital and know-how transfers (32.2%), 91 had received only the physical capital transfer (29.9%), and 115 eventually did not receive any Soviet transfers (37.8%).

3.2 Plant-Level Data in the Steel Industry

We manually collected and digitized restricted, plant-level annual reports that the Steel Association compiled every year from 1949 to 2000 for all the plants operating in the steel industry. The reports contain rich information on plant performance, such as quantity and quality of steel products, inputs usage, specific machineries and technologies in use, and the number and types of workers (unskilled workers, high-skilled workers, and engineers). Using the plant name, location, county, and province, we manually and uniquely matched the 304 plants in the 20 steel industrial clusters to the historical records indicating the Soviet plants that were supposed to replicate and the type of Soviet transfers they eventually received.

A natural question is whether data on plant performance, at the core of our analysis, are accurate. For instance, plant supervisors may have had incentives to misreport some data to meet the goals set by the central government or to show better-than-actual performance. To attenuate this concern, we assert three points. First, the Steel Association reports were primarily intended for internal government use and therefore required an accurate evaluation of plant performance. For this reason, these reports were highly monitored and

verified by industry peers, significantly reducing the manipulation margins. Moreover, the officially released aggregate production data was compiled by Statistics China, a separate and independent source. Manipulations were more likely to occur in the aggregate data rather than in the Steel Association reports. Second, after the Sino-Soviet Split, the Chinese government wanted to tie up loose ends with the Soviet Union as quickly as possible.[6] 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.[7] Third, we cross-check our data with several sources. In particular, we rely on the studies of the US Professor Gardner Clark, who examined the Chinese steel industry between 1949 and 1993. Specifically, he repeatedly visited the major Chinese steel plants with the goal of assessing the quality of capital they were using (Clark, 1995). His works conclude that the data from the Steel Association Reports, our main source, appear credible.[8] More details about our data cross-check can be found in Appendix B.

We complement this data with information on subsequent foreign technology adoption at the plant-level, that we collected from the Chinese Ministry of Commerce and the Ministry of Industry and Information Technology historical archives. Specifically, we retrieved the contracts signed with technology-advanced Western countries, such as Belgium, West Germany, Japan, France, Italy, Canada, the United Kingdom, the United States, Switzerland, Sweden, France, Netherlands, Norway, and Denmark between 1978 and 2000, that contain detailed description of the type of technology imported (machineries, equipment, licensing and consulting) and their use within plants.

3.3 Firm-Level Data in All Industries

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 firms between 1949 and the early 1990s. It covers more than 40 industries within the industrial sector, containing 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 name, location, and province, we manually and uniquely matched the

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

[7] 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).

[8] More specifically, in Table B.1, we repeat our main analysis using Clark (1995)'s data, which leads to results fully consistent with our main findings.

139 industrial firms to their performance in 1985. From the Survey, we also collected and digitized county-level and prefecture-level industrial production data.[9]

Finally, we manually matched the 139 industrial firms with their 1998–2013 performance from the China Industrial Plants database. This database, compiled yearly from 1998 to 2013, covers more than 1 million public and private industrial firms above a designated size in China.[10] It includes a rich set of information on firms: firm output, number of employees, and profits, as well as ownership structure and capital investment.

4 Identification Strategy

The core of our analysis focuses on the steel industry, that received almost half investments of the 156 Projects and for which we have performance data for each year between 1949 and 2000. The initial agreements between the Soviet Union and China envisioned the construction of 304 steel plants that, after beginning their operation with Chinese capital, would have all received a physical capital transfer (in form of state-of-the-art machinery and equipment) and a know-how transfer (in form of training for high-skilled workers, engineers and production supervisors). However, on the ground, the implementation of the 156 Projects experienced many issues on the Soviet side, which dramatically delayed their completion. When in 1960 the Soviet Union suddenly interrupted the program, some plants had already received both physical capital and know-how transfers, some others had only gotten Soviet physical capital, while the remaining ones didn't get any Soviet transfers and continued to employ traditional Chinese capital.

We estimate the effects of the Soviet technology and know-how transfers via the following equation, estimated on the sample of 304 steel plants belonging to the 20 steel industrial clusters:

$$\begin{aligned}\text{outcome}_{ift} = &\sum_{\tau=-5}^{40} \beta_\tau(\text{Physical Capital}_i \cdot \text{Years after Transfer}{=}\tau_{it}) + \delta \cdot \text{Physical Capital}_i \\ &+ \sum_{\tau=-5}^{40} \gamma_\tau(\text{Know-How}_i \cdot \text{Years after Transfer}{=}\tau_{it}) + \lambda \cdot \text{Know-How}_i \\ &+ \text{Soviet Entreprise}_f \cdot \text{Agreed Year}_i + \theta_\tau + \epsilon_{ift} \end{aligned} \quad (1)$$

where outcome_{ift} is logged tons of steel and TFP of Chinese plant i supposed to duplicate

[9] 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.

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

Soviet plant f in year t;[11] Pysical Capital$_i$ is an indicator for plants that received Soviet physical capital transfer; Know-How$_i$ is an indicator for plants that also received Soviet know-how transfer; Years after Transfer=τ_{it} is an indicator when a calendar year is τ years before or after the year in which plant i received or was supposed to receive the Soviet transfer. The excluded year is $\tau = -1$. Soviet Entreprise$_f$ $\cdot$ Agreed Year$_i$ is a set of fixed effect that interacts indicators for the Soviet plant f that Chinese plant i was supposed to duplicate with the indicators for the year in which the Soviet transfers were expected to be delivered to Chinese plant i. These fixed effects allows us to estimate the effects of the Soviet transfers within plants that were supposed to duplicate the *same* Soviet plant and to receive the Soviet transfer in the *same* year. θ_τ controls for nonlinear variation in outcomes over time. ϵ_{ift} is the error term. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications to control for potential auto-correlation within industrial clusters. As all plants were still alive and state-owned in 2013, equation 1 estimates an intensive margin effect.

Under the identification assumption that the transfer eventually received (or not received) by a plant was orthogonal to its characteristics or its potential success, the coefficient β_τ captures the effect of Soviet physical capital on plant performance, relative to plants that did not receive any Soviet transfer τ years after receiving it; the coefficient γ_τ captures the additional effect of Soviet know-how on top of physical capital τ years after receiving it. The remainder of this section provides evidence in support of the research strategy.

4.1 Were the 304 Steel Plants Comparable the Year before Receiving the Soviet Transfers?

We start our analysis by showing that the expected delivery years of Soviet physical capital and the expected arrival years of Soviet experts were substantially the same across plants that received physical capital, know-how or no Soviet transfers (Table 2, Panel A, columns 1-3). Notably, the coefficients estimated by regressing these two variables on indicators for plants that received Soviet physical capital, for plants that also received the know-how transfer, and Soviet enterprise-agreed year fixed effects are small in magnitude, not statistically significant and not jointly statistically different from zero (Table 2, Panel A, columns 4-6). This is a crucial test for our identification because it corroborates the idea that differences in the transfers eventually received (or not) by the 304 steel plants were not driven by the initial design of the program. In other words, plants expected to receive the transfers in earlier years were *not* more likely to get them before the Split, relative to plants expected to receive them in later years.

[11] 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.

We next show that the 304 plants were comparable in terms of their characteristics and outcomes the year before they were supposed to receive the Soviet transfers, when they were operating with the same Chinese capital. Means of quantity and quality of steel production, sales and productivity, number of employees and their composition, as well as loans and transfers received from the government, appear very similar across them (Table 2, Panel A, columns 1-3). For all these variables, the estimated coefficients on indicators for the transfers eventually received are never jointly statistically different from zero (Table 2, Panel A, columns 4-6).

Moreover, we test if the 304 plants were located in areas with different geographical conditions and access to natural resources. This instance could have allowed plants to prosper in the long run due to natural advantages, rather than due to the Soviet intervention. However, distance from national and provincial borders, the coast and Treaty Ports[12] where most economic activities were concentrated were not statistically different among plants that received or did not receive the Soviet transfers (Table 2, Panel B, columns 4-6). Similarly, distance form highways and railroads was not systematically different between the three groups of plants. Finally, we show that plants that received the Soviet transfers were not closer to natural resources, such as coal or coke deposits (Table 2, Panel B, columns 4-6).

Based on the evidence presented in this section, we conclude that the three groups of plants were statistically equivalent in the year before receiving the Soviet transfer.

4.2 Were the 304 Steel Plants on the Same Trend before Receiving the Soviet Transfers?

We next test whether the 304 steel plants were on the same performance trend in the five years before receiving the Soviet transfer, while producing with Chinese domestic capital. We first estimate a constant linear time trend model in which we interact a constant linear trend with indicators for receiving Soviet physical capital and also receiving Soviet know-how transfer. The estimated coefficients are close to zero and not statistically significant (Table A.1). Moreover, the estimated coefficients on the indicators alone are not statistically different from zero in all the specifications, confirming the results of the balancing tests of Table 2, Panel A.

Second, we replace the linear time trend with a full set of indicators for each year before receiving the Soviet transfer interacted with indicators for receiving Soviet physical capital and also receiving Soviet know-how transfer. The estimated coefficients on the indication terms are small in magnitude and never statistically different from zero (Table A.2). Moreover, some are positive and some are negative, confirming lack of any pattern. Finally, the

[12] Treaty Ports were Chinese ports open to trade with the Western World beginning in the mid-19th century.

F-statistics at the bottom of each panel indicate that we can never reject the null hypothesis that the interaction terms are jointly equal to zero.

These findings suggest that the 304 steel plants were following a statistically indistinguishable performance trend in the five years before receiving the Soviet transfer.

4.3 Comparison between Projects and Counties that Hosted the 304 Steel Plants

We continue our analysis by showing that the industrial clusters the 304 plants belonged to and the counties that hosted them were comparable when the Sino-Soviet agreements were signed and approved. One may worry that, even if our comparison looks at plants supposed to duplicate the same Soviet plants, belonging to industrial clusters with different characteristics may have affected plant growth in addition to the Soviet transfers. To rule out this concern, we regress industrial cluster characteristics the 304 plants belonged to on an indicator for receiving physical capital and an indicator for receiving know-how transfer. None of the coefficients is statistically significant and in all cases we fail to reject the null hypothesis of joint equality of the coefficients to zero (Table A.3, columns 1-3).

A similar concern may rise at the county level, if plants that got different transfers were located in counties with different baseline characteristics, likely to impact plant outcomes. However, regressing county characteristics in 1953 on an indicator for receiving physical capital and an indicator for receiving know-how transfer estimates small and non statistically significant coefficients (Table A.4, columns 1-3).

These results are fully consistent with the historical records that explain how variation in the transfers received was strongly affected by the accidents on the Soviet side, but was largely unrelated to the industrial cluster or county characteristics (Filatov, 1975; Hirata, 2018).

4.4 Were Resources Reallocated across the 304 Steel Plants?

A potential threat to our identification strategy may arise if the Chinese government reallocated the Soviet physical capital or know-how to plants that did not receive any Soviet transfers. First, it is worth noting that this scenario would go against us finding results. Second, as explained in Section 2.4, reallocating the transfers before the Split would have been very challenging both because China was heavily dependent on Soviet help and because the transfers aimed at duplicating specific Soviet plants. In fact, the historical records do not report any deviation from the Soviet plans, despite Chinese complaints about the delays in 156 Project completion. After the Split, China had more autonomy in allocating resources, but it would have been highly unprofitable for the government to remove brand-

new furnaces from productive plants, especially in light of the difficulties the country was facing in producing steel and equipment on its own (Zeitz, 2011; Ji, 2019). Regarding the know-how diffusion, individual records to trace worker movement do not exist, to the best of our knowledge, but historical anecdotes indicate that managers and engineers were in shortage even in plants that got Soviet training, which makes their employment elsewhere unlikely (Hirata, 2018). Moreover, even within the same industrial clusters, different plants operated independently and with different equipment. Finally, migration in China at that time was highly restricted due to the household registration (*hukou*) system, which made worker movements across the country extremely rare.

Still, it is possible that after the Split, the Chinese government disproportionately directed its investments to plants that received the Soviet transfers. In Section 5.3, we will show that plants that received or did not receive the Soviet transfers did not get differential quotas allocation, loans and transfers from the central government (Tables A.11 and A.12), not finding evidence in support of this hypothesis.

4.5 IV Estimation

Since the transfers eventually received by the 304 steel plants depended on issues on the Soviet side, we also propose an IV approach in which we instrument the probability of receiving the physical capital transfer with the accidents that Soviet physical capital to be delivered to a specific plant suffered and the probability of receiving know-how transfer with the delays in trips to China experienced by Soviet experts.

The exclusion restriction implies that such events affected plant outcomes only through the transfers eventually received (or not). While this hypothesis is not directly testable, we show that the two types of events are not predicted by the plant characteristics (Table A.5). However, they do strongly predict if a plant received any Soviet transfer. Accidents to physical capital that a plant was supposed to receive lower its probability of receiving the physical capital transfer before 1960 by 16.7%, with the chances being 19.2% lower according to the estimation of the marginal effects of a probit model (Table A.6, columns 1 and 2). Similarly, delays to the Soviet experts a plant was supposed to host reduce its probability of receiving a know-how transfer before the Split by 18.8%, a result confirmed by the probit estimation, which indicates a 20.8% lower probability (Table A.6, columns 3 and 4). Taken together, the results presented in this section indicate lack of correlation between plant characteristics and accidents to machineries or experts' delays that, however, are strongly and negatively correlated with the probability of receiving the technology or know-how transfers.

5 Effects of Physical Capital and Know-How Transfers

In this section, we study the effect of the physical capital and know-how transfers on the performance of the 304 plants built in the 20 steel industrial clusters. The richness of our data allows us to follow such plants every year from 1949 and 2000. We first show that plants that received Soviet physical capital had higher output and productivity relative to plants that did not receive any Soviet transfers in the short-run, but the effects disappeared over time, especially after China opened up to international trade in 1978. Plants that also received the know-how transfer showed an additional increase in performance compared to plants that received only the physical capital transfer, that widened over time and in particular after 1978. We next rule out potential alternative explanations for our findings and we assess the role of other major historical events China experienced in the same time period. Finally, we show that our results hold if we extend the analysis to all plants part of the 156 Projects, for which we have data in 1985 and between 1998 and 2013.

5.1 Production and Productivity of Steel Plants

The results of estimating equation 1 indicate that output, measured in tons of steel, produced by plants that received Soviet physical capital was not significantly larger than that of plants that did not receive any Soviet transfers for the first two years after receiving the state-of-the-art machineries, probably due to the difficulties in operating them without proper training. It then started differentially growing, reaching a 14.7 percent higher level six years after the Soviet intervention. After that, the effects started slowly decreasing and were no longer significant after 20 years, when China gradually opened to international trade (Figure 2, Panel A).

We next show that output of plants that also received the know-how transfer rose by 8.4 percent relative to that of plants that only received the physical capital transfer within two years since the Soviet intervention and by 19.7 percent within 20 years. The gap between the two groups of plants continued to widen, with an estimated output increase of 49.5 percent 40 years after the program (Figure 2, Panel B). Single-difference event studies indicate that our findings are largely driven by the increased performance of plants that received either one or both types of Soviet transfers, while output of plants that did not receive any Soviet transfers remained mostly flat during this time period (Figure 2, Panel C).

Soviet transfers also affected the quality of steel. Relative to plants that did not receive any Soviet transfer and continued to use domestic capital goods, plants that received the physical capital transfer increased the production of crude steel (considered the best-quality steel) and reduced the quantities of pig iron (considered of lower quality given its higher

carbon content) up to 10 years. When the life-cycle of Soviet machineries estimated to be 15 years at the time ended, the difference in production of higher-quality steel between the two groups of plants dramatically reduced and was no longer statistically significant (Table A.7, columns 1–2). Conversely, the increase of crude steel and reduction in pig iron production in plants that also received a know-how transfer remained systematically higher than in plants that only received the Soviet physical capital (Table A.7, columns 1–2). This difference in quality using the same physical capital could be related to the adoption of more efficient production methods in plants that received the Soviet know-how, that became embedded in firm organizations (Zhang et al., 2006). For instance, adopting Soviet quality control methods, 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 transfers on productivity. Specifically, we estimate total factor productivity quantity as $\log \text{TFPQ}{=}\log \text{TFPR-}\log \widetilde{p}$, where $\widetilde{p}$ is the revenue-share weighted average of the prices of plant products and total factor productivity revenue (TFPR) is calculated using Gandhi et al. (2020)'s method. The dynamic of productivity follows a similar pattern as output. TFPQ of plants that received a physical capital transfer rose up to six years after the Soviet transfer with a 14.5 percent increase relative to plants that did not receive any Soviet transfers, and was no longer significant after 20 years. TFPQ of plants that also received a know-how transfer increased between 8.3 percent two years after the Soviet transfer to 47.9% after 40 years, relative to plants that only received Soviet physical capital (Figure 2, 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 inputs, such as number of worker and coke and iron quantities, were not statistically different between the three groups of plants (Table A.7, columns 3–5).[13] This result also suggests that the government did not allocate more or better inputs to plants that received the Soviet intervention and therefore their increased performance is related to the transfers received.

IV Results. Repeating this analysis with the IV specification largely confirms our findings and leads to point estimates very close to the OLS ones. The effects of receiving Soviet physical capital increased output and TFPQ by 14.2 and 13.9 percent, respectively ten years after the intervention relative to plants that did not received any Soviet transfers

[13] While Chinese economy was a noncompetitive environment until at least the late 1980s and all plants in a given industry faced the same prices in a given year, any non-market clearing prices set by the government would be absorbed by year fixed effects in our regressions. Moreover, it is worth noting that this feature implies that we do not have any bias due to unobservable enterprise-specific variation in output or input prices.

(Table A.8, columns 2 and 4). The effects then constantly decreased over time and were no longer significant 20 years after the Soviet intervention. The impact of also receiving a know-how transfer is associated with a 20.3 percent increase in output and a 19.2 percent increase in TFPQ 20 years after the intervention, with these numbers jumping to 50.8 and 49.1 percent after 40 years, relative to plants that only received the physical capital transfer (Table A.8, columns 2 and 4). The similar magnitude of the estimates between OLS and IV specifications indicate that variations in the transfers eventually received by each plant largely depended on the accidents the Soviet machineries suffered or on experts' delays, rather than on their allocation to the most promising establishments.

5.2 Robustness Checks

Our findings are robust to a variety of modifications to the baseline specification. Specifically, our results remain very similar in magnitude if we control the industrial cluster fixed effects or plant and year fixed effects (Table A.9, columns 1, 2, 4, and 5). While regressions with plant and year fixed effects are widely used in event studies, recent works document possible shortcomings of these two-way fixed effects specifications (De Chaisemartin and D'Haultfoeuille, 2020; Goodman-Bacon, 2021; Borusyak et al., 2021). In particular, Sun and Abraham (2021) explains that, in presence of heterogeneous treatment effects, the coefficients on the leads and lags of the treatment variable in an event study might place negative weights on the average treatment effects for certain groups and periods. To address this concern, we use an "interaction-weighted" (IW) estimator, as proposed by Sun and Abraham (2021) themselves, that confirm our main findings (Table A.9, columns 3 and 6). Moreover, clustering at different level of aggregation, such as at the plant, the county or the prefecture level confirm the significance of our main specification (Table A.10).

To test for potential manipulation in our plant-level data, we use the estimates made by Clark (1995) that assessed the minimum and maximum possible levels of steel production, based on the capital in use in each steel plant. Even assuming that plants which received the Soviet transfers produced at the minimum capacity and plants that did not receive any Soviet transfers at the maximum level, we would still find a persistent effect of the receiving know-how transfer and a short-lived effect of receiving a physical capital transfer, consistent with our main results (Table B.1, columns 4-8). This also confirms Clark (1995)'s conclusion that the data from the Steel Association Reports are accurate.

Finally, issues related to so-called quality bias may arise: the Chinese government may have set prices that were not reliable indicators of underlying input quality. For instance, plants that received the Soviet transfers may have used the same quantity of better-quality inputs as plants that did not receive any transfer. We test for the possibility of quality bias as follows. First, 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 (Table C.1, column 5). Second, 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 (Table C.1, column 6). Consistent with these results, the historical records indicate that Chinese prices indeed reflected quality differences. In 1985, for instance, Statistics China set the crude 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.

5.3 Ruling Out Alternative Explanations

Allocation of quotas. A potential concern in interpreting our main results is that the higher production of plants that received physical capital and/or know-how transfers may depend on the allocation of higher steel quotas from the central government. To address this issue, we show that the quotas relative to quantity and quality of steel imposed by the government until 1978 did not systematically change across the three group of plants (Table A.11). While this finding may seem counterintuitive, quotas, established when steel plants were built, were subject to little or no changes over time (Lardy, 1995; Zhang et al., 2006; Hirata, 2018). Moreover, after the Sino-Soviet Split, the Chinese government wanted to show that production using domestic technology could achieve the same level of output than producing with the Soviet one, further reducing the incentives to allocate higher quotas to plants that received the Soviet transfers.

Additional funding from the government. Even if receiving or not receiving physical capital and know-how transfers from the Soviet Union was orthogonal to plant characteristics, it could still be the case that in the years after the Split the government granted special favors to plants that received the Soviet transfers, that, in turn, allowed their performance to flourish. We already showed that plants that got the Soviet transfers did not receive higher quotas or better inputs from the government relative to plants that did not get any transfer. However, the government may have allocated more money to such plants or may have invested more in counties were they were located.

To investigate this potential issue, we first show that the government did not allocate more transfers or granted more loans to plants that received the physical and know-how transfers relative to plants that did not get any transfer, neither in the short run nor in the long run (Table A.12, columns 1–2). Next, we check whether counties where such plants were located received more aid. We find that total investments, the investments in both in steel and other industries, as well as the investment in infrastructure did not differentially change across counties hosting the three groups of plants (Table A.13, columns 1–4). Taken

together, these results do not support that the government favored plants that received the Soviet transfer or the counties where they where located.

Since firm exit was virtually non-existent in China until the 1990s, one may wonder if the Chinese government artificially kept alive plants that did not receive any Soviet transfer after the Sino-Soviet Split. To test for this possibility, we compare plants built under the Sino-Soviet Alliance, but that did not get any Soviet transfer, with other steel plants built in other industrial clusters after 1960. The former performed better and were larger than the latter, but there were no observable differences in the types of technology and production process in use in these plants (Table A.14, columns 1-5). While these results do not have any causal interpretation, they seems to suggest that, even for the plants that eventually did not receive any Soviet transfer, Soviet help in their initial planning was beneficial. Moreover, the fact that they used the same technology as other steel plants built in the following years is consistent with the evidence that they were not intentionally neglected or treated worse by the government.

Construction of infrastructure. Another factor that may explain the better performance of plants that received the Soviet transfers is that over time they may have become more accessible thanks to the construction of roads and railroads. However, the distance from railroads and roads, statistically indistinguishable when the Sino-Soviet Alliance started, did not differentially change between the three groups of plants in the following decades (Table A.12, columns 3–4).

Political connection. Plants that received Soviet transfers may have also become more politically connected than plants that did not receive any transfer over time, or perhaps better politicians were allocated to their administrative areas, contributing to their economic success. 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 plants that received any Soviet transfer were located were more likely to be born or have studied locally or whether they were more educated than those who worked where plants that did not get any Soviet transfer were located. Having studied in the same areas where 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 the three groups of plants in the 40 years after the Soviet transfer (Table A.15, columns 1–6), which suggests that political connections and politician quality remained comparable over time.

5.4 Discussing Other Concurrent Historical Events

The 1960s and 1970s in China were decades dense of historical events that, among other consequences, affected Chinese industrialization. In this section, we explore whether such events may have had a differential impact on steel plants that either received or did not receive the Soviet transfers.

Great Leap Forward. In 1958 Mao launched the Great Leap Forward, China's Second Five Year Plan, to speed up industrialization, especially in the steel industry, and increase agricultural collectivization. During these years, the government put more emphasis on smaller-scale projects and the use of backyard furnaces, only able to produce pig iron, was largely encouraged. From an ideological point of view, since the goal of the government was to demonstrate that economic development could be achieved by using domestic technology, the events related to the Great Leap Forward should, if anything, downward bias our results.

Nevertheless, a potential concern may rise if the government shifted the production of lower quality steel to plants that did not receive the Soviet transfers, further lowering their productivity. However, the quotas requested by the government for the production of high-quality crude steel and low-quality pig iron did not differentially change for plants that did not receive the Soviet transfers relative to plants that did (Table A.11).[14] Clark (1995) explains how the Soviet know-how allowed plant management to mitigate the pressure induced by the Great Leap Forward thanks to the introduction of input-saving techniques to operate the blast furnaces (p. 9).

The Great Leap Forward not only affected steel production, but also caused a massive reallocation of workers from the agricultural to the industrial sector, that was not associated with a proportional increase in the agricultural productivity. For this reason, the Great Leap Forward is considered a ultimate cause of the Great Famine that by 1961 killed between 16.5 and 45 million people (Dikötter, 2010; Meng et al., 2015). While investigating the human costs of the Great Leap Forward goes beyond the scope of this paper, such a big disruption in the workforce may have differently impacted the 304 plants. Using 2000 county-level cohort loss as an estimate for the Great Famine severity as in Chen and Yang (2019), we do not find evidence of differential exposure to the Famine deaths in the counties that hosted

[14] To the best of our knowledge, none of the 304 plants were relocated to the country-side as a consequence of the Great Leap Forward.

the three groups of plants (Table A.16, column 1).

Third Front Movement. A few years later, starting in 1964, China undertook another massive industrialization campaign, the "Construction of the Third Front" (TF), that lasted for over a decade and built or moved large manufacturing plants to the South-Western and North-Western part of the country, the so-called "Third Front Region." 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. While the location of TF plants had a minimal overlap with the 156 Projects and none of the 304 plants was moved as a consequence of its construction, this fairly large investment may have differentially diverted resources from steel plants that received or did not receive the Soviet transfers.[15] However, counties where plants that received the Soviet transfers were located did not receive more investments than counties where plants that did not receive any Soviet transfers operated during the TF years (Table A.16, column 2). Moreover, in Table A.12 we have already shown that government loans and transfers did not differentially change across 304 plants in the 20 years after the Soviet intervention, when the TF construction took place, further suggesting that the TF movement did not differentially impact them.

Cultural Revolution. Finally, between 1966 and 1976, the Cultural Revolution aimed at purging any remnants of capitalism and caused the imprisonment of a large fraction of high-skilled workers, as well as the closure of schools and universities. While the aggregate steel production declined during these years, the 304 plants were too important for the Chinese heavy industry production and were left almost untouched (Esherick et al., 2006). The historical records that we accessed do not report any dismissal of managers or high-skilled workers from these plants during the Cultural Revolution decade. This finding is consistent with what Hirata (2018) describes in details for the Anshan Iron and Steel Company, arguing that the "Cultural Revolution's radical political campaigns were reconciled with the goals of industrial production, ensuring a continuity in the steel production."

In conclusion, we do not find evidence of any of these historical events to have differentially affected steel plants that received or did not receive the Soviet transfers.

5.5 Effects in All Industries

While annual performance data are available every year between 1949 and 2000 only for the steel industry, we collected data on firms in all industries in 1985 and between 1998 and 2013. We therefore test if our results in the steel industry hold for all the industries in the medium and in the long-run. Specifically, we estimate the following cross-country specification for 1985:

[15] Specifically, only 4.4 percent of the counties that hosted any of the 304 plants also hosted TF plants.

$$\text{outcome}_i = \alpha + \beta \cdot \text{Physical Capital}_i + \gamma \cdot \text{Know-How}_i + \mu_{cs} + \eta_i \tag{2}$$

and the following panel specification between 1998 and 2013:

$$\text{outcome}_{it} = \alpha + \beta \cdot \text{Physical Capital}_i + \gamma \cdot \text{Know-How}_i + \theta_{cst} + \nu_{it} \tag{3}$$

where outcome is value added, TFPR calculated using Gandhi et al. (2020)'s method and workers of firm i in 1985 in equation 2 and of firm i in year t between 1998 and 2013 in equation 3; Physical Capital$_i$ is an indicator for firms that received a physical capital transfer; Know-How$_i$ is an indicator for firms that also received a know-how transfer; and μ_{cs} are county-sector fixed effects, and θ_{cst} are county-sector-year fixed effects. Standard errors are clustered at the industrial cluster level.

These estimates confirm our main results from the steel industry. In 1985 and between 1998 and 2013, value added, TFPR and employees of firms that received a physical capital transfer were not significantly different than those of firms that did not receive any transfer (Table A.17, columns 1, 3 and 5). By contrast, value added of firms that also received a know-how transfer was, respectively, 41.5% and 52.0% higher than that of firms that only received a physical capital transfer, and TFPR was 39.5% and 49.3% higher, with no statistically significant differences in employment (Table A.17, columns 2, 4 and 6). The magnitude of the estimates on the full sample are remarkably similar to those obtained from the steel sample, which indicates that our results could be extended beyond the steel industry.

6 Mechanisms

The results shown in section 5 shows that the effects of receiving the know-how transfer on top of the physical capital transfer persisted over time, and increased more after 1978, when China open up to international trade. By contrast, the effects of the physical capital transfer only were short-lived. In this section, we examine potential mechanisms, distinguishing between the pre- and post-1978 periods.

6.1 Upgrading of Domestic Technology before 1978

Between 1960 and 1978, due to the Soviet Split and the embargo of Western countries, Chinese firms could only rely on their resources to innovate. Did the transfers receive from Soviet Union affect plant ability to conduct internal research and upgrade their technology? During the 1960s, a new steel-making process, the basic oxygen, that blew oxygen through molten pig iron and lower the alloy's carbon content, became predominant (Clark, 1973).

According to historical records, plants that received the know-how transfer were able to domestically develop and adopt this process innovation (Ji, 2019). Consistently, data on the production processes used in the steel industry indicate that plants that also received the know-how transfer had a 25.2 percent higher probability of using the basic oxygen process five years after the Soviet transfer and 65.1 percent higher probability twenty years after, relative to plants that received the physical capital transfer only (Table 3, column 1), but the latter were not more likely to use this technique relative to plants that did not receive any Soviet transfer. This finding is likely related to the organizational and technological classes that high-skilled workers of plants that received the know-how transfer attended. In fact, part of the training focused on the development on internal research labs to discover new and more efficient production methods (Gangchalianke, 2002).

The Soviet capital was state-of-the-art in the 1950s, but became obsolete in the late 1960s, due to the development of continuous casting furnaces, that plants that received the know-how transfer were able to home-fabricate and use to replace Soviet open-hearth ones (Fruehan et al., 1997).[16] As a result, such plants were between 26.7 and 78.4 percent more likely to use continuous casting furnaces relative to plants that only received physical capital between 10 to 20 years after the Soviet transfer (Table 3, column 2). Conversely, the latter did not show more continuous casting furnaces usage than plants that didn't get any Soviet transfer, suggesting that the capital transfer is not associated with more innovation or better production processes if not associated to proper human capital training. Not surprisingly, the effects of Soviet physical capital faded out twenty years after the Soviet intervention, when the estimated life-cycle of Soviet capital ended. By contrast, plants that also received the know-how transfer were able to increase the production of better-quality steel relative to plants that only received the physical capital transfer, well beyond the life-cycle of the Soviet-imported machineries.

6.2 Trade with Western World after 1978

In the late 1970s, China began gradually opening to international trade, especially with the Western world. Among other consequences, this implied that Chinese plants could import machineries from the United States and Western Europe and export their products there. Khandelwal et al. (2013) has shown that the removal of quotas on Chinese textile and clothing exports to the U.S., E.U. and Canada in the 2000s led to larger productivity growth than that expected from eliminating trade barriers due to the concomitant abolition of the institutions that grew up around them. In a similar vein, we study if trade with

[16] More specifically, the continuous casting furnaces solidified molten metal into a "semifinished" billet, bloom, or slab for subsequent rolling in the finishing mills. Prior to that, steel was poured into stationary molds to form ingots. Continuous casting furnaces improved output, quality, productivity and cost efficiency.

Western world contributed to explain the observed further increase in performance of steel plants that also received Soviet know-how in the 1980s and 1990s.

Detailed data on foreign technology imports allow us to examine whether opening to trade differentially affected the 304 steel plants after 1978. Specifically, from the contracts description we can distinguish between imports of Western physical capital used to replace domestic one and imports of equipment complementary with plants' capital. The results indicate that plants that received the Soviet know-how imported 17.2 percent less physical capital to substitute their current one, relative to plants that only received the Soviet physical capital (Table 4, column 1). However, they imported 20.4 percent more foreign equipment used as a complement for their machineries (Table 4, column 2). Such plants were also able to take advantage of the new export possibilities. They exported 33.9 percent more steel into the Western world than plants that only received Soviet physical capital and produced 32.0 percent more steel above the international standards (Table 4, columns 3–4). This finding indicates that the quality of steel produced by plants that received the Soviet know-how was recognized not only in China, but also by the international steel market. By contrast, we do not observe differential imports of foreign capital and exports between plants that received Soviet physical capital and plants that eventually did not receive any Soviet transfer. This aspect can also contribute to explain the short-lived effect of Soviet capital transfer. When both types of plants could import foreign machineries, plants that received Soviet capital did no longer have a productivity advantage over plants that did not receive any Soviet transfer.

6.3 Human Capital

We next examine whether the composition of plant human capital could be a mechanism for long-run persistence. The high-skilled and low-skilled workers were in comparable numbers across the three types of plants at time of opening, as we have shown in our balancing tests (Table 2, Panel A), while total employment remained comparable over time (Table A.7, column 3). However, plants that received Soviet know-how opened training schools for high-skilled technicians and offered within-firm training programs to their engineers (Hirata, 2018; Ji, 2019). Consequently, over years such plants employed more engineers and high-skilled technicians and fewer low-skilled workers than plants that received the Soviet capital, that may have boosted plant productivity, allowing the effects of the know-how transfer to persist (Table A.18, columns 1–3). While it is hard to trace where these plants recruited new workers, given the strong limitation to migration imposed by the central government and lack of skilled human capital in the country (Hirata, 2018), it is likely that engineers and production supervisors trained by Soviet experts in turn internally trained their own employees, allowing them to reach more qualified positions in the firm hierarchy. Finally,

we do not observe differential changes in human capital composition between plants that received Soviet capital or that did not receive any Soviet capital, which further corroborates the importance of human capital training on firm performance.

7 Spillover Effects

One goal of the Soviet technology transfer was to create large industrial facilities to push local industrial development. In this section, we assess whether the transfer was successful in doing so, by examining the types of spillovers it generated.

7.1 Horizontal and Vertical Spillovers

We start our analysis by analyzing horizontal and vertical spillovers. On top of the 304 steel plants used in our main analysis, the Soviet aid involved the construction of 684 other smaller plants that were complementary to them, but that were not eligible to receive the Soviet transfers and used Chinese domestically capital. We consider such plants horizontally related to the 304 steel plants if they were in the same industry, and vertically related if they operated in upstream or downstream industries.[17] We estimate the following equation, separately for horizontally and vertically-related plants:

$$\begin{aligned} \text{outcome}_{jift} = \alpha \cdot \text{Physical Capital}_i + \beta(\text{Physical Capital}_i \cdot \text{Post Transfer}_t) \quad (4) \\ + \gamma \cdot \text{Know-How}_i + \delta(\text{Know-How}_i \cdot \text{Post Transfer}_t) \\ + \text{Soviet Entreprise}_f \cdot \text{Agreed Year}_i + \theta_\tau + \epsilon_{ift} \quad (5) \end{aligned}$$

where outcome_{jift} is logged tons of steel and TFP of plant j horizontally/vertically related to plant i supposed to duplicate Soviet plant f in year t; Pysical Capital_i is an indicator for plants horizontally/vertically related to plants that received Soviet physical capital transfer; Know-How_i is an indicator for plants horizontally/vertically related to plants that also received Soviet know-how transfer; and the other variables are defined as in equation 1.

Plants horizontally related to plants that received the know-how transfer showed better performance relative to those horizontally related to plants that received the physical capital after 1960. Specifically, they produced 12.9% more output and were 12.4% more productive (Table 5, columns 1–2). Moreover, they were more likely to adopt the same

[17] We do so by retrieving the two-digit industry code from the Steel Association Reports. If firms had the same two-digit industry code of the 304 plants, we consider them horizontally related. If firms had a different two-digit industry, we use the input-output matrix provided by the National Bureau of Statistics of China to assess whether firm products were vertically related to the 304 plants. More details about this process can be found in Appendix B.4.

technology as plants that received the know-how transfer, using the basic oxygen converters and continuous-casting furnaces before 1978, and exporting significantly more and produced a higher quantity of steel above the international standards after 1978. By contrast, we do find evidence of differences in production, productivity and technological adoption between plants horizontally related to plants that received only the Soviet physical capital and to plants that eventually did not receive any Soviet capital.

Plants vertically related to plants that received the Soviet physical capital only had higher production relative to plants vertically related to plants that did not receive any Soviet transfer. Compared to the latter, in the former the quantity of steel produced, comparable before the Soviet transfer, is 14.2 percent higher (Table 6, column 1). These findings are fully consistent with the increased production of plants that received Soviet physical capital, which in turn may have affected their supply chain. However, only plants vertically related to plants that also received the know-how transfer experienced a productivity increase after the Split, estimated to be 14.1 percent, relative to plants vertically related to plants that received the Soviet physical capital (Table 6, column 2). These companies are also the only ones to register 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 6, columns 3–6). The higher quality of supplied inputs may have in turn helped the differential performance of plants that received the know-how transfer to persist over time.

Overall, the spillover analysis presented so far is consistent with the findings in Greenstone et al. (2010), that show how productivity spillovers generated by the Million Dollar Plants are related mainly to workers' flow rather than to differences in inputs and outputs. In our case, spillovers appear to be generated by a flow of knowledge among plants horizontally and vertically related. By contrast, such plants do not appear harmed by the proximity of large steel plants. This is not surprising, given the booming Chinese demand for steel in the 1950s, that continued to be larger than the supply until at least the end of the 1970s.

7.2 The Role of Institutional Reforms

Starting in the late 1990s, the Chinese government undertook a number of market-liberalization reforms. The goal of these initiatives was to release resources that could be more profitably employed by privatizing state-owned firms (Hsieh and Song, 2015). In Section 7.1 we showed that plants related to plants that received the Soviet know-how outperformed those under the control of plants that received either only the Soviet physical capital or that eventually did not receive any transfer from the Soviet Union. We therefore test if these effects persisted after market liberalization, extending our analysis to firms in all the industries between 1998 and 2013.

The results indicate that firms horizontally or vertically related to plants that received the Soviet know-how performed better in terms of value added, TFPR and exports than firms related to plants that only received Soviet physical capital, only if they were privatized (Table A.19, Panel A, columns 1–4). Moreover, new private firms that related to plants that received the Soviet know-how had an additional performance gain relative to new firms related to plants that received either only the Soviet physical capital or that eventually did not receive any transfer from the Soviet Union. By contrast, firms that remained state-owned did no longer show a competitive advantage (Table A.19, Panel A, columns 1–4). Similarly, private and state-owned firms related to plants that received either only the Soviet physical capital or that eventually did not receive any transfer did not show differential outcomes (Table A.19, Panel A, columns 7–8).[18]

At the county-level, these changes were associated to an increased share of industrial output produced by private firms. Specifically, counties that hosted plants that received Soviet know-how had on average 16.6 percent more private firms relative to counties that hosted plants that only received Soviet physical capital and 25.2 percent more privately-produced industrial output (Table A.20, columns 1 and 4). Conversely, there were no differences between counties that hosted plants that only received Soviet physical capital and plants that did not receive any Soviet transfer.

Which mechanisms drove these results? We first test if counties that hosted plants that received the Soviet know-how had a higher concentration of industry-specific human capital. Historical anecdotes, in fact, explain that such plants offered training programs for engineers and created professional schools for high-skilled technicians working at their own plants during the Cultural Revolution, when most universities in the country were shut down, that were institutionalized after 1978 (Filatov, 1980). Consequently, we find that universities in counties that hosted plants that received the know-how transfer were 10.4 percentage points more likely to offer STEM (science, technology, engineering, and math) university degrees and had a 16.8 percent higher number of technical schools per inhabitant relative to counties that hosted plants that received the physical capital transfer (Table A.21, columns 1 and 2). This was associated to a 14.3 percent higher number of STEM college graduates and a 17.6 percent higher number of high-skilled workers over population (Table A.21, columns 3 and 4). When firms started competing for inputs in the local market, companies that became privately owned in counties that hosted plants which received the Soviet know-how may have been able to hire these better educated workers, with positive effects on their performance.

Another potential mechanism could be that the government may have invested more re-

[18] It is worth noting that in industries not related to the 156 Projects, we do not observe any difference in performance among firms in the same counties (Table A.19, Panel B).

sources in counties that hosted such plants, allowing firms located there to perform better, despite the technology transfer received. In Section 5.3, we showed that total investments, and investments in related and unrelated industries of the 156 Projects, were not statistically different between counties that hosted different types of Soviet plants between 1949 and 2000 (Table A.13, columns 1–3), which suggests that this potential channel is not driving our results.

The findings documented in this section may seem at odd with those reported by Heblich et al. (2020), that compare counties where the 156 Projects were located with counties suitable to host them but that were not selected, finding that the former had a significant productivity advantage that was fully eroded during the 1990s due to overspecialization and reduced innovation. However, we compare plants and counties that were selected to be part of the 156 Projects and eventually received different types of Soviet transfers or did not. In other words, we show that, even within specialization in the 156 Projects, the type of transfers received from the Soviet Union determined different long-run spillover effects. More in general, the goal of our paper is to disentangle the effects of different types of foreign interventions following the same plants over 50 years, rather than estimating the county long-run spillover effects of industrial policy interventions.

7.3 Cost-Benefit Analysis

The historical literature describes the Sino-Soviet Alliance as vital factor in Chinese early industrial development (Lardy, 1995; Naughton, 2007; Zhang et al., 2006). In this section, we assess whether the investment in the 156 Projects was profitable for the Chinese economy, performing a simple cost-benefit analysis between 1952 and 1978.

We compute the direct costs of the 156 Projects as the sum of their total value when they were built ($80 billion in 2020 figures) and the loan China received from the 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." While we cannot estimate the welfare costs caused by this decision, we calculate the opportunity costs of the 156 Projects 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). We compute the benefits of the Sino-Soviet Alliance as the contribution to the Chinese GDP by the 156 Projects, whose value added amounted to $15.7 billion (in 2020 figures) on average per year between 1952 and 1978. Therefore, the benefits of the Soviet

transfer were 2.5 times higher than the costs, confirming the historical evidence.[19]

8 Conclusions

This paper studies the effects of industrial policy and the impact of technology and know-how transfers on early industrial development. We collected novel data on the 156 Projects sponsored by the Soviet Union for the construction of technologically advanced, capital-intensive industrial clusters in China in the 1950s. To identify the causal effect, we rely on idiosyncratic delays on the Soviet side, combined with the Sino-Soviet Split in 1960, due to which some plants received both physical capital and know-how transfers, some others only got Soviet physical capital, while the remaining ones didn't get any Soviet transfers and continued to employ traditional Chinese capital goods. We find that the know-how transfer had long-lasting effects on plant performance, that further improved after 1978, when China opened up to international trade, thanks to exports. Receiving only Soviet physical capital had, by contrast, a short-lived impact on plant outcomes. Plants that received the know-how transfer also generated positive horizontal and vertical spillovers, and a higher production reallocation from state-owned to privately owned companies since the late 1990s.

Studying China, a country that moved from being largely agricultural in 1949 to being one of the major industrial powers since the 2000s, not only provides detailed documentation of one of the fastest structural transformations of a large economy (Morrison, 2019), but could also be informative for various developing countries today, where technology and know-how transfers remain among the most common means of international aid from the most developed economies (McKenzie and Woodruff, 2014).

More broadly, this paper sheds new light on the short-, medium-, and long-run impact of industrial policies and how they interact with major economic changes, such as the opening to trade and privatization campaigns, contributing to a nascent but rapidly growing literature that exploits natural experiments to study the origin of industrial development (Juhász, 2018; Giorcelli, 2019; Mitrunen, 2020; Lane, 2023). 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 know-how, not only for improving firm performance and technology development but also for propagating knowledge to other companies, with the subsequent creation of industry-specific high-skilled human capital in the long run.

[19] The calculation is performed as followed: billion [$15.7*25/($80 +$2.93+$2.6*25)]=2.65

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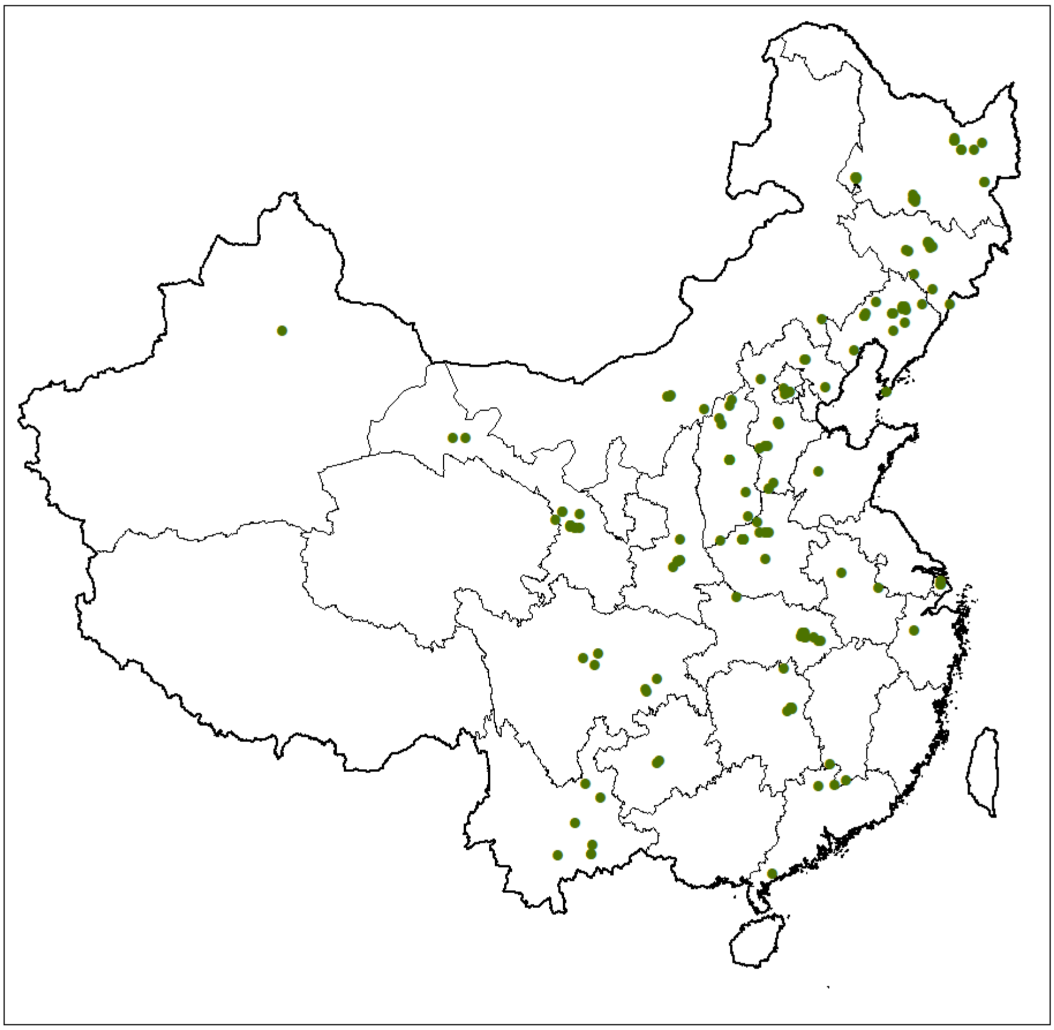
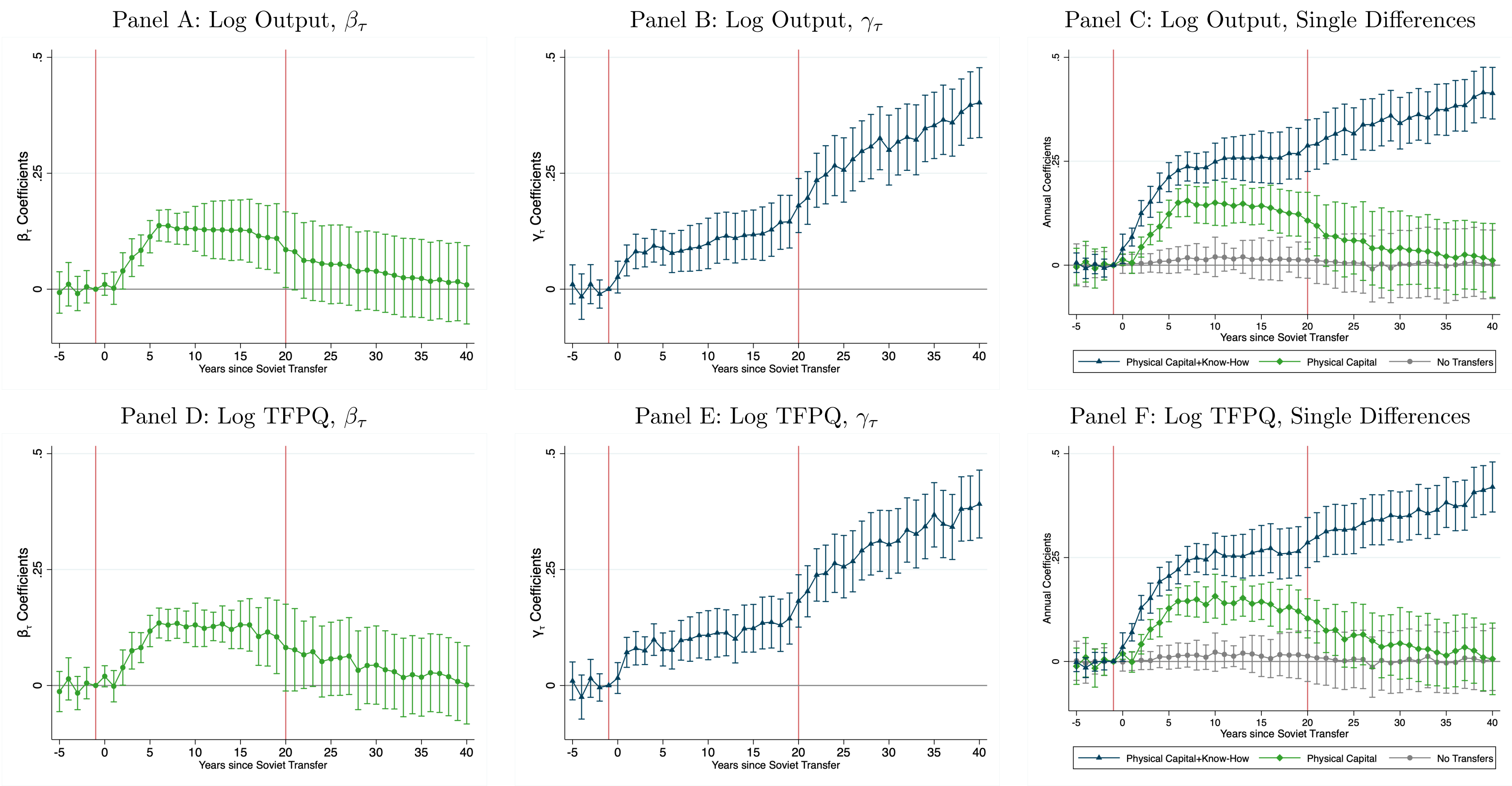
Figures and Tables

Figure 1: Distribution of the 156 Projects



Notes. 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.

Figure 2: Yearly Effects of Soviet Physical and Know-How Transfers on Plant Production and Productivity



Notes. Annual β_τ coefficients (Panels A and D) and γ_τ coefficients (Panel B and E) from Equation 1 and single differences (Panels C and F) for 304 steel plants belonging to the 156 Projects. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Physical output* is logged quantities (in million tons) of steel. *Productivity (TFPQ)* is logged total factory productivity quantity, 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. The first vertical line identifies the beginning of the Soviet transfer. The second vertical line identifies China's opening to international trade. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 1: Summary Statistics for the 156 Projects

	Mean (1)	SD (2)	Min (3)	Max (4)
Panel A: All Projects				
Approval Year	1953.42	1.48	1952	1957
Start Year	1955.22	1.11	1953	1958
Expected Physical Capital Delivery Year	1957.87	3.06	1954	1961
Expected Soviet Experts Arrival Year	1958.62	2.77	1955	1963
Planned Investment (m)	580.34	224.14	80.03	3,232.81
Actual Investment (m)	549.76	215.89	91.87	3,201.93
Expected Equipment Value (m)	259.35	49.76	48.79	1,340.55
Number of Workers (k)	39.91	14.1	25.8	70.61
Number of Plants	8.69	1.57	2	9
Expected Length	5.64	1.39	3	9
Observations	139	139	139	139
Panel B: Steel Industry				
Approval Year	1953.67	1.56	1952	1957
Start Year	1955.41	0.69	1952	1957
Expected Physical Capital Delivery Year	1957.26	2.96	1954	1962
Expected Soviet Experts Arrival Year	1958.49	2.85	1955	1963
Planned Investment (m)	746.89	361.29	167.28	3,232.81
Actual Investment (m)	725.48	343.76	169.02	3,201.93
Expected Equipment Value (m)	469.39	36.78	103.71	1,340.55
Number of Workers (k)	46.67	11.38	31.29	70.61
Number of Plants	15.20	1.33	6	22
Expected Length	6.12	0.72	5	9
Observations	20	20	20	20

Notes. Summary statistics for the 139 industrial clusters, known as the 156 Projects. Data are provided at the project level from the National Archives Administration of China. Columns 1-4 present, respectively, mean, standard deviation, minimum and maximum of characteristics of all the 139 industrial clusters in Panel A and for 20 industrial clusters in the steel industry in Panel B. *Expected Physical Capital Delivery* is the plants' cluster average expected year of Soviet physical capital delivery; *Expected Soviet Experts Arrival* is the plants' cluster average expected year of Soviet experts arrival. *Approval* and *Start Year* are the approval and start year of each cluster; *Planned*, *Actual Investment* and *Expected Equipment Value* are, respectively, the investment planned at the approval time, the investment eventually realized, and the value of the equipment a cluster was expecting to receive from Soviet Union, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Number of Workers(k)* is number of employees per cluster, in thousands; *Number of Plants* is number of plants per clusters; *Expected Length* is the expected length to complete construction in years; *Expected Capacity* is the capacity planned at the approval time of each cluster, measured in 10,000 tons per kilowatt.

Table 2: Balancing Tests for the 304 Steel Plants, Panel A: Plant Characteristics and Outcomes

	Mean (1-3)			Difference (4-6)		
	Physical capital + Know-How	Physical capital	No Soviet Transfer	Physical Capital	Know-How	*p*-value
	(1)	(2)	(3)	(4)	(5)	(6)
Expected Physical Capital Year	1957.31	1957.44	1957.08	-0.13	0.36	0.781
	(3.45)	(3.59)	(3.12)	(0.78)	(0.81)	
Expected Soviet Experts Year	1958.56	1958.78	1958.21	-0.22	0.57	0.715
	(2.96)	(2.71)	(2.88)	(0.93)	(0.81)	
Steel Production (m tons)	602.06	604.24	602.85	-2.04	1.02	0.602
	(19.43)	(18.67)	(23.67)	(3.71)	(3.67)	
Crude Steel Production (m tons)	153.49	152.82	154.62	0.81	-1.89	0.726
	(13.98)	(14.18)	(14.23)	(2.26)	(2.68)	
Pig Iron Production (m tons)	96.08	101.04	99.31	-4.91	1.76	0.523
	(15.18)	(15.70)	(15.12)	(4.39)	(2.53)	
Current Assets (m)	17.84	17.96	19.10	-0.13	-0.91	0.625
	(2.82)	(2.09)	(2.08)	(0.36)	(1.90)	
Annual Sales (m)	17.83	17.18	18.04	0.069	-0.89	0.708
	(3.30)	(3.56)	(2.45)	(1.15)	(1.08)	
Value Added (m)	2.59	2.53	2.51	0.06	0.04	0.548
	(0.16)	(0.27)	(0.20)	(0.11)	(0.07)	
Productivity (log TFPQ)	1.21	1.28	1.25	-0.08	0.04	0.523
	(0.32)	(0.55)	(0.25)	(0.17)	(0.13)	
Employees (k)	3.49	3.60	3.44	-0.11	0.14	0.753
	(1.03)	(0.72)	0.83	(0.19)	(0.21)	
Engineers (k)	0.38	0.36	0.37	0.02	-0.02	0.567
	(0.04)	(0.05)	(0.05)	(0.03)	(0.02)	
High-Skilled Technicians (k)	0.51	0.57	0.52	0.15	-0.24	0.636
	(0.14)	(0.36)	(0.33)	(0.18)	(0.27)	
Unskilled Workers (k)	2.60	2.64	2.62	-0.06	-0.05	0.604
	(1.05)	(0.75)	(0.91)	(0.07)	(0.09)	
Loans	5.24	5.43	5.09	-0.20	0.34	0.768
	(0.96)	(1.86)	(2.18)	(0.29)	(0.44)	
Transfers	4.10	4.37	3.96	-0.29	0.41	0.706
	(1.05)	(2.15)	(2.12)	(0.35)	(0.52)	
Observations	98	91	115	304	304	304

Table 2: Balancing Tests for the 304 Steel Plants, Panel B: Geographical Location and Natural Resources

	Mean (1-3)			Difference (4-6)		
	Physical capital + Know-How	Physical capital	No Soviet Transfer	Physical Capital	Know-How	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
Distance Border (km)	231.60	230.44	229.45	1.15	0.98	0.738
	(61.34)	(62.15)	(65.74)	(1.89)	(1.66)	
Distance Province (km)	67.32	68.25	68.18	-0.91	0.09	0.788
	(17.89)	(16.58)	(18.01)	(1.15)	(0.77)	
Distance Coast (km)	515.64	517.76	514.28	-2.10	3.41	0.742
	(54.39)	(58.71)	(56.32)	(2.38)	(4.09)	
Distance Treated Ports (km)	581.30	582.83	580.93	-1.55	1.92	0.637
	(41.32)	(43.98)	(42.72)	(2.09)	(2.39)	
Distance Highway (km)	38.11	37.65	38.42	0.49	-0.79	0.732
	(12.43)	(11.57)	(13.42)	(0.89)	(1.12)	
Distance Railway (km)	63.49	62.55	62.31	0.96	0.21	0.608
	(21.19)	(22.40)	(19.87)	(0.99)	(0.31)	
Distance Coal Deposits (km)	5.77	6.03	5.82	-0.23	0.26	0.698
	(2.58)	(2.41)	(2.98)	(0.34)	(0.39)	
Distance Coke Deposits (km)	7.59	7.68	7.21	-0.11	0.49	0.648
	(3.48)	(3.87)	(3.09)	(0.29)	(0.61)	
Observations	98	91	115	304	304	304

Notes. Balancing tests for 304 steel plants in the 20 steel industrial clusters. Data are provided at plant level from the Steel Association Reports. Columns 1-3 report mean and standard deviation (in parentheses) of characteristics and outcomes (Panel A) and geographical location and access to natural resources (Panel B), separately for 98 plants that received both physical capital and know-how transfers from the Soviet Union (column 1), 91 plants that received only physical capital transfer from Soviet Union (column 2), and 115 plants that did not receive any Soviet transfer (column 3). Columns 4 and 5 report the coefficients estimated from regressing each plant variable on an indicator for receiving the Soviet physical capital transfer, an indicator for receiving the Soviet know-how transfer, and fixed effects for Soviet factory supposed to be replicated interacted with the year when Soviet transfer was supposed to be received. Column 6 reports the p-value of testing jointly equality of the coefficients to zero. *Expected Physical Capital Year* is the expected year of Soviet physical capital delivery in a plant. *Expected Soviet Experts Year* is the expected year of Soviet experts' arrival in a plant. *Steel, Crude Steel* and *Pig Iron Production* are in million tons. *Current Assets, Annual Sales* and *Value Added* are 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Productivity (logged TFPQ)* is logged total factor productivity quantity, 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 Gandhi et al. (2020)'s method; *Employees per plant, Engineers, High-Skilled Technicians*, and *Unskilled Workers* are, respectively, thousands of employees, engineers, high-skilled technicians and unskilled workers; *Loans* and *Transfers* are, respectively, loans and free transfers that the government granted to each plant, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. *Distance Border, Province, Coast, Treated Ports, Highway, Railways, Coal* and *Coke Deposits* are the plant distance in km from the national border, province border, coast, Treated Ports, highway and railway as in 1952, and coal and coke deposits. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Effects of Soviet Transfer on Chinese Technology Development before 1978

	Prob. Oxy. (1)	Prob. Cast. (2)		Prob. Oxy. (1)	Prob. Cast. (2)
Physical Capital * Year 1	0.006	0.005	Know-How * Year 1	0.003	0.008
	(0.005)	(0.009)		(0.010)	(0.011)
Physical Capital * Year 5	0.009	0.007	Know-How * Year 5	0.252***	0.019
	(0.010)	(0.008)		(0.041)	(0.013)
Physical Capital * Year 10	0.009	0.006	Know-How * Year 10	0.345***	0.267***
	(0.010)	(0.008)		(0.053)	(0.051)
Physical Capital * Year 20	0.007	0.010	Know-How * Year 20	0.651***	0.784***
	(0.009)	(0.014)		(0.151)	(0.143)
Plant FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	12,160	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1. Data are provided at the plant level from Steel Association Reports from 1949 to 2000. *Prob. Oxy* and *Prob. Cast.* are indicators for plants using the basic oxygen converters and the continuous casting furnaces. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Trade with Western World after 1978

	Substitute Capital (1)	Complementary Equipment (2)	Log Exports (3)	Log Int. Stand. (4)
Physical Capital * Post 1978	0.012	0.013	0.014	0.010
	(0.009)	(0.010)	(0.018)	(0.012)
Know-How * Post 1978	-0.159***	0.186***	0.292***	0.278***
	(0.048)	(0.051)	(0.041)	(0.043)
Plant FE	Yes	Yes	Yes	Yes
Observations	12,160	12,160	12,160	12,160

Notes. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received know-how transfer. *Post* is an indicator for years after receiving the Soviet transfer. *Post 1978* is an indicator for years after 1978. *Substitute Capital, Complementary Equipment, Exports* and *Int. St.* are logged values of foreign imported capital used to replace Soviet one, foreign equipment complementary with plant physical capital, exports, and quantity of steel that meet international standards. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: 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)
Physical Capital	-0.018	-0.016	-0.009	0.007	0.008	0.009
	(0.022)	(0.038)	(0.010)	(0.011)	(0.010)	(0.012)
Know-How	0.012	0.014	0.006	0.011	0.005	0.006
	(0.014)	(0.016)	(0.008)	(0.015)	(0.007)	(0.009)
Physical Capital * Post	0.006	0.011	0.009	0.012	0.007	0.012
	(0.008)	(0.015)	(0.010)	(0.013)	(0.011)	(0.013)
Know-How * Post	0.122***	0.117***	0.308***	0.319***	0.016	0.019
	(0.017)	(0.015)	(0.111)	(0.123)	0.011)	(0.016)
Physical Capital * Post 1978	-0.015	0.022	0.004	0.006	0.005	0.009
	(0.020)	(0.021)	(0.010)	(0.011)	(0.008)	(0.012)
Know-How * Post 1978	0.022***	0.018***	0.033***	0.045***	0.187***	0.201***
	(0.007)	(0.006)	(0.012)	(0.009)	(0.051)	(0.065)
Plant FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,550	13,550	13,550	13,550	13,550	13,550

Notes. *Physical Capital* is an indicator for plants horizontally related to plants that received Soviet physical capital. *Know-How* is an indicator for plants horizontally related to plants that also received know-how transfer. *Post* is an indicator for years after receiving the Soviet transfer. *Post1978* is an indicator for years after 1978. *Log Output* is logged quantities (in million tons) of steel. *Log TFPQ* is logged total factor productivity quantity, 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 block-bootstrapped at the industrial cluster level with 1,000 replications. ***p<0.01, **p<0.05, *p<0.1.

Table 6: 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)
Physical Capital	0.008	0.004	0.005	0.006	0.004	0.007
	(0.011)	(0.006)	(0.007)	(0.010)	(0.009)	(0.010)
Know-How	0.003	0.009	0.004	0.009	0.005	0.006
	(0.004)	(0.006)	(0.005)	(0.010)	(0.008)	(0.009)
Physical Capital * Post	0.133***	0.011	0.009	0.006	0.016	0.012
	(0.022)	(0.014)	(0.011)	(0.009)	(0.015)	(0.016)
Know-How * Post	0.152***	0.132***	0.106***	0.100***	0.004	0.006
	(0.035)	(0.039)	(0.031)	(0.025)	(0.005)	(0.009)
Physical Capital * Post 1978	-0.015	0.022	0.004	0.006	0.009	0.011
	(0.020)	(0.021)	(0.010)	(0.011)	(0.010)	(0.025)
Know-How * Post 1978	0.034***	0.028***	0.029***	0.037***	0.145***	0.138***
	(0.008)	(0.007)	(0.008)	(0.006)	(0.032)	(0.031)
County-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,340	15,340	15,340	15,340	15,340	15,340

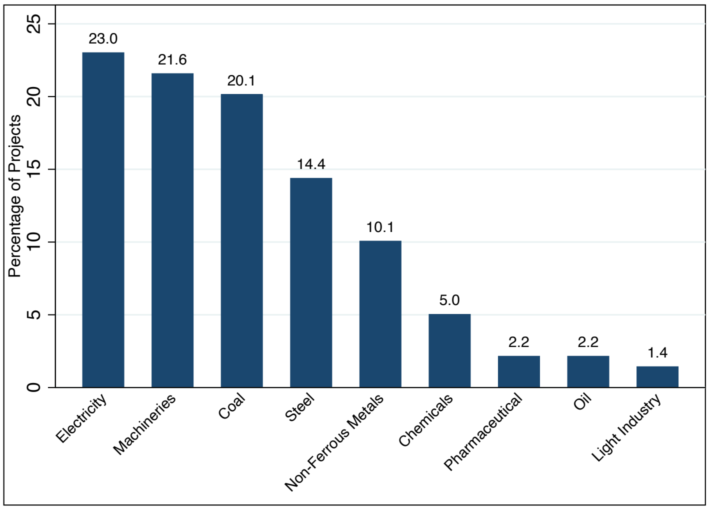
Notes. *Physical Capital* is an indicator for plants vertically related to plants that received Soviet physical capital. *Know-How* is an indicator for plants vertically related to plants that received also know-how transfer. *Post* is an indicator for years after receiving the Soviet transfer. *Post1978* is an indicator for years after 1978. *Log Output* is logged quantities (in million tons) of steel. *Log TFPQ* is logged total factor productivity quantity, 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 block-bootstrapped at the industrial cluster level with 1,000 replications. ***p<0.01, **p<0.05, *p<0.1.

Online Appendix — Not for Publication

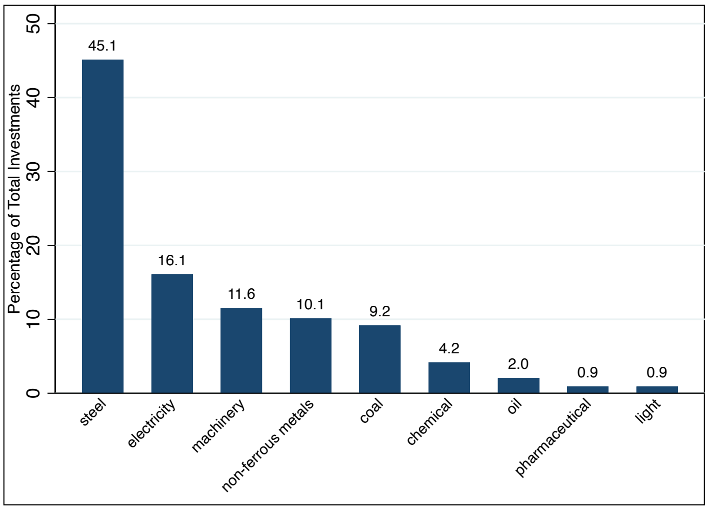
Additional Figures and Tables

Figure A.1: The 156 Projects by Industry

Panel A: Number of Industrial Clusters by Industry



Panel B: Percentage of Total Investments per Industry



Notes. Distribution of the 139 civilian industrial clusters, known as the 156 Projects. Panel A reports the number of industrial clusters by industry. Panel B reports the percentage of total investments by industry. Data are provided at the project level from the National Archives Administration of China.

Table A.1: Pre-Soviet Intervention Difference in Time Trends among the 304 Steel Plants

	Log Steel	Log Crude Steel	Log Pig Iron	Log Current Assets
	(1)	(2)	(3)	(4)
Physical Capital * Trend	-0.001	0.006	-0.004	0.002
	(0.001)	(0.009)	(0.004)	(0.003)
Know-How * Trend	0.005	0.002	-0.005	-0.003
	(0.008)	(0.003)	(0.007)	(0.004)
Time Trend	-0.009	-0.002	-0.004	0.009
	(0.010)	(0.002)	(0.006)	(0.012)
Physical Capital	0.003	-0.005	0.007	-0.005
	(0.006)	(0.009)	(0.015)	(0.011)
Know-How	0.005	-0.012	-0.012	-0.007
	(0.005)	(0.010)	(0.016)	(0.014)
	Log Sales	Log Value Added	Log TFPQ	Log Employees
Physical Capital * Trend	-0.002	0.002	-0.002	-0.006
	(0.005)	(0.003)	(0.012)	(0.008)
Know-How * Trend	0.002	0.001	-0.016	0.009
	(0.005)	(0.002)	(0.017)	(0.010)
Time Trend	0.002	-0.002	-0.004	-0.002
	(0.003)	(0.001)	(0.005)	(0.005)
Physical Capital	-0.005	-0.014	-0.007	0.010
	(0.017)	(0.012)	(0.006)	(0.011)
Know-How	-0.015	0.013	-0.013	0.016
	(0.016)	(0.017)	(0.016)	(0.014)
	Log Engineers	Log High-Skilled	Log Loans	Log Transfers
Physical Capital * Trend	0.002	0.007	-0.004	0.013
	(0.004)	(0.009)	(0.006)	(0.016)
Know-How * Trend	-0.002	0.004	-0.003	0.014
	(0.004)	(0.003)	(0.011)	(0.011)
Time Trend	-0.005	-0.003	0.001	-0.013
	(0.009)	(0.003)	(0.010)	(0.011)
Physical Capital	-0.009	-0.011	0.017	0.004
	(0.014)	(0.015)	(0.018)	(0.005)
Know-How	0.018	-0.013	0.010	0.007
	(0.013)	(0.011)	(0.012)	(0.012)
Observations	2,114	2,114	2,114	2,114
Soviet Entreprise x Agreed Year FE	Yes	Yes	Yes	Yes

Notes. OLS regressions predicting plant outcomes before receiving the Soviet transfer. Data are provided at plant level from the Steel Association Reports. Outcomes are allowed to vary according to a linear time trend that differs for plants that received Soviet physical capital and Soviet know-how. *Steel, Crude Steel* and *Pig Iron Production* are in million tons. *Current Assets, Sales* and *Value Added* are measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Productivity (logged TFPQ)* is logged total factor productivity quantity, 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; *Employees, Engineers,* and *High-Skilled Technicians* are, respectively, thousands of employees, engineers, and high-skilled technicians; *Loans* and *Transfers* are, respectively, loans and free transfers that the government granted to each plant, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.2: Pre-Soviet Technology Intervention Difference in Yearly Time Trends among the 304 Steel Plants – continues

	Log Steel	Log Crude Steel	Log Pig Iron	Log Current Assets
	(1)	(2)	(3)	(4)
Physical Capital * (t-2)	0.001	-0.011	0.007	-0.004
	(0.006)	(0.014)	(0.012)	(0.012)
Physical Capital * (t-3)	0.012	-0.012	-0.008	-0.008
	(0.016)	(0.011)	(0.007)	(0.009)
Physical Capital * (t-4)	0.004	-0.006	0.009	-0.007
	(0.007)	(0.007)	(0.012)	(0.007)
Physical Capital * (t-5)	-0.002	-0.016	-0.013	-0.008
	(0.006)	(0.015)	(0.023)	(0.009)
Know-How * (t-2)	0.006	-0.004	0.002	-0.012
	(0.006)	(0.007)	(0.004)	(0.015)
Know-How * (t-3)	0.005	-0.009	-0.008	-0.009
	(0.006)	(0.013)	(0.012)	(0.012)
Know-How * (t-4)	0.008	-0.011	0.008	-0.005
	(0.007)	(0.013)	(0.012)	(0.011)
Know-How * (t-5)	0.004	-0.009	-0.006	-0.006
	(0.007)	(0.015)	(0.015)	(0.011)
Observations	2,114	2,114	2,114	2,114
Soviet Plant x Agreed Year FE	Yes	Yes	Yes	Yes
F-statistics	0.486	0.435	0.251	0.699

	Log Sales	Log Value Added	Log TFPQ	Log Employees
Physical Capital * (t-2)	-0.006	-0.012	-0.009	0.014
	(0.009)	(0.011)	(0.009)	(0.016)
Physical Capital * (t-3)	-0.012	0.012	-0.008	-0.007
	(0.015)	(0.010)	(0.007)	(0.011)
Physical Capital * (t-4)	-0.007	-0.012	-0.004	0.012
	(0.011)	(0.013)	(0.005)	(0.016)
Physical Capital * (t-5)	-0.008	0.021	0.017	0.013
	(0.013)	(0.029)	(0.015)	(0.014)
Know-How * (t-2)	0.003	-0.012	-0.012	0.006
	(0.004)	(0.014)	(0.016)	(0.006)
Know-How * (t-3)	0.005	0.007	-0.006	0.006
	(0.008)	(0.010)	(0.009)	(0.009)
Know-How * (t-4)	-0.008	-0.008	-0.005	0.004
	(0.009)	(0.013)	(0.009)	(0.008)
Know-How * (t-5)	0.010	0.006	-0.007	0.007
	(0.015)	(0.009)	(0.007)	(0.012)
Observations	2,114	2,114	2,114	2,114
Soviet Plant x Agreed Year FE	Yes	Yes	Yes	Yes
F-statistics	0.563	0.427	0.361	0.623

Table A.2: Pre-Soviet Technology Intervention Difference in Yearly Time Trends among the 304 Steel Plants – continued

	Log Engineers	Log High-Skilled	Log Loans	Log Transfers
Physical Capital * (t-2)	-0.009	-0.007	-0.018	-0.007
	(0.013)	(0.013)	(0.013)	(0.006)
Physical Capital * (t-3)	0.013	-0.005	0.017	0.009
	(0.019)	(0.007)	(0.015)	(0.016)
Physical Capital * (t-4)	-0.014	-0.011	0.007	0.009
	(0.020)	(0.012)	(0.006)	(0.009)
Physical Capital * (t-5)	0.011	-0.009	0.006	0.015
	(0.018)	(0.011)	(0.006)	(0.014)
Know-How * (t-2)	-0.016	-0.010	0.004	0.008
	(0.019)	(0.012)	(0.0607)	(0.010)
Know-How * (t-3)	0.015	-0.019	0.016	0.008
	(0.020)	(0.020)	(0.018)	(0.009)
Know-How * (t-4)	-0.014	-0.003	0.008	0.012
	(0.020)	(0.005)	(0.008)	(0.015)
Know-How * (t-5)	0.007	-0.009	0.012	0.012
	(0.011)	(0.014)	(0.013)	(0.016)
Observations	2,114	2,114	2,114	2,114
Soviet Plant x Agreed Year FE	Yes	Yes	Yes	Yes
F-statistics	0.709	0.337	0.380	0.410

Notes. OLS regressions predicting plant outcomes before in the five years before receiving the Soviet transfer. Data are provided at plant level from the Steel Association Reports. The trend is allowed to vary freely for each year before receiving the Soviet transfer for plants that received Soviet physical capital and Soviet know-how. Time period indicators are included, but not reported. The omitted period is t=-1, the year before receiving the Soviet transfer. *Steel, Crude Steel* and *Pig Iron Production* are in million tons. *Current Assets, Sales* and *Value Added* are measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Productivity (logged TFPQ)* is logged total factor productivity quantity, 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 Gandhi et al. (2020)'s method; *Employees, Engineers,* and *High-Skilled Technicians* are, respectively, thousands of employees, engineers, and high-skilled technicians; *Loans* and *Transfers* are, respectively, loans and free transfers that the government granted to each plant, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. The F-statistics test whether all the interaction terms between physical capital and know-how and the year indicators are jointly zero. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.3: Differences in the Industrial Clusters Hosting the 304 Steel Plants

	Physical Capital (1)	Know-How (2)	p-value (3)
Approval Year	0.012	-0.008	0.608
Start Year	-0.015	0.003	0.767
Planned Investment (m)	-0.019	0.011	0.861
Actual Investment (m)	0.011	-0.005	0.619
Expected Equipment Value (m)	0.013	-0.006	0.561
Number of Workers (k)	-0.009	0.010	0.667
Number of Plants	-0.008	0.005	0.522
Expected Length	0.003	0.002	0.538
Expected Capacity (m tons)	0.010	-0.007	0.441
Observations	304	304	304

Notes. Coefficients from regressing industrial cluster characteristics each plant belonged to on an indicator for receiving the Soviet physical capital transfer, an indicator for receiving the Soviet know-how transfer, and fixed effects for Soviet factory supposed to be replicated interacted with year when Soviet transfer was supposed to be received. Data are provided at the project level from the National Archives Administration of China. Column 3 reports the p-value of testing jointly equality of the coefficients to zero. *Approval* and *Start Year* are the approval and start year of each industrial cluster; *Planned*, *Actual Investment* and *Expected Equipment Value* are, respectively, the investment planned at the approval time, the investment eventually realized, and the value of the equipment an industrial cluster was expected to receive from the Soviet Union, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Number of Workers* is number of employees, in thousands; *Number of Plants* is number of plants in the industrial cluster; *Expected Length* is the expected project length in years; *Expected Capacity* is the capacity planned at the approval time of each project, measured in 10,000 tons per kilowatt. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.4: Differences in Counties Hosting the 304 Plants in 1953

	Physical Capital	Know-How	p-value
	(1)	(2)	(3)
Log Total Firms	0.018	-0.013	0.556
	(0.013)	(0.011)	0.631
Log Population	-0.015	0.012	0.743
	(0.016)	(0.013)	0.518
Employment Share	0.006	0.003	0.691
	(0.014)	(0.006)	0.544
Log Gvt. Funds	0.004	0.007	0.701
	(0.011)	(0.012)	0.498
Observations	304	304	304

Notes. Coefficient from regressing county characteristic each plant was located in on an indicator for receiving the Soviet physical capital transfer, an indicator for receiving the Soviet know-how transfer, and fixed effects for Soviet factory supposed to be replicated interacted with year when Soviet transfer was supposed to be received. Data are provided at county-level from the People's Republic of China Population Digest in 1953. Column 3 reports the p-value of testing jointly equality of the coefficients to zero. *Log total firms* is logged total number of firms per county; *Log population* is logged total population of a county; *Employment Share* is the fraction of employed population over total population; *Log Gvt. Funds* is logged free transfers that the government granted to a county, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. Standard errors are clustered at the county level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.5: Correlation Between Plant Characteristics and Probability of Machinery and Experts Accidents

	Pr Accident Physical Capital (1)	Pr Experts Delays (2)
Steel Production (m tons)	-0.002	0.013
	(0.003)	(0.018)
Crude Steel Production (m tons)	-0.002	-0.008
	(0.003)	(0.004)
Pig Iron Production (m tons)	0.001	-0.003
	(0.002)	(0.005)
Value Added (m)	-0.002	0.002
	(0.005)	(0.003)
Productivity (log TFPQ)	-0.004	-0.008
	(0.008)	(0.007)
Employees per Plant (k)	0.002	-0.002
	(0.004)	(0.003)
Engineers (k)	0.003	0.002
	(0.004)	(0.003)
High-Skilled Technicians (k)	-0.002	-0.001
	(0.006)	(0.001)
Unskilled Workers (k)	0.003	0.003
	(0.004)	(0.005)
Loans	-0.005	-0.002
	(0.006)	(0.003)
Transfers	-0.002	0.005
	(0.002)	(0.008)
Distance Cole Deposits (km)	0.002	-0.004
	(0.003)	(0.006)
Distance Coke Deposits (km)	-0.001	-0.005
	(0.002)	(0.004)
Soviet plant x Agreed Year FE	Yes	Yes
Observations	304	304

Notes. *Pr Accident Physical Capital* is an indicator for plants whose Soviet physical capital suffered an accident. *Pr Experts Delays* is an indicator for plants whose Soviet experts' trips were delayed from the Soviet side. Data are provided at plant level from the Steel Association Reports. *Steel, Crude Steel* and *Pig Iron Production* are the in million tons. *Value Added* is in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Productivity (logged TFPQ)* is logged total factor productivity quantity, 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; *Employees, Engineers, High-Skilled Technicians*, and *Unskilled Workers* are, respectively, thousands of employees, engineers, high-skilled technicians and unskilled workers; *Loans* and *Transfers* are, respectively, loans and free transfers that the government granted to each plant, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. *Distance Coal* and *Coke Deposits* are the plant distance in km from and coal and coke deposits. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.6: Soviet Accidents and Probability of Receiving Soviet Transfers

	Physical Capital		Know-How	
	(1)	(2)	(3)	(4)
Physical Capital Accidents	-0.167***	-0.192***		
	(0.017)	(0.012)		
Soviet Experts Delays			-0.188***	-0.208***
			(0.055)	(0.044)
Steel Production (m tons)	0.002	0.005	0.004	0.009
	(0.007)	(0.011)	(0.008)	(0.010)
Crude Steel Production (m tons)	-0.006	0.002	0.001	-0.002
	(0.010)	(0.003)	(0.002)	(0.005)
Pig Iron Production (m tons)	-0.001	-0.014	0.002	0.011
	(0.004)	(0.019)	(0.004)	(0.014)
Value Added (m)	0.005	0.005	0.011	0.010
	(0.012)	(0.007)	(0.014)	(0.012)
Productivity (log TFPQ)	-0.001	0.006	-0.002	-0.003
	(0.015)	(0.006)	(0.004)	(0.005)
Employees per Plant (k)	0.005	0.006	0.005	0.007
	(0.009)	(0.007)	(0.006)	(0.008)
Engineers (k)	0.014	0.012	0.009	0.011
	(0.016)	(0.014)	(0.012)	(0.014)
High-Skilled Technicians (k)	0.011	0.010	0.003	0.003
	(0.025)	(0.022)	(0.004)	(0.004)
Unskilled Workers (k)	-0.015	-0.013	0.009	0.012
	(0.016)	(0.018)	(0.015)	(0.018)
Loans	-0.012	-0.011	0.014	0.013
	(0.011)	(0.017)	(0.021)	(0.019)
Transfers	0.017	0.013	-0.009	-0.015
	(0.021)	(0.018)	(0.010)	(0.019)
Distance Cole Deposits (km)	0.003	0.005	0.004	0.003
	(0.004)	(0.005)	(0.006)	(0.004)
Distance Coke Deposits (km)	0.002	0.003	0.001	0.002
	(0.003)	(0.004)	(0.004)	(0.003)
Model	OLS	Probit	OLS	Probit
Soviet Plant x Agreed Year FE	Yes	Yes	Yes	Yes
Observations	304	304	304	304

Notes. Linear probability model (columns 1 and 3) and marginal effects from a Probit model (columns 2 and 4) for the probability of receiving Soviet transfers. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received know-how transfer. *Physical Capital Accidents* is an indicator for Chinese plants whose machineries suffered an accident from the Soviet side. *Soviet Experts Delays* is an indicator for Chinese plants whose Soviet experts' trips were delayed from the Soviet side. Data are provided at plant level from the Steel Association Reports. *Steel, Crude Steel* and *Pig Iron Production* are in million tons. *Value Added* is in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020; *Productivity (logged TFPQ)* is logged total factor productivity quantity, 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; *Employees per plant, Engineers, High-Skilled Technicians*, and *Unskilled Workers* are, respectively, thousands of employees, engineers, high-skilled technicians and unskilled workers; *Loans* and *Transfers* are, respectively, loans and free transfers that the government granted to each plant, measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. *Distance Coal* and *Coke Deposits* are the plant distance in km from and coal and coke deposits. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.7: Effects of the Soviet Intervention on Output Quality, Workers, and Inputs in the 304 Steel Plants

	Log Crude Steel	Log Pig Iron	Log Workers	Log Coke	Log Iron
	(1)	(2)	(3)	(4)	(5)
Physical Capital * Year 1	0.011	-0.018	-0.009	0.005	-0.008
	(0.011)	(0.020)	(0.008)	(0.007)	(0.012)
Physical Capital * Year 5	0.099**	-0.069***	0.005	0.004	-0.002
	(0.051)	(0.017)	(0.006)	(0.006)	(0.005)
Physical Capital * Year 10	0.159***	-0.123***	-0.003	0.003	0.004
	(0.033)	(0.035)	(0.004)	(0.007)	(0.006)
Physical Capital * Year 20	0.061	-0.058	-0.008	0.006	-0.005
	(0.047)	(0.049)	(0.010)	(0.005)	(0.009)
Physical Capital * Year 30	0.017	-0.016	0.004	0.007	0.009
	(0.044)	(0.019)	(0.007)	(0.007)	(0.011)
Physical Capital * Year 40	0.004	-0.032	0.005	-0.005	0.003
	(0.035)	(0.030)	(0.007)	(0.006)	(0.004)
Know-How * Year 1	0.055***	-0.048***	-0.006	-0.003	-0.002
	(0.015)	(0.012)	(0.008)	(0.005)	(0.003)
Know-How * Year 5	0.178***	-0.138***	0.002	-0.002	-0.003
	(0.046)	(0.044)	(0.003)	(0.004)	(0.007)
Know-How * Year 10	0.209***	-0.189***	-0.001	0.004	-0.005
	(0.049)	(0.048)	(0.003)	(0.006)	(0.008)
Know-How * Year 20	0.223***	-0.202***	-0.008	-0.002	0.007
	(0.057)	(0.055)	(0.011)	(0.011)	(0.012)
Know-How * Year 30	0.258***	-0.217***	0.005	0.003	-0.002
	(0.061)	(0.057)	(0.007)	(0.004)	(0.003)
Know-How * Year 40	0.293***	-0.251***	0.008	0.006	-0.004
	(0.070)	(0.063)	(0.010)	(0.009)	(0.005)
Soviet Plant x Agreed Year FE	Yes	Yes	Yes	Yes	Yes
Observations	12,160	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients estimated from Equation 1. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Crude Steel, Pig Iron, Coke, Iron* are logged quantities (in million tons) of crude steel, pig iron, coke and iron; *Log Employees* is logged thousands of employees per plant. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.8: Effects of Soviet Physical and Know-How Transfers on Plant Production and Productivity, OLS and IV Estimates

	Log Output (1–2)		Log TFPQ (3–4)	
	(1)	(2)	(3)	(4)
Physical Capital * Year 1	0.002	0.004	0.001	0.002
	(0.018)	(0.015)	(0.017)	(0.014)
Physical Capital * Year 5	0.113***	0.118***	0.106***	0.119***
	(0.017)	(0.016)	(0.018)	(0.019)
Physical Capital * Year 10	0.130***	0.133***	0.128***	0.130***
	(0.025)	(0.021)	(0.023)	(0.022)
Physical Capital * Year 20	0.085*	0.088*	0.081*	0.083*
	(0.046)	(0.042)	(0.047)	(0.047)
Physical Capital * Year 30	0.039	0.033	0.035	0.036
	(0.044)	(0.041)	(0.041)	(0.041)
Physical Capital * Year 40	0.009	0.010	0.001	0.002
	(0.043)	(0.044)	(0.043)	(0.033)
Know-How * Year 1	0.062***	0.066***	0.061***	0.064***
	(0.017)	(0.012)	(0.016)	(0.016)
Know-How * Year 5	0.089***	0.085***	0.078***	0.074***
	(0.018)	(0.016)	(0.018)	(0.013)
Know-How * Year 10	0.098***	0.103***	0.093***	0.091***
	(0.029)	(0.033)	(0.026)	(0.022)
Know-How * Year 20	0.180***	0.185***	0.173***	0.176***
	(0.030)	(0.032)	(0.029)	(0.028)
Know-How * Year 30	0.292***	0.297***	0.281***	0.285***
	(0.038)	(0.040)	(0.037)	(0.031)
Know-How * Year 40	0.402***	0.411***	0.391***	0.399***
	(0.040)	(0.037)	(0.035)	(0.032)
Model	OLS	IV	OLS	IV
Soviet Plant x Agreed Year FE	Yes	Yes	Yes	Yes
Observations	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1 (columns 1 and 3) and using accidents to Soviet machineries as an instrument for receiving Soviet physical capital transfer and accidents to Soviet experts as an instrument for receiving know-howl transfer (columns 2 and 4). Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Output* is logged quantities (in million tons) of steel. *TFPQ* is logged total factor productivity quantity, computed as $\log \text{TFPQ} = \log \text{TFPR} - \tilde{p}$, 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. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.9: Robustness Checks of Main Results to Alternative Fixed Effects

	Log Output (1–3)			Log TFPQ (4–6)		
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital * Year 1	0.002	0.003	0.006	0.001	0.003	0.006
	(0.018)	(0.019)	(0.016)	(0.017)	(0.019)	(0.016)
Physical Capital * Year 5	0.113***	0.115***	0.117***	0.106***	0.108***	0.109***
	(0.017)	(0.020)	(0.025)	(0.018)	(0.020)	(0.019)
Physical Capital * Year 10	0.130***	0.138***	0.139***	0.128***	0.132***	0.141***
	(0.025)	(0.022)	(0.024)	(0.023)	(0.026)	(0.027)
Physical Capital * Year 20	0.085*	0.090*	0.087*	0.081*	0.085*	0.091*
	(0.046)	(0.050)	(0.051)	(0.047)	(0.048)	(0.049)
Physical Capital * Year 30	0.039	0.041	0.042	0.035	0.039	0.044
	(0.044)	(0.045)	(0.041)	(0.041)	(0.042)	(0.040)
Physical Capital * Year 40	0.009	0.008	0.011	0.001	0.002	0.006
	(0.043)	(0.041)	(0.046)	(0.043)	(0.045)	(0.041)
Know-How * Year 1	0.062***	0.065***	0.066***	0.061***	0.066***	0.070***
	(0.017)	(0.015)	(0.021)	(0.016)	(0.018)	(0.020)
Know-How * Year 5	0.089***	0.093***	0.098***	0.078***	0.080***	0.085***
	(0.018)	(0.020)	(0.024)	(0.018)	(0.019)	(0.021)
Know-How * Year 10	0.098***	0.103***	0.105***	0.093***	0.097***	0.103***
	(0.029)	(0.032)	(0.031)	(0.027)	(0.030)	(0.029)
Know-How * Year 20	0.180***	0.184***	0.183***	0.173***	0.175***	0.181***
	(0.030)	(0.028)	(0.034)	(0.029)	(0.030)	(0.034)
Know-How * Year 30	0.292***	0.293***	0.295***	0.281***	0.284***	0.290***
	(0.038)	(0.036)	(0.041)	(0.037)	(0.039)	(0.042)
Know-How * Year 40	0.402***	0.409***	0.411***	0.391***	0.394***	0.400***
	(0.040)	(0.042)	(0.039)	(0.035)	(0.039)	(0.039)
Soviet Plant x Agreed Year FE	Yes	Yes	No	Yes	Yes	No
Industrial Cluster FE	Yes	No	No	Yes	No	No
Plant FE	No	Yes	Yes	No	Yes	Yes
Year FE	No	Yes	Yes	No	Yes	Yes
Sun and Abraham (2021)	No	No	Yes	No	No	Yes
Observations	12,160	12,160	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1 controlling for industrial cluster fixed effects (columns 1 and 4) and plant and year fixed effects (columns 2 and 5). In columns 3 and 6, we estimate weights underlying two-way fixed effects regressions based on Sun and Abraham (2021)'s method, using the Stata command `eventstudyweights`. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Output* is logged quantities (in million tons) of steel. *TFPQ* is logged total factor productivity quantity, 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. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.10: Robustness Checks of Main Results to Alternative Clustering

	Log Output (1–3)			Log TFPQ (4–6)		
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital * Year 1	0.002	0.002	0.002	0.001	0.001	0.001
	(0.018)	(0.017)	(0.015)	(0.017)	(0.015)	(0.012)
Physical Capital * Year 5	0.113***	0.113***	0.113***	0.106***	0.106***	0.106***
	(0.017)	(0.015)	(0.014)	(0.018)	(0.017)	(0.015)
Physical Capital * Year 10	0.130***	0.130***	0.130***	0.128***	0.128***	0.128***
	(0.025)	(0.022)	(0.020)	(0.023)	(0.020)	(0.019)
Physical Capital * Year 20	0.085*	0.085*	0.085*	0.081*	0.081*	0.081*
	(0.046)	(0.045)	(0.044)	(0.047)	(0.046)	(0.045)
Physical Capital * Year 30	0.039	0.039	0.039	0.035	0.035	0.035
	(0.044)	(0.043)	(0.042)	(0.041)	(0.040)	(0.039)
Physical Capital * Year 40	0.009	0.009	0.009	0.001	0.001	0.001
	(0.043)	(0.040)	(0.039)	(0.043)	(0.041)	(0.040)
Know-How * Year 1	0.062***	0.062***	0.062***	0.061***	0.061***	0.061***
	(0.017)	(0.016)	(0.014)	(0.016)	(0.015)	(0.013)
Know-How * Year 5	0.089***	0.089***	0.089***	0.078***	0.078***	0.078***
	(0.018)	(0.015)	(0.014)	(0.018)	(0.016)	(0.014)
Know-How * Year 10	0.098***	0.098***	0.098***	0.093***	0.093***	0.093***
	(0.029)	(0.025)	(0.023)	(0.026)	(0.024)	(0.022)
Know-How * Year 20	0.180***	0.180***	0.180***	0.173***	0.173***	0.173***
	(0.030)	(0.029)	(0.026)	(0.029)	(0.025)	(0.022)
Know-How * Year 30	0.292***	0.292***	0.292***	0.281***	0.281***	0.281***
	(0.038)	(0.036)	(0.033)	(0.037)	(0.035)	(0.033)
Know-How * Year 40	0.402***	0.402***	0.402***	0.391***	0.391***	0.391***
	(0.040)	(0.038)	(0.035)	(0.035)	(0.034)	(0.031)
Plant	Yes	No	No	Yes	No	No
County	No	Yes	No	No	Yes	No
Prefecture	No	No	Yes	No	No	Yes
Observations	12,160	12,160	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1 with standard errors clustered at the plant level (columns 1 and 4), the county level (columns 2 and 5) and the prefecture level (columns 3 and 6). Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Output* is logged quantities (in million tons) of steel. *TFPQ* is logged total factor productivity quantity, 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 Gandhi et al. (2020)'s method. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A.11: Effects of the Soviet Intervention on Government Imposed Quotas in the 304 Steel Plants

	Log Steel (1)	Log Crude Steel (2)	Log Pig Iron (3)
Physical Capital * Year 1	0.018	-0.012	-0.010
	(0.021)	(0.022)	(0.018)
Physical Capital * Year 5	0.014	0.015	-0.011
	(0.019)	(0.016)	(0.015)
Physical Capital * Year 10	-0.017	0.012	-0.011
	(0.021)	(0.022)	(0.014)
Physical Capital * Year 20	0.012	0.008	-0.012
	(0.019)	(0.016)	(0.013)
Know-How * Year 1	0.015	-0.007	-0.006
	(0.018)	(0.009)	(0.007)
Know-How * Year 5	0.016	-0.014	0.002
	(0.017)	(0.014)	(0.005)
Know-How * Year 10	0.008	0.005	-0.011
	(0.010)	(0.009)	(0.013)
Know-How * Year 20	0.004	-0.008	0.004
	(0.007)	(0.009)	(0.008)
Expected Delivery FE	Yes	Yes	Yes
Soviet plant x Agreed Year FE	Yes	Yes	Yes
Observations	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients estimated from Equation 1. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Steel, Crude Steel* and *Pig Iron* are logged quantities (in million tons) of government imposed quotas on steel, crude steel, and pig iron. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.12: Government Loans and Access to Roads and Railroads

	Log Loans	Log Transfers	Log Dist. Road	Log Dist. Railroad
	(1)	(2)	(3)	(4)
Physical Capital * Year 1	0.004	-0.009	-0.003	-0.005
	(0.006)	(0.010)	(0.006)	(0.007)
Physical Capital * Year 5	0.005	-0.006	-0.002	0.009
	(0.009)	(0.009)	(0.004)	(0.013)
Physical Capital * Year 10	-0.003	-0.008	-0.004	-0.003
	(0.004)	(0.008)	(0.006)	(0.005)
Physical Capital * Year 20	-0.007	0.004	-0.005	-0.003
	(0.013)	(0.006)	(0.008)	(0.007)
Physical Capital * Year 30	0.005	-0.009	-0.003	-0.009
	(0.008)	(0.012)	(0.008)	(0.011)
Physical Capital * Year 40	-0.012	0.002	-0.003	0.009
	(0.011)	(0.004)	(0.004)	(0.017)
Know-How * Year 1	-0.008	-0.005	-0.007	-0.010
	(0.013)	(0.011)	(0.010)	(0.012)
Know-How * Year 5	-0.009	0.008	-0.004	0.004
	(0.011)	(0.015)	(0.005)	(0.008)
Know-How * Year 10	0.002	-0.009	-0.005	-0.005
	(0.004)	(0.013)	(0.008)	(0.010)
Know-How * Year 20	0.003	-0.007	-0.004	-0.005
	(0.004)	(0.017)	(0.006)	(0.012)
Know-How * Year 30	-0.012	0.002	-0.003	-0.003
	(0.015)	(0.007)	(0.005)	(0.007)
Know-How * Year 40	-0.007	0.006	-0.009	0.004
	(0.008)	(0.015)	(0.011)	(0.006)
Soviet plant x Agreed Year FE	Yes	Yes	Yes	Yes
Observations	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1. Data are provided at the plant level from Steel Association Reports from 1949 to 2000. *Log Loans* and *Log Transfers* are, respectively, logged loans and free transfers that the government granted to the 304 steel plants and are measured in 2020 US$ millions, reevaluated at 1 RMB in 1955=3.9605 USD in 2020. *Log Dist. Roads* and *Railroads* measure the logged distance in km from the closest roads and railroads to each plant. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.13: County-Level Government Investments

	Log Investment			Log Infrastructure
	All	Steel Industries	Other Industries	
	(1)	(2)	(3)	(4)
Physical Capital * Post	0.004	-0.011	0.015	0.015
	(0.005)	(0.044)	(0.028)	(0.038)
Physical + Know-How * Post	-0.006	0.013	-0.007	-0.009
	(0.010)	(0.003)	(0.010)	(0.020)
Year FE	Yes	Yes	Yes	Yes
Observations	3,240	3,240	3,240	3,240

Notes. *Log Investment* is logged government investment in all industries, in steel industries and other industries. *Log Infrastructure* is logged government investment in infrastructure. Data are provided at the county level from the Statistical Yearbooks between 1949 and 2008. *Physical Capital* is an indicator for counties where plants that received the Soviet physical capital were located. *Physical + Know-How* is an indicator for counties where plants both Soviet physical and know-how were located. *Post* is an indicator for years after 1952, when the Sino-Soviet Alliance started. Standard errors are clustered at the county level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.14: Correlation between Plants that Did Not Receive Soviet Transfers and Other Steel Plants

	Log Output	Log TFPQ	Log Workers	Prob. Ox.	Prob. Cast.
	(1)	(2)	(3)	(4)	(5)
Sino-Soviet Plants * Year 1	0.022	0.011	0.010	0.011	0.012
	(0.015)	(0.010)	(0.008)	(0.010)	(0.012)
Sino-Soviet Plants * Year 5	0.029***	0.012***	0.015***	0.007	0.009
	(0.010)	(0.004)	(0.005)	(0.009)	(0.011)
Sino-Soviet Plants * Year 10	0.033***	0.014***	0.020***	0.009	0.006
	(0.011)	(0.005)	(0.006)	(0.011)	(0.008)
Sino-Soviet Plants * Year 20	0.035***	0.015***	0.022***	0.005	0.012
	(0.007)	(0.005)	(0.007)	(0.008)	(0.015)
Sino-Soviet Plants * Year 30	0.039***	0.014***	0.023***	0.006	0.008
	(0.010)	(0.004)	(0.006)	(0.007)	(0.010)
Sino-Soviet Plants * Year 40	0.035***	0.010***	0.020***	0.006	0.004
	(0.007)	(0.003)	(0.005)	(0.008)	(0.007)
Plant FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	36,220	36,220	36,220	36,220	36,220

Notes. The sample includes plants that were part of the 156 Projects but eventually did not receive any transfers from Soviet Union and steel plants built by the Chinese government under other industrial projects started after the Sino-Soviet Split. *Sino-Soviet Plants* is an indicator for plants built as part of the 156 Projects. *Log Output* is logged quantities (in tons) of steel. *Log TFPQ* is logged total factor productivity quantity, 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 Gandhi et al. (2020)'s method. *Log Workers* is logged number of workers. *Prob. Oxy* and *Prob. Cast.* are indicators for plants using the basic oxygen converters and the continuous casting furnaces. Data are provided at the plant level from the Steel Association Reports between 1949 and 2000. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.15: Political Connections

	Secretaries			Mayors		
	Born City	University City	Years Education	Born City	University City	Years Education
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital * 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)
Physical Capital * 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)
Physical Capital * 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)
Physical Capital * 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)
Physical Capital * 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)
Physical Capital * 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)
Know-How * 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)
Know-How * 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)
Know-How * 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)
Know-How * 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)
Know-How * 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)
Know-How * 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)
Soviet plant x Agreed Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,160	12,160	12,160	12,160	5,265	5,265

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1 for the 304 steel plants belonging to the 156 Projects. *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 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 city level from the People's Daily Online database between 1949 and 2013. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.16: Role of Major Concurrent Historical Events

	Great Famine Deaths	Investments during TF Years
	(1)	(2)
Physical Capital	-0.019	-0.011
	(0.025)	(0.044)
Physical +Know-How	-0.022	0.009
	(0.023)	(0.003)
Observations	81	81

Notes. Great Famine Deaths is the estimated number of deaths caused by the Great Famine (1958-1961), estimated though cohort loss from 2000 census. *Investments during the TF Years* is the county-level investments during the years of the Third Front Movements construction (1964-1980), collected from Xi (2014). *Physical Capital* is an indicator for counties where plants that received Soviet physical capital were located. *Physical + Know-How* is an indicator for counties where plants that received both Soviet physical and know-how were located. *Post* is an indicator for years after 1952, when the Sino-Soviet Alliance started. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.17: Effects of Soviet Physical Capital and Know-How Transfers in all 156 Projects, 1985 and 1998–2013

	Log Value Added		Log TFPR		Log Employees	
	1985	1998-2013	1985	1998-2013	1985	1998-2013
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital	0.047	0.008	0.038	0.006	0.006	0.008
	(0.043)	(0.010)	(0.023)	(0.011)	(0.008)	(0.016)
Know-How	0.347***	0.419***	0.333***	0.401***	0.003	0.009
	(0.053)	(0.069)	(0.048)	(0.058)	(0.005)	(0.010)
Sector-Province FE	Yes	No	Yes	No	Yes	No
Sector-Province-Year FE	No	Yes	No	Yes	No	Yes
Observations	139	2,085	139	2,085	139	2,085

Notes. β and γ coefficients estimated from Equation 3. Data are provided at the plant level from the Second Annual Survey in 1985 (columns 1, 3 and 5) and from the China Industrial Plants database between 1998 and 2013 (columns 2, 4 and 6). *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; *Log Employees* is logged thousands of employees per plant. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table A.18: Effects of the Soviet Technology Transfer on Steel Plant Human Capital

	Log Engineers (1)	Log High-Skilled (2)	Log Unskilled (3)
Physical Capital * Year 5	0.005	-0.003	-0.002
	(0.007)	(0.005)	(0.004)
Physical Capital * Year 10	0.006	0.003	-0.009
	(0.008)	(0.005)	(0.014)
Physical Capital * Year 20	0.012	0.015	-0.022
	(0.018)	(0.020)	(0.024)
Physical Capital * Year 30	0.014	0.011	-0.026
	(0.015)	(0.010)	(0.027)
Physical Capital * Year 40	0.009	0.005	-0.013
	(0.010)	(0.008)	(0.016)
Know-How * Year 1	0.004	0.005	-0.010
	(0.011)	(0.012)	(0.014)
Know-How * Year 5	0.003	-0.005	0.002
	(0.007)	(0.005)	(0.004)
Know-How * Year 10	0.026***	0.028***	-0.045***
	(0.007)	(0.005)	(0.004)
Know-How * Year 20	0.043***	0.038***	-0.080***
	(0.007)	(0.005)	(0.004)
Know-How * Year 30	0.063***	0.045***	-0.101***
	(0.007)	(0.007)	(0.004)
Know-How * Year 40	0.085***	0.058***	-0.133***
	(0.007)	(0.007)	(0.009)
Soviet Plant x Agreed Year FE	Yes	Yes	Yes
Observations	12,160	12,160	12,160

Notes. Selected annual β_τ and γ_τ coefficients estimated from Equation 1. Data are provided at the plant level from Steel Association Reports from 1949 to 2000. *Log Engineers, High-Skilled,* and *Unskilled* are logged thousands of engineers, high-skilled technicians, and unskilled employees. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.19: Spillover Effects, 1998–2013

	Log Value Added		Log TFPR		Log Exports	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Related Firms						
Physical Capital	0.013	0.010	-0.005	-0.003	-0.012	-0.010
	(0.025)	(0.020)	(0.018)	(0.009)	(0.015)	(0.012)
Know-How	0.011	-0.009	0.003	0.004	0.008	-0.015
	(0.020)	(0.012)	(0.008)	(0.004)	(0.007)	(0.018)
Physical Capital * 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)
Know-How * Private	0.215***	0.206***	0.209***	0.200***	0.134***	0.124***
	(0.031)	(0.044)	(0.045)	(0.041)	(0.033)	(0.028)
Physical Capital * 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)
Know-How * Private * New	0.033***	0.030***	0.031***	0.025***	0.050***	0.044***
	(0.011)	(0.009)	(0.006)	(0.005)	(0.012)	(0.010)
Sector-Province-Year FE	Yes	No	Yes	No	Yes	No
Sector-Prefecture-Year FE	No	Yes	No	Yes	No	Yes
Observations	160,123	160,123	160,123	160,123	160,123	160,123
Panel B: Not Related Firms						
Physical Capital	0.012	-0.004	-0.003	-0.015	-0.005	-0.004
	(0.015)	(0.011)	(0.018)	(0.016)	(0.012)	(0.009)
Know-How	0.004	-0.003	0.004	0.003	0.003	-0.002
	(0.006)	(0.006)	(0.008)	(0.007)	(0.005)	(0.004)
Physical Capital * 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)
Know-How * Private	0.002	0.005	0.003	-0.004	0.001	0.007
	(0.006)	(0.010)	(0.004)	(0.005)	(0.002)	(0.008)
Physical Capital * Private * New	0.002	0.005	-0.002	-0.003	0.003	0.001
	(0.006)	(0.008)	(0.005)	(0.009)	(0.005)	(0.003)
Know-How * 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)
Sector-Province-Year FE	Yes	No	Yes	No	Yes	No
Sector-Prefecture-Year FE	No	Yes	No	Yes	No	Yes
Observations	124,762	124,762	124,762	124,762	124,762	124,762

Notes. *Physical Capital* is an indicator for firms related to plants that received Soviet physical capital were located. *Know-How* is an indicator for firms related to plants that also received Soviet know-how were located. *Private* is an indicator equal to one for non-state-owned firms. *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 Plants database between 1998 and 2013. Standard errors are block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.20: County-Level Output Production by Privatized Plants, 1998-2013

	Share Privately Owned Firms			Share Private Output		
	All	Related	Unrelated	All	Related	Unrelated
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital	0.015	0.012	0.018	0.016	0.012	0.004
	(0.021)	(0.027)	(0.009)	(0.014)	(0.018)	(0.006)
Know-How	0.166***	0.161***	0.005	0.252***	0.242***	0.011
	(0.020)	(0.015)	(0.005)	(0.044)	(0.049)	(0.013)
Prefecture-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,296	1,296	1,296	1,296	1,296	1,296

Notes. *Physical Capital* is an indicator for counties where plants that received Soviet physical capital were located. *Know-How* is an indicator for counties where plants that also received Soviet know-how were located. *Share Privately Owned Firms* is the per county share of firms that became private between 1998 and 2013. *Share Private Steel Output Owned Firms* is the per county share of output produced by privately-owned firms. *Related Industries* includes firms in the same, upstream, or downstream industry of the 304 plants; *Unrelated Industries* includes firms not in the same, upstream, or downstream industry of the 304 plants. Data are provided at the county level from the Statistical Yearbooks from 1998 to 2013. Standard errors are clustered at the county level. ***p<0.01, **p<0.05, *p<0.1.

Table A.21: Channels of Persistence of the Soviet Technology Transfer

	STEM Universities	Technical Schools	College Graduates	High-Skilled Workers
	(1)	(2)	(3)	(4)
Physical Capital	0.009	-0.010	0.015	0.007
	(0.013)	(0.012)	(0.021)	(0.011)
Know-How	0.104***	0.156***	0.133***	0.162***
	(0.034)	(0.041)	(0.030)	(0.035)
Prefecture-Year FE	Yes	Yes	Yes	Yes
Observations	1,296	1,296	1,296	1,296

Notes. *Physical Capital* is an indicator for counties where plants that received Soviet physical capital were located. *Know-How* is an indicator for counties where plants that also received Soviet know-how were located. *STEM Universities* is the share of universities offering a STEM degree per county. *Technical schools* is the number of technical schools per inhabitant county. *College Graduates* and *High-Skilled Workers* are the logged number of college graduates and high-skilled technicians over population per county. Data are provided at the county level from the China Education Yearbooks from 1998 to 2013. Standard errors are clustered at the county-level. ***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.2). 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, number of workers, 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, that includes 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. 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 next collected data on the accidents that the Soviet physical capital planned to be delivered to Chinese steel plants suffered and for the delays that trips of Soviet experts to China experienced. We retrieve such data from the Russian State Archive of the Economy (Rossiiskii Gosudarstvennyi Arkhiv Ekonomiki, Moscow). In an attempt to closely monitor physical capital and experts for China, the Soviet Union kept precise records on the reasons of the accidents and the delays and information on the Chinese plants to which physical capital was planned to be delivered and that Soviet experts were supposed to visit. This data allows us to match accidents and delays to the Soviet side to the 304 steel plants. Physical capital

suffered three types of accidents: fires and flood in Soviet factories that completely destroyed machineries and equipment for Chinese plants and trains' derails during the transportation to China which caused a similar destruction. Given that the average time to rebuild steel machineries and equipment spanned from 2 to 3 years, such accidents represent a major obstacle to the 156 Project completion (Filatov, 1980). Moreover, it is worth noting that only one railway connected Soviet Union to China in the 1950s, making it impossible to use alternative routes after trains derails, which further complicated machineries delivery and experts' visits. Total accidents were 115: 48 were fires (41.7%), 30 were floods (26.1%), and 37 were trains' derails (32.8%). Soviet experts' trips to China could be delayed for three reasons. First, if machineries they had to learn to use got destroyed, they needed to wait for them to be rebuilt before learning how to use them. Second, they could have been retained to deal with an unexpected breakdown or machinery repairs in their own Soviet factories. Finally, often translators assigned to their trips needed more time to learn Chinese. Out of the 109 planned Soviet experts' trips to China 87 percent were delayed: 40 (42.1%) were delayed due to physical capital accidents, 37 due to urgent matters in Soviet factories (38.9%) and 18 due to translators' issues (19.0%).

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 firms in the steel industry for a total of 1,410 plants. 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 in different rounds between August 2020 and December 2021.

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

[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

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, population, capital, investment, and number of workers.

Data Validation. While dealing with plant-level data, one always has to consider the possibility that the outcomes provided by the plants may not be accurate. In our context, for instance, plant supervisors may have misreported their production information to show better-than-actual performance. Two important institutional details matter here. First, our main data source, the Steel Association Reports, was highly monitored and checked by industry peers, which strongly limited the possibility of manipulation. Moreover, the officially-released aggregate production data was complied by Statistics China, a different and independent source. Manipulations were therefore more likely to occur in the latter rather than in the former reports. Second, 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. This is especially true during the Great Leap Forward, when the Chinese government wanted to show the

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.

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).

Beyond these consideration, we cross-checked our data against different sources, as follows. First, we turned to Clark (1995) who studied the Chinese steel industry, by collecting data on steel plants with a capacity of at least 100,000 tons, between 1949 and 1993. Specifically, for each plant, he estimated the minimum and the maximum yearly steel output 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 (1995)'s data and find that our estimated coefficients using the annual reports are between the coefficients obtained using their minimum and maximum estimates (Table B.1, columns 2, 3, 6 and 7).[3] Even assuming that plants that received the Soviet transfers produced at the minimum level and plants that did not receive any transfer at the maximum level estimated by Clark (1995), we would still find a persistent effect of the know-how transfer and a short-lived effect of the physical capital transfer, in line with our main results (Table B.1, columns 4-8).

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.

Data Digitization. Between August 2019 and December 2021, 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 75% of the data entries.

[3] As Clark (1995)'s study goes until 1993, we can repeat our main analysis only in the first 30 years after the Soviet transfer.

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 304 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 the 304 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.[4]

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.

B.4 Identification of Firms Economically Related to the 304 Plants

We constructed a list of firms economically related to the 304 steel plants as follows. We retrieved each firm's two-digit industry code from the Steel Association Reports, as we observe the firm products. If firms had the same two-digit industry code of the 304 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

[4] 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.

nor downstream, we consider firms not economically related to the 304 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).

Table B.1: Robustness Checks using Alternative Data Sources

	Log Output (1–5)					Log TFPQ (6–10)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Physical Capital * Year 1	0.002	0.001	0.003	0.001	0.001	0.002	0.001	0.003
	(0.018)	(0.016)	(0.015)	(0.016)	(0.017)	(0.013)	(0.011)	(0.015)
Physical Capital * Year 5	0.113***	0.179***	0.101***	0.077***	0.106***	0.173***	0.096***	0.068***
	(0.017)	(0.020)	(0.015)	(0.015)	(0.018)	(0.021)	(0.012)	(0.015)
Physical Capital * Year 10	0.130***	0.203***	0.117***	0.085***	0.128***	0.189***	0.189***	0.076***
	(0.025)	(0.028)	(0.019)	(0.022)	(0.023)	(0.022)	(0.020)	(0.018)
Physical Capital * Year 20	0.085*	0.095*	0.079*	0.055*	0.081*	0.088*	0.073*	0.046*
	(0.046)	(0.052)	(0.045)	(0.034)	(0.047)	(0.050)	(0.048)	(0.027)
Physical Capital * Year 30	0.039	0.045	0.033	0.021	0.035	0.041	0.027	0.019
	(0.044)	(0.049)	(0.041)	(0.033)	(0.041)	(0.043)	(0.031)	(0.033)
Know-How * Year 1	0.062***	0.081***	0.055***	0.050***	0.061***	0.073***	0.050***	0.043***
	(0.017)	(0.023)	(0.016)	(0.015)	(0.016)	(0.018)	(0.015)	(0.012)
Know-How * Year 5	0.089***	0.101***	0.078***	0.066***	0.078***	0.097***	0.069***	0.057***
	(0.018)	(0.027)	(0.016)	(0.013)	(0.018)	(0.019)	(0.019)	(0.015)
Know-How * Year 10	0.098***	0.155***	0.086***	0.079***	0.093***	0.143***	0.077***	0.066***
	(0.029)	(0.033)	(0.026)	(0.02)	(0.026)	(0.029)	(0.025)	(0.020)
Know-How * Year 20	0.180***	0.267***	0.167***	0.154***	0.173***	0.253***	0.156***	0.142***
	(0.030)	(0.044)	(0.036)	(0.027)	(0.029)	(0.029)	(0.028)	(0.018)
Know-How * Year 30	0.292***	0.309***	0.283***	0.272***	0.281***	0.289***	0.271***	0.261***
	(0.038)	(0.041)	(0.031)	(0.026)	(0.037)	(0.031)	(0.037)	(0.034)
Specification	Main	Max	Min	Min-Max	Main	Max	Min	Min-Max
Observations	12,160	12,160	12,160	12,160	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1 (columns 1 and 5), using the minimum production estimates from Clark (1995) (columns 2 and 6), the maximum production estimates (columns 3 and 7), and the minimum production estimates for plants that got Soviet physical capital and plants that also got Soviet know-how and the maximum production estimates for plants that didn't get any Soviet transfers (columns 4 and 8). *Output* is logged quantities (in million tons) of steel. *TFPQ* is logged total factor productivity quantity, 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. Standard errors are clustered block-bootstrapped at the industrial cluster level with 1,000 replications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B.2: List of Variables, With Their Definitions and Sources

Variable	Definition	Level, Source and Years of Coverage
Log Steel	Logged million tons of steel produced	Plant-year, Steel Association, 1949–2000
Log Coke/Iron/Pig Iron	Logged million 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 Oxygen	Logged tons of steel produced with the basic oxygen process	Plant-year, Steel Association, 1949–2000
Log Continuous Casting	Logged tons of steel produced with the continuous casting method	Plant-year, Steel Association, 1985–2000
Log Exports	Logged values of exports to Western world countries	Plant-year, Steel Association, 1985–2000
Log International Standard	Logged million tons of steel above international standards quality	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 Workers	Total number of workers	Plant-year, Steel Association, 1949–2000
Log Substitute Capital	Logged values of foreign imported capital to substitute domestic one	Plant-year, Chinese Ministry of Commerce, 1978-2000
Log Complementary Equipment	Logged values of foreign imported equipment complementary to domestic capital	Plant-year, Chinese Ministry of Commerce, 1978-2000
Log Value Added	Difference between firm gross income and intermediate inputs	China Industrial Enterprises, 1998–2013
Log Fixed Assets	Logged value of land, buildings, and machines owned by the firm	China Industrial Enterprises, 1998–2013
Log Capital Stock	See table notes	China Industrial Enterprises, 1998–2013
Log TFPR	Total Factor Productivity Revenue; for estimation see Appendix C.	China Industrial Enterprises, 1998–2013
Log Revenues	Operating revenues	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
STEM Universities	Share of universities offering a STEM degree per county	County-year, China Education Yearbooks, 1998-–2013
Technical School	Number of technical schools per inhabitant per county	County-year, China Education Yearbooks, 1998-–2013
Log College Graduates	Logged number of college graduates over population	County-year, China Education Yearbooks, 1998-–2013
Log High-Skilled Workers	Logged number of high-skilled workers over population	County-year, China Education Yearbooks, 1998-–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 20 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 20 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 Robustness and Discussion of TFP Estimation

In our main specification, we estimate total factor productivity (TFP) 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 $\log \text{TFPQ}{=}\log\text{TFPR}\text{-}\log \tilde{p}$, where $\tilde{p}$ 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.

For robustness, in Table C.1 we show that our results of TFP do not depend on the estimation methodology. Estimating TFP using the OP and LP methodologies, OLS, and the factor shares (Solow's residuals) lead to almost identical results than using the GNR methodology.

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, the 304 plants, given their large size, were given substantial freedom in terms of inputs, labor choices, and output production decisions.[5] 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

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

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, if anything, larger than our baseline ones (Table C.1, columns 5 and 6).

Table C.1: Alternative TFP Estimations

	Log TFPQ					
	GNR	OP	LP	FS	OLS	US Prices
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital * Year 1	0.001	0.001	0.001	0.001	0.001	0.001
	(0.017)	(0.015)	(0.014)	(0.016)	(0.015)	(0.016)
Physical Capital * Year 5	0.106***	0.107***	0.105***	0.109***	0.111***	0.109***
	(0.018)	(0.019)	(0.015)	(0.016)	(0.014)	(0.016)
Physical Capital * Year 10	0.128***	0.125***	0.129***	0.130***	0.137***	0.130***
	(0.023)	(0.021)	(0.025)	(0.022)	(0.022)	(0.027)
Physical Capital * Year 20	0.081*	0.080*	0.079*	0.0810*	0.083*	0.082*
	(0.047)	(0.044)	(0.046)	(0.045)	(0.046)	(0.044)
Physical Capital * Year 30	0.035	0.034	0.036	0.039	0.040	0.038
	(0.043)	(0.042)	(0.038)	(0.040)	(0.046)	(0.043)
Physical Capital * Year 40	0.001	0.002	0.001	0.003	0.001	0.002
	(0.043)	(0.040)	(0.044)	(0.041)	(0.039)	(0.040)
Know-How * Year 1	0.061***	0.062***	0.064***	0.065***	0.069***	0.064***
	(0.016)	(0.018)	(0.017)	(0.015)	(0.012)	(0.014)
Know-How * Year 5	0.078***	0.080***	0.081***	0.079***	0.085***	0.081***
	(0.018)	(0.017)	(0.019)	(0.020)	(0.015)	(0.017)
Know-How * Year 10	0.093***	0.094***	0.095***	0.097***	0.099***	0.095***
	(0.026)	(0.030)	(0.028)	(0.027)	(0.021)	(0.025)
Know-How * Year 20	0.173***	0.175***	0.178***	0.181***	0.179***	0.177***
	(0.029)	(0.028)	(0.026)	(0.030)	(0.033)	(0.032)
Know-How * Year 30	0.281***	0.283***	0.280***	0.285***	0.293***	0.286***
	(0.037)	(0.034)	(0.035)	(0.033)	(0.043)	(0.041)
Know-How * Year 40	0.391***	0.390***	0.392***	0.396***	0.401***	0.398***
	(0.035)	(0.031)	(0.033)	(0.036)	(0.036)	(0.039)
Observations	12,160	12,160	12,160	12,160	12,160	12,160

Notes. Selected annual β_τ coefficients and γ_τ coefficients from Equation 1 computing total factor productivity 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 (column 1, GNR), Olley and Pakes (1996)'s method (column 2, OP), Levinsohn and Petrin (2003)'s method (column 3, LP), factor shares (column 4, FS), OLS (column 5) to offset transmission and quality bias as explained in de Roux et al. (2020), and using American Iron and Steel Institute prices instead of Chinese ones to compute $\widetilde{p}$ (column 6). *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors are clustered block-bootstrapped at the industrial cluster level with 1,000 replications. *** p < 0.01, ** p < 0.05, * p < 0.1.

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