NBER WORKING PAPER SERIES

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

Michela Giorcelli
Bo Li

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

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2021, revised September 2024

We thank Ran Abramitzky, David Atkin, Nick Bloom, Bruno Caprettini, Laura Cohen, Dora Costa, Michele Di Maio (discussant), Alvaro Garcia, Rick Hornbeck (discussant), Jiandong Ju, Naomi Lamoreaux, Nicholas Li, Ernest Liu, Kalina Manova (discussant), Nathan Nunn, Dimitris Papanikolau, Fernando Parro, Luigi Pascali, Nancy Qian, Martin Rotemberg, Dimitrije Ruzic (discussant), Vincenzo Scrutinio, Xuan Tian, John Van Reneen, Eric Verhoogen, Shang-Jin Wei, Guo Xu, and Ting Xu (discussant), as well as Elira Kuka, Jared Rubin, and Danila Serra through the Adopt-a-Paper program. We also thank seminar and conference participants at Harvard, Stanford, Yale, Berkeley Haas, UCLA, LSE, UBC, Michigan, George Washington, Tucson, Auburn, Wilfrid Lauriel, Oxford, LUISS, Bologna, Padova, Melbourne, Tsinghua, Chicago Fed, the NBER Summer Institute, the NBER Productivity Lunch, the Cliometrics Conference, the Second Women in International Economics Conference, the AFA, the CEPR/LEAP Workshop in Development Economics, the Barcelona GSE Summer Forum, the Pacific Conference for Development Economics, the Webinar Series in Finance and Development, the LSE Asia Economic History Seminar, the Online Economic History Workshop, and the Ridge Conference for helpful comments and discussion. We are also thankful to senior officials at Statistics China for declassifying the historical data for this research and to historians at the National Archives Administration of China for their help in accessing archival materials. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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

ABSTRACT

This paper studies the long-term effects of technology and know-how transfers on structural transformations. In the 1950s, the Soviet Union supported the construction of the 156 Projects, which were large-scale, capital-intensive industrial clusters in China. These projects included a technology transfer, consisting of state-of-the-art Soviet machinery and equipment, and a know-how transfer, via the training of Chinese engineers, production supervisors, and high-skilled technicians by Soviet experts. We use newly assembled data that follow steel plants for over four decades, and we exploit natural variation in the transfers they eventually received. We find that, while production advantages stemming from Soviet technology faded away if not complemented with training, the know-how transfer had a long-lasting impact on plant performance, stimulated technology upgrade when China was a closed economy, and increased exports to the Western world when China engaged in international trade. The know-how transfer also generated productivity and technology spillovers onto complementary establishments.

Michela Giorcelli
Department of Economics
University of California at Los Angeles
Bunche Hall 9262
315 Portola Plaza
Los Angeles, CA 90095
and NBER
mgiorcelli@econ.ucla.edu

Bo Li
Tsinghua University
43 Chengfu Rd
Beijing, China
100083
lib@pbcsf.tsinghua.edu.cn

1 Introduction

Industrialization is a key driver of economic development. As economic activity has moved from the agricultural sector to the more-productive industrial sector, states have grown rich (Gollin et al., 2013; Herrendorf and Schoellman, 2015; Porzio et al., 2021). Several developing countries have attempted to accelerate this process with "Big Push" development strategies. Such strategies involve building a modern industrial sector through massive and simultaneous public investments in capital-intensive industries (Rosenstein-Rodan, 1943; Murphy et al., 1989; Allen, 2011), frequently supported by technology and know-how transfers from the most advanced economies (Hoekman et al., 2004; Robinson, 2009; Stokey, 2021).

Despite the widespread use of industrial policy in the last century, empirical evidence on its causal and long-run implications remains limited. This is mostly due to lack of natural variation in its 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. It is also 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 the 1950s, to help China industrialize, 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. Considered the most comprehensive technology transfer in modern industrial history and a vital factor in Chinese economic development, the 156 Projects entailed a technology transfer, consisting of state-of-the-art Soviet machinery and equipment, and a know-how transfer, via the training of Chinese engineers, production supervisors, and high-skilled technicians by Soviet experts (Lardy, 1995).

In building a comprehensive new dataset, collected and digitized from several historical archives, we have combined information on the 156 Projects with annual reports on plant performance in the steel industry. These documents provide granular data on output quantity and quality, production processes and workforce between 1949 and 2000, which we complement with records of plant technological upgrade. For all the other industries, we collected data on firm-level outcomes when available, in 1985 and between 1998 and 2013.

Our identification strategy relies on the fact that the 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 Soviet physical capital and know-how, others had gotten only Soviet physical capital, and the remainder eventually got no Soviet transfers. In our empirical analysis, we compare the outcomes of these three groups of plants over 40 years, after showing that they had statistically similar characteristics at baseline, were located in comparable geographical areas, and had similar access to natural resources and inputs. Furthermore, they were on statistically indistinguishable performance trends before receiving the Soviet transfers, when they were all operating with only Chinese domestic capital.

Our core results show that while the production advantages stemming from Soviet technology faded away if not complemented with training, the know-how transfer had a long-lasting impact that widened over time. The steel industry plants that received Soviet physical capital had a differential performance increase relative to plants that received no Soviet transfers in the six years after the intervention. Then, the effects started to decay and were no longer significant after 20 years. By contrast, production and productivity of plants that also received the know-how transfer rose by around 20% within 20 years of Soviet intervention, relative to that of plants that got only physical capital, and continued to grow, reaching a cumulative effect of roughly 50% after 40 years. These findings do not appear driven by different quota allocations, access to infrastructure, political connections, or exposure to concurrent historical events like the Great Leap Forward or the Cultural Revolution.

We next show that the complementarities between Soviet capital and know-how stimulated quality and technology upgrade, which contribute to explain the persistent results we observe. In the 1960s and 1970s, when China's interaction with foreign countries was extremely limited, only plants that also received the know-how transfer increased production of high-quality steel, developed new steel-making processes, and adopted modern machinery, which ultimately replaced Soviet capital when it became obsolete. Once China began gradually opening to international trade, in 1978, such plants relied dramatically less on Western physical capital, they imported more foreign equipment complementary to their machinery, and exported systematically more high-quality steel than plants that received Soviet physical capital. These results are consistent with their performance improving even more after 1978. Conversely, we find no difference between plants that received only Soviet physical capital and plants that got no Soviet transfer.

A major implication of the Big Push theory is that large investments in heavy industries can become self-sustaining due to spillover effects across industries (Kline and Moretti, 2014). Did the 156 Projects generate such effects? We find that only establishments with backward and forward linkages with plants that received Soviet know-how exhibited higher productivity, more technological upgrades when China was a closed economy, and more exports when China opened to international trade. These results confirm the importance of human capital spillovers in fostering increased productivity and local economic development (Glaeser et al., 1992; Moretti, 2004).

The contribution of this paper is threefold. First, our paper relates to the literature on technology transfer and diffusion in developing countries (see Verhoogen, 2023 for a comprehensive review). Given the low quality of domestic innovations, firms in less-developed economies may find it profitable to adopt technologies from the most advanced ones instead of developing their own (Caselli and Coleman, 2001; Comin and Hobijn, 2010; de Souza, 2022). Consistently, several papers have shown the positive impact of foreign technologies embedded in capital goods on firm performance (Pavcnik, 2002; Mel et al., 2008; Goldberg et al., 2010; Bloom et al., 2013; Bruhn et al., 2018; Giorcelli, 2019; Hardy and Jamie, 2021), while others have documented the existence of substantial barriers to their adoption (Atkin et al., 2017; Bloom et al., 2020; Juhász et al., 2024). Our paper shows that the impact of technologically advanced capital goods does not persist if it is not accompanied by proper engineering know-how. In doing so, our work also contributes to research on the role of engineers on economic development. Considered a key link between scientific insights and practical application during the First Industrial Revolution (Mokyr, 2005; Yuchtman, 2017; Hanlon, 2022), engineers became even more important during the Second Industrial Revolution when the increasing global knowledge needed to be adapted locally (Squicciarini and Voigtlander, 2015; Maloney and Valencia Caicedo, 2022; Juhász et al., 2024). Focusing on more recent times, Romer (1990)'s model of endogenous growth put "research engineers" at the center of the growth process, while Murphy et al. (1991) show that countries with a higher share of engineers grow faster than those with more lawyers. Our paper highlights that engineers are not only complementary to physical capital in early stages of industrialization, but also prevent investments in new technologies from becoming obsolete by promoting technological upgrade. This channel can generate long-run local development even in a close, command-economy, as China was until the early 1980s.

Second, our paper adds to the literature on the Big Push and industrial policies. Building on the seminal contributions of Rosenstein-Rodan (1943) and Murphy et al. (1989), a growing body of research has documented that large public investments in strategic industries of little-industrialized countries have positive and persistent effects on local development, manufacturing employment, targeted sectors, downstream users, and individual long-term outcomes (Wade, 1990; Carlin et al., 2013; Kline and Moretti, 2014; Liu, 2019; Hanlon, 2020; Choi and Levchenko, 2021; Kim et al., 2021; Bianchi and Giorcelli, 2023; Lane, 2023; Mitrunen, 2024). To the best of our knowledge, this paper is the first to use granular, nonexperimental data to disentangle the effects of technology and know-how transfers of industrial policies, tracking industrial clusters from their foundation to recent years. Our focus on the Big Push toward industrialization of China, the country that experienced "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). Our results echo Carlin et al. (2013), who show how command economies that were preindustrial when planning was imposed benefited more, in terms of long-run GDP per capita, from physical and human capital investments than they were harmed by the economic costs of weak market incentives.

Third, our paper is related to the literature on spillover effects. Existing research has focused on spillovers determined by foreign direct investments, the opening of large plants (Javorcik, 2004; Javorcik et al., 2008; Greenstone et al., 2010; Alfaro-Urena et al., 2022), worker mobility (Stoyanov and Zubanov, 2012), managerial-knowledge diffusion (Bloom et al., 2013; Bianchi and Giorcelli, 2022), and sectoral industrial policies (Liu, 2019; Fan and Zou, 2021). Our setting allows us to disentangle the spillover effects of technology transfer from spillovers that follow know-how diffusion. In terms of context, a closely related paper to ours is Heblich et al. (2022), which compares counties that hosted the 156 Projects with similar counties that did not, showing negative long-run spillovers on production due to overspecialization. By contrast, our paper focuses on the short-, medium-, and long-run direct effects of the 156 Projects, juxtaposing plants built under the Sino-Soviet Alliance that received or did not receive the Soviet transfers, and documenting productivity spillovers and technology upgrade stemming from engineering knowledge diffusion.

The rest of this paper is organized as follows. Section 2 describes the Sino-Soviet Alliance. Section 3 introduces the data. Section 4 presents the empirical framework and discusses the identification strategy. Section 5 studies the effects of the technology and know-how transfers on plant outcomes. Section 6 examines firm upgrade, while Section 7 focuses on the spillover effects. Section 8 concludes.

2 The Sino-Soviet Alliance and the 156 Projects

2.1 The Big Push Towards the Industrialization of China

After the establishment of the People's Republic of China (PRC) in 1949, one of the major goals of the newly-formed government was to build a modern industrial system. Lacking the expertise to do so independently, PRC officials sought collaboration from the Soviet Union (Ji, 2019). Since the 1930s, the latter had followed a Big Push development strategy. Industrialization was pursued through centrally-planned and coordinated investments in heavy industry and interlinked sectors (Allen, 2003; Cheremukhin et al., 2017). To replicate this model in China, on February 14, 1950, the two countries signed the "Sino-Soviet Treaty of Friendship, Alliance, and Mutual Assistance," that established, in addition to military assistance, widespread economic cooperation.

The Big Push towards Chinese industrialization was promoted through the construction of large-scale capital-intensive industrial clusters in heavy industries, known as the "156 Projects" (Zhang et al., 2006). These projects aimed to replicate whole Soviet factories and encompassed a comprehensive transfer of technology and know-how from Soviet Union. Central to the First Five-Year Plan (1953–1957), their total value amounted to $80 billion (in 2020 figures; $20.2 billion in 1955 RMB), equivalent to 45.7% of Chinese and 6.5% of Soviet GDP in 1949 (Lardy, 1995; Zhang et al., 2006).[1]

The importance of the 156 Projects in Chinese economic history can hardly be overestimated. Defined as "a major turning point in the course of China's modernization" (Yimin and Mingchang, 2015), these projects are considered the "largest technology transfer in human history" (Cehn and Zofka, 2022), "unprecedented in scale and scope," even relative to the U.S. Marshall Plan (Bayasgalan, 2022), and a vital factor in Chinese industrialization and economic development (Lardy, 1995; Zhang et al., 2006; Zhang, 2015).

While the 156 Projects were by far the largest foreign-development plan undertaken by the Soviet Union, they were part of a broader, global strategy implemented during the Cold War to limit the U.S. influence (Guan-Fu, 1983). Between the 1950s and 1980s, the Soviet Union offered technology transfers to several Communist countries, including Vietnam, Laos, Cambodia, North Korea, and Cuba, and other states, for instance India, Egypt, Ghana,

[1] 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 was to be used to "repay the Soviet Union's delivery of machinery and equipment [...]" (Lardy, 1995). The prices of such items were calculated according to world market prices.

and Turkey.[2] Notably, the Soviet intervention promoted similar Big Push industrialization strategies in all these countries, by supporting the construction of large, publicly owned factories in heavy industries.

2.2 The 156 Projects

The implementation of the 156 Projects was designed through several agreements signed by China and the Soviet Union between 1952 and 1957. Each project involved the construction of multiple plants— duplicates of Soviet establishments — and was supposed to receive both technology and know-how transfers from the Soviet Union. The technology transfer involved state-of-the-art Soviet physical capital, such as machinery, equipment, and blueprints, 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). Through this transfer, China received the best available Soviet physical capital and transitioned from having industrial technology that was a century behind that of developed nations in 1949 to a comparable level in just ten years (Naughton, 2007).

The know-how transfer included in-plant technical and industrial training by Soviet experts to the engineers and production supervisors, as well as instructions to high-skilled Chinese technicians on how to operate the new machinery. The engineer training was comprehensive: classes in math, physics, and chemistry, along with lectures on organizational, technological, and planning methods. Supervisor training, based on "scientific management" principles, included classes on operational planning, statistical and quality-control methods, and worker management (Clark, 1973).[3]

The Soviet experts were expected to spend on average three years in Chinese plants, sharing technical data and engineering and product designs, helping to survey geological conditions, selecting plant sites, and directing plant construction (Zhang et al., 2006).[4] Still today, Soviet knowledge transfer is thought to have "accelerat[ed] the progress of science and laid the foundation for modern technology in China" (Xinhua, 2009).

The location of the 156 Projects was chosen to protect them from potential military attacks (Lardy, 1995). Consequently, they were concentrated in the northeastern (Heilongjiang, Jilin, Liaoning) and inner regions (Shaanxi, Shanxi, Gansu, and Hubei; Figure 1).[5] In this

[2] Soviet technology transfer to India was an essential part of the Indian Third Five-Year Plan (1961–1966). It provided design services, production equipment, technical guidance, and personnel training for 102 projects in the public sector, 80 of which were eventually implemented (Engerman, 2018). Since 1966, the Indo-Soviet cooperation was expanded to incorporate military supply. For instance, the Soviet Union transferred technology to co-produce the Mikoyan-Gurevich MiG-21 jet fighter, earlier denied to China.

[3] For instance, Soviet experts introduced quality-control methods to reduce scrapped output. They also organized duty management, having the outgoing shift thoroughly inspect the machines and hand them over to the next shift in good condition, so production could start immediately (Wu and Yi, 2022). Notably, "scientific management" principles were adopted by Soviet planners in the early 1930s from the United States. (Hirata, 2018).

[4] 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.

[5] Only 10 projects were on the site of preexisting firms, which had been completely destroyed during the

respect, the 156 Projects shaped the geographical distribution of Chinese industrialization, since the few existing firms in 1950 were located in the coastal areas (Lardy, 1995).

Soviet Aid in the Steel Industry. Chinese leaders, in particular Chairman Mao Zedong, believed that Chinese industrial development should strongly rely on steel production. Not surprisingly, the steel industry accounted for 45% of the total investment in the 156 Projects and led to the construction of 20 clusters. Each cluster was in turn composed of several steel plants, 304 in total. Notably, while all the plants within an industrial cluster were formally under a unique company, they operated as different firms, each with its own planning, financial, and labor departments (Angang Shizhi Bianzuan, 1991).

Soviet technology in the 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 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 in the United States, 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 effort in promoting Chinese management impressed India's Prime Minister Nehru. While visiting the Anshan plant, he compared the Soviet transfer in China with the British and U.S. ones 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).

2.3 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. By 1955 almost every Soviet industrial area had received orders for capital goods from China, but they proved difficult to deliver (Zhang et al., 2006). Given the high demand for steel that China was facing at the time, the Soviet and Chinese governments decided to temporarily install old, domestic Chinese capital in all the newly built plants with the idea of replacing it with state-of-the-art Soviet machinery as soon as it was delivered (State Economic Commission, 1958b, 1959; Ji, 2019). However, the pressure to produce beyond capacity caused several accidents on the Soviet side. Multiple factory fires, floods, and railway accidents destroyed critical equipment produced for China, 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 machinery, little employed even within the Soviet Union, before traveling to China, and they relied on translators, who often needed more time than expected to learn Chinese (Filatov, 1975; Hirata, 2018).

Civil War and were rebuilt from scratch (Hirata, 2018).

In light of these delays, it would have been profitable for China to prioritize the most promising projects, but the country faced many challenges in doing so. First, it was too dependent on aid from the Soviet Union, which 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 ones made it impractical to reallocate machinery or equipment across the 156 Projects (Filatov, 1975). And unfortunately, the Soviet experts who did arrive in China had just learned how to operate specific machinery, and their translators had been trained in project-specific terminology, which strongly limited the possibility of reallocation across different projects (Borisov and Koloskov, 1980).

Further complicating matters, the Sino-Soviet Alliance descended into turmoil in the late 1950s over political and ideological disputes. Despite attempting to maintain a bilateral relationship in the early 1960s, the two countries couldn't reach an agreement; 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 July 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. By the time of the Split, some plants had already received both Soviet physical capital and know-how, other plants had only received Soviet physical capital, and the remainder got no Soviet transfers and continued to operate with Chinese domestic capital. In fact, China still lacked the resources and human capital to replicate the Soviet plants and capital goods autonomously, and Soviet experts took all the relevant materials with them (Lardy, 1995; Zhang et al., 2006). Moreover, China faced an embargo from the Western world until at least 1978, which forced the country to rely almost exclusively on its own resources for about 20 years after the Split.[6]

Notably, the final differences across plants had little to do with the initial design of the projects. For instance, the Bautou, Tangshan, and Taiyuan Projects 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 Tangshan were shipped in 1957, a fire decimated the one for Taiyuan. The 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 the Soviet Union, implied that Soviet experts had themselves to learn how to operate them before leaving for China. The team, also delayed by translators who couldn't learn Chinese fast enough, eventually left in 1958, but could visit and train Chinese workers only in Bautou; due to the Split, they were forced to

[6] Notably, after the Sino-Soviet Split, Albania, in ideological and political disagreement with Soviet Union, became the sole foreign partner of China (Mëhilli, 2017). To foster this alliance, under the Sino-Albanian Friendship Society (1959–1978), China offered economic, military, and political assistance, as well as food and in-kind subsidies, though doing so was often beyond its productive and financial possibilities. Overall, the cooperation was not very successful, strongly limited by geographical distance and profound historical and cultural differences, and often resulted in an enormous waste of resources (Biberaj, 1986). When China started resuming its interactions with the United States, the diplomatic relationships with Albania rapidly deteriorated, leading to the Sino-Albanian Split in 1978.

return to the Soviet Union before heading to Tangshan (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 to 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 Tangshan 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 Taiyuan 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).

2.4 Firm Incentives in a Command Economy

From 1949 until at least the early 1980s, China operated as a command economy. This meant that all industrial factories were owned by the state, which both decided the level of production through the allocation of quotas and set the prices of goods and services (Perkins, 2014). As a consequence, the average state-owned firm had limited influence on decisions about inputs and production. Moreover, because all firm profits had to be given to the state (which also covered losses), companies had incentives to maximize production rather than profits. In fact, exceeding the production quotas were often associated with promotions for managers, regardless of the quality of the final output (He, 1958).

Given their importance for the Chinese economy, the 156 Projects — and in particular, the 304 steel plants — operated under unusual conditions and different incentives. The government, in light of the country's large need for high-quality steel, became increasingly worried about a "moral hazard" problem of such plants. If their goal was just maximizing output, they could overproduce without being responsible for the costs of their operations and the demand for their products, and without caring about the quality of the final products (State Economic Commission, 1958b, 1959; Hirata, 2018).

To counterbalance this issue, the government gave the 304 plants substantial economic autonomy and considerably expanded the authority of their managers (State Economic Commission, 1958a; He, 1958). They could purchase and sell products, borrow from banks directly, and were given plenty of discretion in personnel management (Hirata, 2018). While the proximity to natural resources meant a direct access to raw materials, managers could buy other inputs from more than 2,200 suppliers, created to guarantee a stable supply (State Economic Commission, 1963). According to firm reports, this system of suppliers was successful in stabilizing production and eliminating input backlogs (He, 1958; Ji, 2019). Consequently, the 304 plants were little exposed to the cyclical input shortages that characterize command-economy enterprises.

Although production quotas were formally allocated to the 304 plants, they were not considered a key performance indicator. Subject to little or no changes over time, they ended up being systematically exceeded by these plants (He, 1958; Ji, 2019; Angang Shizhi Bianzuan, 1991). Following the newly established principle of "quality first" for the industrial steel clusters (State Economic Commission, 1958a), the managers of the 304 plants were rewarded also based on profits (part of which was retained within the firm), cost reduction, and product quality rather than solely on production quantities (He, 1958; Hirata, 2018; Ji, 2019).[7] Finally, given the serious lack of technological and managerial expertise in the country, engineers and managers of the 304 plants were little exposed to rotation from Chinese Communist Party (CCP), while low-skilled workers were recruited at the local level (Hirata, 2018).

Anecdotical evidence suggests that this system was successful in incentivizing firms to consider profits and cost control. Bankers stationed in Angang were reporting that "each plant individually [takes] responsibility for losses and profits, and receive[s] strict supervision of state banks. This has changed the [past] bias, in which the enterprises only planned spending and did not plan incomes" (He, 1958).

The historical evidence presented so far indicates that the 304 plants operated under the same economic conditions and faced the same incentives and the same production constraints. Based on these consideration, we conclude that standard firm outcomes, albeit different from market economies, could be reasonable indicators of the 304 plants' performance within the Chinese context.

3 Data

In this section, we describe the data we collected and digitized from several historical archives. Additional details and the definitions of all the variables used in the analysis can be found in Appendix B.

3.1 The 156 Projects

We retrieved the list of the 156 Projects built under the Sino-Soviet Alliance by accessing the official agreements signed by the Soviet Union and the PRC between 1950 and 1957, available at the National Archives Administration of China. While the initial discussions aimed at 156 civilian projects, the final number was 139. For each project, we collected information on name, location, industry, total investments, capacity, number of workers, and name and number of plants. For each plant, we retrieved reports compiled during the program completion that indicate whether and when plants received Soviet physical capital and equipment or the visits of Soviet experts.

[7] Specifically, the State Economic Commission (1958a) explains that in the 304 plants the four mandatory indicators of plant performance were: profits, value added, cost reduction, and output of major products' types. Other indicators, such as total production, total output value, and, notably, production quotas, became optional. The situation was radically different in small firms and agricultural communities, where the government strictly allocated production quotas and inputs accordingly, and managers were rewarded only on total output (Lardy, 1995).

The 156 Projects predominantly focused on heavy industries: 23.0% were in electricity, 21.6% in machinery, 20.1% in coal, and 14.4% in steel (Figure A.1, Panel A). Only two projects (1.4%) were in light industries. In terms of expenditures, the steel sector alone accounted for 45.1% of total investments (Figure A.1, Panel B).

The average project was planned to start in 1955 and last 5.6 years, while the expected arrival of Soviet physical capital and experts spanned between 1954 and 1963. The 156 Projects were massive, with average investments of $580.3 million (in 2020 values), 8.7 plants, and 39,910 employees (Table 1, Panel A, column 1).[8]

The 20 steel projects were larger in terms of investments ($746.9 million), number of plants (15.2), and number of workers (46,670) than those in other industries, confirming their vital importance in the First Five-Year Plan (Table 1, Panel B, column 1). They were composed of 304 steel plants, which in turn aimed at duplicating 14 different Soviet plants. When the Split suddenly interrupted 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 received no 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 machinery 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 built in the 20 steel industrial clusters to their performance data.

A natural question is whether plant performance data, at the core of our analysis, are accurate. In fact, until at least the early 1980s, China was a command economy, which creates potential conceptual and measurement shortcomings on its officially released statistics. First, variation in the quality and methods used to compile official statistics, as well as the high decentralization of the statistical institutes, undermines their internal validity (Koch-Weser, 2013). Second, as in most authoritarian regimes, systematic misreporting or data falsification may have occurred, especially in periods of economic instability or to hide government policy failures (Koch-Weser, 2013). Third, plant managers themselves, rewarded for firm performance, may have had incentives to show better-than-actual outcomes, for instance to meet the production goals set by the central government (Lardy, 1995).

While we cannot say for sure that the Steel Association reports were exempt from these issues, four points should be considered while using this data. First, the Steel Association reports were primarily intended for internal government use and therefore required accurate evaluation of plant performance. For this reason, these reports were highly monitored and

[8] Total employment in the 156 Projects amounted to 5.5 million workers—only 3% of China's total workforce, but almost 40% of the country's employment in the industrial sector in 1952.

verified by industry peers, significantly reducing the manipulation margins.[9] 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, the fact that the 304 plants were usually exceeding the government-set production quotas and could purchase inputs and sell their own products reduced the incentives of over-reporting. Third, the Steel Association reports contain the quantities of steel production, usually difficult to manipulate since their products were delivered to downstream state-owned firms, which could cross-check the information. Fourth, while assessing the direction of data manipulation ex ante is challenging, after the Sino-Soviet Split, the Chinese government wanted to tie up loose ends with the Soviet Union as quickly as possible.[10] Therefore, in this specific setting it is reasonable to think that, if any manipulation occurred, it should have aimed at underestimating rather than overestimating the impact of the Soviet intervention, especially in the long run. This would go against us finding results.[11]

Moreover, to have a more objective measure of the production processes in the 304 plants, we complement the production data with information on subsequent technology adoption at the plant level, which we collected from the Chinese Ministry of Commerce and the Ministry of Industry and Information Technology historical archives. This data not only comes from a different source but also provides a more direct measure of the plant technological upgrade, less subject to measurement issues. More specifically, these data have information on whether firms adopted a new technology or production techniques or if they developed new product or processes. After China opened up to international trade, we also collected information on foreign technology adoption by digitizing the contracts signed with technologically advanced countries, such as United States, Western Europe states, and Japan between 1978 and 2000. These data contain detailed descriptions of the type of technology imported from abroad (machinery, equipment, licensing, and consulting) and their use within plants.

3.3 Firm-Level Data in All Industries

We manually collected and digitized confidential, firm-level data from the Second Industrial Survey, conducted by Statistics China in 1985 and declassified for this project. It covers the 7,592 largest firms in 1985, spanning across 40 industries and provides key performance data, such as output, sales, profits, fixed assets, and employees. Using name, location, and province, we manually and uniquely matched the 139 projects to their 1985 performance.

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

[9] The substantially higher reliability of the internal reports relative to the official statistics has been acknowledged by several Chinese economic historians (Zeitz, 2011; Wu and Yi, 2022).

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

[11] 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 intervention (Clark, 1973; Lardy, 1995).

2013, covers more than 1 million public and private industrial firms above a designated size in China.[12] 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 identification strategy of this paper relies on the delays in the implementation of the 156 Projects combined with the Sino-Soviet Split. When in 1960 the Soviet Union suddenly interrupted the program, all 304 steel plants had been built and had begun operating with Chinese capital. However, some of them had already received both Soviet physical capital and know-how, others had received only Soviet physical capital, and the remainder had received no Soviet transfers and continued to employ Chinese domestic capital.

We estimate the effects of the Soviet technology and know-how transfers via the equation:

$$\text{outcome}_{it} = \alpha_i + \theta_t + \sum_{\tau=-5}^{40} \beta_\tau (\text{Physical Capital}_i \cdot \text{Years after Transfer}{=}\tau_{it}) \quad (1)$$
$$+ \sum_{\tau=-5}^{40} \gamma_\tau (\text{Know-How}_i \cdot \text{Years after Transfer}{=}\tau_{it}) + \epsilon_{it}$$

where outcome_{it} is logged tons of steel and productivity (TFPQ) of Chinese plant i in year t;[13] 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; $\text{Years after Transfer}{=}\tau_{it}$ 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 $\tau = -1$. Plant fixed effects α_i control for variation in outcomes across firms constant over time. Year fixed effects θ_t control for nonlinear variation in outcomes over time. ϵ_{it} is the error term. Standard errors are block-bootstrapped at the industrial-cluster level with 1,000 replications to control for potential autocorrelation within clusters. As all plants were still alive and state-owned in 2000, Equation 1 estimates an intensive margin effect.

Under the identifying assumption that the performance of the 304 plants would have been on the same trend in the absence of Soviet transfers, the coefficient β_τ captures the effect of Soviet physical capital on plant performance, relative to plants that received no 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. While the identification assumption cannot be tested directly, in the rest of this section we discuss several pieces of evidence that corroborate our empirical strategy.

[12] The data include firms with more than 5 million yuan assets before 2011, and 20 million yuan after 2011.

[13] Specifically, we compute total factor productivity quantity (TFPQ) as the residuals of an OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects. Details about productivity estimation can be found in Appendix C2. Table C.3 shows that our productivity results are robust to different methods of estimating TFP.

4.1 Tests for Pre-Trends

We start our analysis by checking whether the 304 plants were on the same performance trend in the five years before receiving the Soviet transfer, when they were all operating with Chinese domestic capital. This is the crucial identification test for our empirical strategy. 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 know-how transfers. The estimated coefficients are close to zero and not statistically significant (Table 2). Moreover, the estimated coefficients on the indicators alone are not statistically significant in all the specifications, indicating a balance in baseline plant characteristics.

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 know-how transfers. The estimated coefficients on the indication terms are small in magnitude and never statistically different from zero (Table A.1). Moreover, some are positive and some are negative, confirming a lack of any pattern. Finally, the 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. Notably, in both tables plant capital stock does not show any trend across the 304 plants, further confirming how similar establishments were before receiving the Soviet transfers.

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

4.2 Balancing Tests at the Plant-Level

The historical evidence discussed in Section 2.3 suggests that receiving or not receiving the Soviet transfers before the Split depended on delays on the Soviet side and was not related to the initial design of the projects. If this was the case, plants that received Soviet physical capital and know-how, only physical capital or no transfers should have had on average similar baseline characteristics.

To systematically test this hypothesis, we first show that plants designed to receive the transfers in earlier years of the Sino-Soviet Alliance—and probably considered more important for Chinese industrialization—were not more likely to get them before the Split than plants designed to receive them in later years. The expected delivery years of Soviet capital and the expected arrival years of Soviet experts were substantially the same across the three types of plants. Moreover, we always fail to reject the null hypothesis of equality across their means (Table 3, Panel A, columns 1, 2,3, 5, 7, and 8).

We next document that the mean values of quantity and quality of steel production, capital stock, value added, and productivity appear very similar across the three groups of plants in the year before they were supposed to receive the Soviet transfers (Table 3, Panel A, columns 1–3). Notably, all these variables exhibit a small variance. The fact that the 304 plants operated with the same Chinese domestic capital while waiting for the Soviet transfers likely leveled off differences in blueprints and specifications used to build them. Moreover, the number of employees and their composition, as well as loans and transfers received from the government, are comparable across the 304 plants. For all these variables, we fail to reject the null hypothesis of equality across their means (Table 3, Panel A, columns 5, 7, and 8).

Finally, we test whether 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, the average distance from national and provincial borders, the coast, and Treaty Ports,[14] where most economic activities were concentrated, and from infrastructures such as highways and railroads is very similar in magnitude among plants that received or did not receive the Soviet transfers (Table 3, Panel B, columns 1–3). We show that plants that received the Soviet transfers were on average not closer to natural resources, such as coal or coke deposits (Table 3, Panel B, columns 1–3). In all these cases, we fail to reject the null hypothesis of equality across such variables' means (Table 3, Panel B, columns 5, 7, and 8).

Based on the evidence presented in this section, we can conclude that the 304 plants were statistically equivalent in the year before the Soviet intervention. These tests are crucial for our identification strategy, because they corroborate the idea that the transfers received did not depend on the original features of the program.

4.3 Balancing Tests at the Cluster- and County-Level

Next, we show that the 304 plants were not located in industrial clusters or counties with systematically different characteristics, which may have affected their outcomes in addition to the Soviet transfers. First, cluster characteristics do not predict the probability of receiving the Soviet transfers. None of the coefficients estimated by regressing the indicators for receiving Soviet physical capital and know-how on cluster characteristics is statistically significant, and we always fail to reject the null hypothesis of joint equality of the coefficients to zero (Table A.2, columns 1–3). Second, regressing these two variables on county characteristics in 1953 estimates small and non-statistically-significant coefficients (Table A.3, columns 1–3).

4.4 Resources Reallocation Across the 304 Steel Plants

A potential threat to our identification strategy may arise if the Chinese government reallocated physical capital and experts from plants that received the Soviet transfers to plants that did not. Before the Split, even in light of the delays faced by the program, it would have been very challenging for the Chinese government to redirect Soviet transfers to the most promising plants, as discussed in Section 2.3. In fact, the 304 plants aimed at replicating specific Soviet ones, making it impractical to reassign machinery, equipment, or experts. This is fully consistent with the evidence presented in Section 4.2, which shows that the 304 plants had very similar baseline characteristics.

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

To generate spillover effects after the Split, the Chinese government may have decided to reallocate Soviet machinery, equipment, and Soviet-trained workers from plants that received the Soviet transfers to plants that did not. However, it would have been highly unprofitable to remove brand-new furnaces from already productive plants, especially in light of the high demand for steel and the costs of moving capital across the country (Zeitz, 2011; Ji, 2019). Moreover, Soviet-trained engineers and technicians, essential for their own plants' operations, were in limited number, which strongly reduced the possibility of reallocation across different enterprises, as discussed in Section 2.4. Beyond these considerations, it is worth noting that a similar scenario would downward-bias our results.[15]

Another possibility is that the Chinese government may have decided to disproportionately channel its investments to plants that received the Soviet transfers, allowing them to prosper even more in the long run. While this is certainly a possibility, after the Split Chinese leaders wanted to show that the country could industrialize even without the advanced Soviet technology (Lardy 1995; Zhang et al. 2006; Zhang 2015). Consistently with the historical narrative, in Section 5.2, we will show that plants that received Soviet transfers did not get differential quota allocation, loans and transfers from the central government, access to infrastructure, or exposure to major historical events, such as the Great Leap Forward or the Cultural Revolution (Tables A.6, A.7, and A.11).

5 Effects of Physical Capital and Know-How Transfers

In this section, we estimate the effects of physical capital and know-how transfers on the performance of the 304 steel plants. We next rule out potential alternative explanations for our findings and assess the role of other major historical events. Finally, we extend our analysis to all of the 156 Projects 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 higher than that of plants that received no Soviet transfers for the first two years after receiving the state-of-the-art machinery, probably due to the difficulties in operating them without proper training. It then started differentially growing, reaching an 12.0% higher level seven years after the Soviet intervention. Then, the effects started slowly decreasing and were no longer significant after 20 years (Figure 2, Panel A and Table A.4, column 1).

[15] Another potential channel of spillovers from plants that received the Soviet transfers to plants that did not could be generated by CCP politicians' rotations. For instance, focusing on the last two decades, Lin et al. (2024) shows that bureaucrats, rotated across prefectures by the CCP, transferred industrial knowledge from the old to the new jurisdiction, and implemented favorable industrial policies. However, between 1949 and 1990, such rotations were less common than in later years. Out of 6,524 CCP bureaucrats who served in the 304 plants' prefectures during these years, only 73 (11.2%) were moved to other administrative areas. Notably, none of them was rotated from prefectures where plants that received the Soviet transfers were located to those where plants that received no transfers operated. We discuss political rotations in more detail in Section 5.2.

Conversely, output of plants that also received the know-how transfer rose by 7.9% relative to that of plants that received only the physical capital transfer in a mere two years since the Soviet intervention and by 19.1% within 20 years. The gap between the two groups of plants continued to widen, with an estimated output increase of 48.7% 40 years after the program (Figure 2, Panel B, and Table A.4, column 1). 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 received no Soviet transfers remained mostly flat over time (Figure 2, Panel C).

The dynamic of plant productivity (TFPQ) 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 7.0% increase relative to plants that received no Soviet transfers, and was no longer significant after 20 years (Table A.4, column 2). TFPQ of plants that also received a know-how transfer increased between 7.6% two years after the Soviet transfer to 46.4% after 40 years, relative to plants that received only Soviet physical capital (Table A.4, column 2).

We further explore the increase in productivity by focusing on the different components of the production function. In addition to the aforementioned increase in output, we do not find not statistically significant differences in number of workers and coke and iron quantities among the three types of plants (Table A.5, columns 1–3),[16] which suggests that the government did not allocate more or better inputs to plants that received the Soviet intervention. By contrast, capital stock, comparable across the 304 plants before the Soviet transfers, mechanically increased in plants that received the Soviet machinery in the intervention year, relative to plants that got no Soviet transfers, with the effects decaying over time, as such capital became obsolete. Capital stock remained comparable between plants that received Soviet machinery and plants that also received Soviet know-how up to ten years after the Soviet intervention, confirming that the latter were able to produce more output despite using comparable inputs (Table A.5, column 4).

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 for fixed effects of the Soviet enterprise to be duplicated (Figures A.2 and A.3, Panels A and D) and industrial clusters (Figures A.2 and A.3, Panels B and E).

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) explain that, in the 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), that confirms our main findings (Figures A.2 and A.3, Panels C

[16] While the 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 nonmarket clearing prices set by the government would be absorbed by year fixed effects in our regressions. This feature implies that we do not have any bias due to unobservable enterprise-specific variation in output or input prices.

and F). Moreover, clustering at a different level of aggregation, such as at the plant, county, or prefecture level confirms the significance of our main specification (Figures A.4 and A.5). Finally, our results are robust to several alternative ways of estimating TFP (Table C.3).

5.2 Ruling Out Alternative Explanations

Allocation of quotas. A potential concern in interpreting our main results is that the higher production of plants that received the Soviet 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.6). While this finding may seem counterintuitive, as explained in Section 2.4, quotas established when the steel plants were built were subject to few or no changes over time (He, 1958; Angang Shizhi Bianzuan, 1991; Ji, 2019). Moreover, after the Sino-Soviet Split, the Chinese government wanted to show that production using domestic technology could achieve the same level of output as 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 that in the years after the Split the government granted special favors to plants that received the Soviet transfers, which, 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 got no 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 grant more loans to plants that received the physical and know-how transfers relative to plants that got no transfer, either in the short run or in the long run (Table A.7, columns 1–2). Next, we check whether counties where such plants were located received more aid. Total investments, investments in both in steel and other industries, and investment in infrastructure did not differentially change across counties hosting the three groups of plants (Table A.8, 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 nonexistent in China until the 1990s, one may wonder if the Chinese government artificially kept alive plants that received no Soviet transfer after the Split. To test for this possibility, we compare plants built under the Sino-Soviet Alliance but that got no Soviet transfer with other steel plants built in other industrial clusters after 1960. The former were larger and performed better than the latter, but there were no observable differences in the types of technology and production process in use in these plants (Table A.9, columns 1–5). While these results have no causal interpretation, they seem to suggest that, even for the plants that ultimately received no Soviet transfer, Soviet help in their initial design 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.7, columns 3–4).

Political connections and politicians' rotations. Plants that received Soviet transfers may have also been more politically connected than plants that received no transfers over time, or perhaps better politicians were allocated to their administrative areas, contributing to their economic success. To test investigate this hypothesis, we collected data from the *People's Daily Online* database, which includes full biographies of both the secretaries of the Municipal Party Committee, directly linked with the central government, and the prefecture mayors, who represented the local government, between 1949 and 2018. Both secretaries and mayors were recruited by the CCP, and periodically rotated across prefectures to limit long-lasting interactions with local elites.[17] We use the database to reconstruct such rotations in the jurisdictions where the 304 plants were located.

Building on previous works of CCP recruitment (Jia et al., 2015; Francois et al., 2023; Wang and Yang, 2024), we test whether exposure to bureaucrats' rotations was different in the 304 plants' prefectures, under the assumption that lower political rotations may indicate stronger ties with plants' top management.[18] However, we do not find statistically significant differences in number of officials' rotations or length of their terms (Table A.10, columns 1,2, 5, and 6). Next, we proxy politicians' quality with years of education and years of experience in previous appointments, not finding statistically significant differences in these two measures across the 304 plants' prefectures (Table A.10, columns 3, 4, 7 and 8).

> These results suggest that political connections and politicians' quality the 304 plants were exposed to remained comparable in the 40 years after the Soviet intervention.

5.3 Discussing Other Concurrent Historical Events

In China, the 1960s and 1970s were decades dense with historical events that, among other consequences, affected Chinese industrialization. In this section, we explore whether such events had a differential impact on the 304 plants.

[17] Inherited from imperial China, bureaucrats' rotations were implemented by CCP since the foundation of PRC (The Economist, 2021). However, they became more salient in the 1990s, when the government embraced market-oriented reforms and started fighting corruption (Zeng, 2017). In Section 4.4, we already showed that we do not observe reallocation of politicians from prefectures where plants that received the Soviet transfers were located to those where plants that received no transfers operated.

[18] Having officials serving in their home province was not common and should, if anything, weaken ties with plants' management, given Mao's aversion to practices that could have been perceived as favoring hometown or college "factions" (Fisman et al., 2020).

Great Leap Forward. In 1958, the Great Leap Forward, China's Second Five Year Plan, was launched 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. 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.6).[19] Clark (1995) explains how 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.

The Great Leap Forward not only affected steel production but also caused a massive reallocation of workers from the agricultural sector to the industrial sector, which was not associated with a proportional increase in agricultural productivity. For this reason, the Great Leap Forward is considered the primary cause of the Great Famine, which by 1961 had 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 county-level cohort loss in 2000 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 counties that hosted the 304 plants (Table A.11, 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), which lasted for over a decade and built or moved large manufacturing plants to the South-Western and North-Western parts 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 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.[20] However, counties where plants that received the Soviet transfers were located did not receive more investments than counties where plants that received no Soviet transfers operated during the TF years (Table A.11, column 2). Moreover, in Table A.7, we have already shown that government loans and transfers did not differentially change across the 304 plants in the 20 years after the Soviet intervention, when the TF construction took place, further suggesting

[19] To the best of our knowledge, none of the 304 plants were relocated to the countryside as a consequence of the Great Leap Forward.

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

that the TF movement did not differentially impact them.

Cultural Revolution. Finally, between 1966 and 1976, the Cultural Revolution, which aimed at purging any remnants of capitalism, led to the imprisonment of many high-skilled workers, as well as the closure of numerous schools and universities. While aggregate steel production declined during these years, the 304 plants were deemed too important for 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. This finding is consistent with what Hirata (2018) described in detail for the Anshan Iron and Steel Company: 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 that any of these historical events differentially affected steel plants that received or did not receive the Soviet transfers.

5.4 Effects in All Industries

We next test whether our results in the steel industry hold for firms in all industries in the medium and long run, using data on their performance in 1985 and between 1998 and 2013. We estimate the following specification:

$$\text{outcome}_{it} = \alpha + \beta \cdot \text{Physical Capital}_i + \gamma \cdot \text{Know-How}_i + \theta_{cst} + \nu_{it} \tag{2}$$

where outcome_{it} comprises value added, total factor productivity revenue (TFPR),[21] and workers of firm i in 1985 or in year t; $\text{Physical Capital}_i$ is an indicator for firms that received a physical capital transfer; Know-How_i is an indicator for firms that received a know-how transfer; and θ_{cst} are county-sector-year fixed effects. For estimation in 1985, we don't have a time dimension, so county-sector-year fixed effects are replaced with county-sector 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 from those of firms that received no transfer (Table A.12, columns 1, 3, and 5). By contrast, value added and TFPR of firms that also received a know-how transfer were, respectively, 41.5% and 39.5% higher than that of firms that received only a physical capital transfer in 1985; and 52.0% and 49.3% higher between 1998 and 2013, with no statistically significant differences in employment (Table A.12, 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.

[21] TFPR is computed as the residuals of regressing firm logged value added on logged workers and capital stock, and plant and year fixed effects.

6 Firm Upgrading

The fact that the effects of technology transfer persisted only if complemented by the know-how transfer is consistent with the capital-skill complementarity hypothesis (Griliches, 1969; Krusell et al., 2000): technologically advanced capital goods and high-skilled workers are relatively more complementary than capital and unskilled labor. However, since high-skilled workers are instrumental in firm upgrading, a greater availability of both these inputs should stimulate quality and technology upgrade (Verhoogen, 2023), a potential mechanism behind our results.

We empirically test this intuition in three steps. First, we check whether the Soviet transfers affected the quality of steel produced by the 304 steel plants. We find weak evidence that plants that received the physical capital transfer produced more crude steel (considered the best-quality steel) and reduced the quantities of pig iron (considered to be lower quality, given its higher carbon content) up to ten years after Soviet intervention, relative to plants that received no Soviet transfer and continued to use domestic capital goods, and no effects after that (Table 4, columns 1–2). Conversely, plants that also received a know-how transfer produced 5.7% to 23.2% more crude steel, relative to plants that only received the physical capital transfer, and 4.9% to 17.2% less pig iron between five and 20 years after the Soviet transfer respectively (Table 4, columns 1–2). These plants also reduced output scrapped due to low quality, between 7.2% and 16.3% in the same period (Table 4, column 3). This difference in product quality among firms that used the same physical capital can be related to the training to engineers and supervisors. For instance, the know-how transfer introduced quality-control methods that reduced the time to determine hot metal chemical composition from 50 minutes to two minutes through systematic sampling. This procedure allowed for quality checks during the steel-making process, rather than at the end, which reduced scrapped output, and subsequently increased production quantity, quality, and productivity (Clark, 1973).

Second, we test the role of the know-how transfer in promoting technology upgrade. During the 1960s, a new steel-making process—the basic oxygen process, which blew oxygen through molten pig iron to 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 substantially higher probability of relying on this process, relative to plants that received the physical capital transfer only (Table 4, column 3). However, the latter were not more likely to use this technique relative to plants that received no Soviet transfers.

The Soviet capital was state-of-the-art in the 1950s, but by the late 1960s, due to the development of continuous casting furnaces, it had become obsolete (Fruehan et al., 1997).[22]

[22] 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.

Plants that received the know-how transfer were considerably more likely to adopt continuous casting furnaces that replaced Soviet capital, relative to plants that received only physical capital between 10 to 20 years after the Soviet transfer (Table 4, column 4).[23] Conversely, the latter did not show more continuous casting furnace usage than plants that got no Soviet transfer. These findings appear related to an important component of the know-how transfer. Part of the training promoted the development of internal research labs to discover new, more-efficient production methods and technologies (Gangchalianke, 2002).

Finally, capital-skill complementarity should have increased the employment of high-skilled workers (Goldin and Katz, 1998). Consistently, we find that over years, plants that received Soviet know-how employed more engineers and high-skilled technicians and fewer low-skilled workers than plants that received the Soviet capital (Table 4, columns 5 and 6).[24] Such plants opened training schools for high-skilled technicians and offered within-firm training programs to their engineers (Hirata, 2018; Ji, 2019), which likely contributed to technology development. This channel was particularly important during the Cultural Revolution, when most advanced education in the country was suspended. Conversely, we do not observe differential changes in human capital composition between plants that received Soviet capital and those that didn't.

Taken together, these results suggest that complementarities between Soviet technology and engineering know-how helped receiving plants to upgrade, in terms of both product quality and subsequent technology development. This channel helps explain why the effects of capital and know-how transfers were long-lasting, while the impact of Soviet capital alone was short-lived. Notably, the influence of Soviet know-how transfer on Chinese steel production persists today. According to the World Steel Association, in 2022 six of the ten largest steel producers in the world were Chinese, five of which belong to industrial clusters that got Soviet know-how (WorldSteel Association, 2023). For instance, the first and third largest producers, China Baowu Group and Ansteel Group, belong to the Wuhan and Anshan industrial clusters, respectively, and received the vaunted blast furnaces from the Soviet Union in the 1950s, along with extensive Soviet training and crucial management expertise (Ji, 2019; Wu and Yi, 2022). By contrast, the Tangshan cluster, which also received the Soviet blast furnaces but without training, is not ranked among the top Chinese steel companies.

6.1 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 machinery from the United States and Western Europe and export their products there. Khandelwal et al. (2013) show that the removal of quotas on Chinese textile and clothing

[23] This is also reflected in an increase in the capital stock of the plants that received Soviet know-how, relative to plants that received Soviet capital only over the same period (Table A.5, column 4).

[24] Notably, the numbers of high-skilled and low-skilled workers were comparable across the three types of plants at time of opening, as we have shown in our balancing tests (Table 3, Panel A), while total employment remained comparable over time (Table A.5, column 3).

exports to the U.S., E.U. and Canada in the 2000s led to larger-than-expected productivity growth, due to the concomitant abolition of the institutions that grew up around trade barriers. In a similar vein, we study whether trade with the Western world helps explain the further increase in performance during the 1980s and 1990s of steel plants that received Soviet know-how.

Detailed data on foreign technology imports allow us to examine whether opening to trade differentially affected the 304 plants after 1978. Specifically, from the contract descriptions, we can distinguish between imports of Western physical capital used to replace domestic ones and imports of equipment complementary with plants' capital. The results indicate that plants that received the Soviet know-how imported 17.2% less physical capital to substitute their current one, but 20.4% more foreign equipment used as a complement for their machinery, relative to plants that received the Soviet physical capital only (Table 5, columns 1 and 2). Such plants were also able to take advantage of the new export possibilities. They exported 33.9% more steel into the Western world than plants that received the Soviet physical capital only and produced 32.0% more steel above the international standards (Table 5, 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 received no Soviet transfer. This aspect can also help explain the short-lived effect of the Soviet capital transfer. When both types of plants could import foreign machinery, plants that received Soviet capital no longer had a productivity advantage over plants that received no Soviet transfer.

7 Spillover Effects

At the core of the Big Push theory is the idea that the initial localized investments could become self-sustaining due to agglomeration economies (Kline and Moretti, 2014). Such agglomerations could be stimulated through the simultaneous installation of complementary industries, with strong backward and forward linkages, to exploit economies of scale (Murphy et al., 1989). Following this strategy, on top of the 304 steel plants that represented the bulk of steel industrial clusters, the Soviet aid involved the construction of 684 complementary plants, which were not eligible to receive the Soviet transfers. Did the 304 plants generate the spillover effects predicted by the literature?

To answer this question, we first construct the backward and forward linkages between the 304 plants and the complementary establishments, using the input-output matrix (more details are available in Appendix B.2). Next, we estimate the following equation:

$$\begin{aligned}\text{outcome}_{jit} = \alpha \cdot \text{Physical Capital}_i + \beta(\text{Physical Capital}_i \cdot \text{Post Transfer}_{it}) \\ + \gamma \cdot \text{Know-How}_i + \delta(\text{Know-How}_i \cdot \text{Post Transfer}_{it}) + \theta_t + \nu_{jit}\end{aligned} \quad (3)$$

where outcome_{jit} are key metrics of performance, technology adoption, and exports of plant j with linkages with plant i in year t; the other variables are defined as in equation 1.

Plants with linkages to plants that received the Soviet physical capital produced on average 10.0% more output than plants with linkages to plants that received no Soviet transfer (Table 6, column 1). These findings are fully consistent with the increased production of plants that received Soviet physical capital, which in turn likely affected their supply chain. However, only plants with linkages to plants that also received the know-how transfer experienced both production and productivity increases after the Split, 20.3% and 19.2%, respectively (Table 6, columns 1 and 2).

When China was a closed economy, these plants also had a higher probability of technological upgrade (Table 6, column 3). Moreover, when China opened up to international trade after 1978, it imported less physical capital to substitute its current one, but more foreign equipment used as a complement for its machinery, and it systematically engaged more in exporting to the Western world (Table 6, columns 4–6).

These results could be explained by the fact that plants that received the Soviet know-how over years offered training programs for engineers and high-skilled technicians working in their own plants and in related plants (Hirata, 2018; Ji, 2019), generating technological externalities through local interactions and learning-by-doing (Glaeser et al., 1992; Moretti, 2004). Such findings also echo previous studies that, in different settings, have documented sizable knowledge spillovers along the supply chain (Greenstone et al., 2010; Kline and Moretti, 2014; Bianchi and Giorcelli, 2022). We add to this literature by showing how, in the Chinese context, the diffusion of engineering know-how to complementary establishments generated productivity spillovers and technology upgrade, while economies of scale stemming from input-output linkages had a more limited impact.

Starting in the late 1990s, the Chinese government undertook a number of market liberalization reforms to release resources that could be more profitably employed by privatizing state-owned firms (Hsieh and Song, 2015). We therefore test whether the spillover effects persisted after market liberalization, using data on firms in all the industries between 1998 and 2013. We find that firms 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.13, 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 only the Soviet physical capital.[25]

County-Level Analysis. To examine whether the 156 Projects generated agglomeration effects, in line with the Big Push predictions, we extend our analysis at the county level.[26] Counties that hosted plants that received Soviet know-how had on average 16.6% more private firms relative to counties that hosted plants that received only Soviet physical capital and 25.2% more privately produced industrial output (Table A.14, columns 1 and

[25] In industries not related to the 156 Projects, we do not observe any difference in performance among firms in the same counties (Table A.13, Panel B).

[26] Because this analysis is at the county-level, we can use data on all the 156 Projects, not only on the steel ones, as in Equation 3.

4). Conversely, there were no differences between counties that hosted plants that received only Soviet physical capital and plants that received no Soviet transfer.

Next, we test whether counties that hosted plants that received the Soviet know-how had a higher concentration of industry-specific human capital. In fact, such plants opened in-house training schools for engineers and high-skilled technicians, especially during the Cultural Revolution, that were institutionalized after 1978. Into the late 1990s, 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 15.6% higher number of technical schools per inhabitant relative to counties that hosted plants that received the physical capital transfer (Table A.15, columns 1 and 2). This was associated with a 13.3% higher number of STEM college graduates and a 16.2% higher number of high-skilled workers over population (Table A.15, columns 3 and 4).[27] When firms started competing for inputs in the local market, having more STEM and high-skilled workers at the county level could have given them better hiring opportunities, with positive effects on their performance.

The results we've presented so far are based on a comparison of counties that hosted the 156 Projects and rely on variation in the Soviet transfers eventually received. A separate interesting question would be how such counties performed relative to the rest of Chinese areas in recent years. A paper closely related to ours, Heblich et al. (2022), performs this analysis and documents that counties that hosted the 156 Projects had a significant production advantage in the 1980s, relative to counterfactual counties that were suitable for hosting the projects but were ultimately not selected. However, this advantage was fully eroded by 2010 due to overspecialization and less innovation. While these findings seem at odd with ours, it is possible to reconcile the two sets of results, given the heterogeneity of the Soviet transfers. Counterfactual counties may have remained less productive than counties that received the Soviet transfers but outperformed counties that eventually received no Soviet transfers, resulting in an aggregate negative effect.

Cost-Benefit Analysis. Finally, 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 ten 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

[27] In Section 5.2, 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.8, columns 1–3), which suggests that this potential channel is not driving our results.

2020 figures).

We compute the benefits of the Sino-Soviet Alliance as the contribution to 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 its essential role on Chinese early industrial development (Lardy, 1995; Zhang et al., 2006; Naughton, 2007).[28] These results are consistent with Carlin et al. (2013), who document that in command economies that were relatively poor when planning started, like China, the higher long-run GDP per capita stemming from physical and human capital investments compensated for the costs in allocative inefficiency and weak incentives for innovation. By contrast, for relative richer countries, the opposite result holds.

8 Conclusions

This paper studies the effects of technology and know-how transfers on structural transformations. We collected novel steel-plant-level data on the 156 Projects, which were sponsored by the Soviet Union to promote Chinese industrialization in the 1950s. Leveraging natural variation in the transfers eventually received by such plants—due to delays on the Soviet side combined with the Sino-Soviet Split in 1960—we find that the effects of the technology transfer persisted over decades only if properly complemented by the know-how transfer, which also stimulated quality and technology upgrade, as well as productivity spillovers in related industries.

Our work sheds new light on Big Push industrial policies, contributing to a nascent but rapidly growing literature that exploits natural experiments to study the origin of industrial development (Juhász, 2018; Giorcelli, 2019; Lane, 2023; Mitrunen, 2024). We show that imported foreign technologies alone are not enough to stimulate economic development in the early stages of industrialization, while engineering know-how and high-skilled human capital can promote technological advancements within and across firms.

Examining China improves our understanding of structural transformations of the country which experienced the fastest industrialization in modern history, among major economies (Morrison, 2019). An important advantage of our setting is the internal validity of the results, but the fact that China was a command economy until at least the 1980s limits their external validity. Nevertheless, we argue that our findings may have implications beyond the Chinese context. First, similar industrialization policies were implemented in several preindustrial economies between the 1950s and 1980s.[29] Moreover, heavy industries, in particular steel, are regarded as strategic by most governments and therefore subject to state control even in nonplanned economies with goals that "do not necessarily coincide with value creation and profit maximization" (Mattera and Dilva, 2018). Finally, an increasing number of low-income African countries are planning to foster economic development by relying

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

[29] As explained in Section 2.1, Big Push development strategies, comparable to the Chinese ones, were sponsored by the Soviet Union in Communist countries such as Vietnam, Laos, Cambodia, North Korea, and Cuba, and India, Egypt, Ghana, and Turkey.

on industrial policy tools, which involve large public investments, limited competition, and a prominent role for the state in promoting economic development, similar to early-stage Chinese industrialization.[30] Notably, China itself is among the largest sponsors of such policies outside the Western world (Walter, 2021).

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[30] For instance, Uganda's third National Development Plan, adopted in 2020, entails a strengthened role for the state in guiding and facilitating development. Ghana and Cote d'Ivoire are considering the introduction of price controls, production caps, and public investments in cocoa production. Senegal, Ethiopia, Nigeria, and Gabon aim to catalyze industrial growth by channeling public investments in the creation of manufacturing clusters (Walter, 2021).

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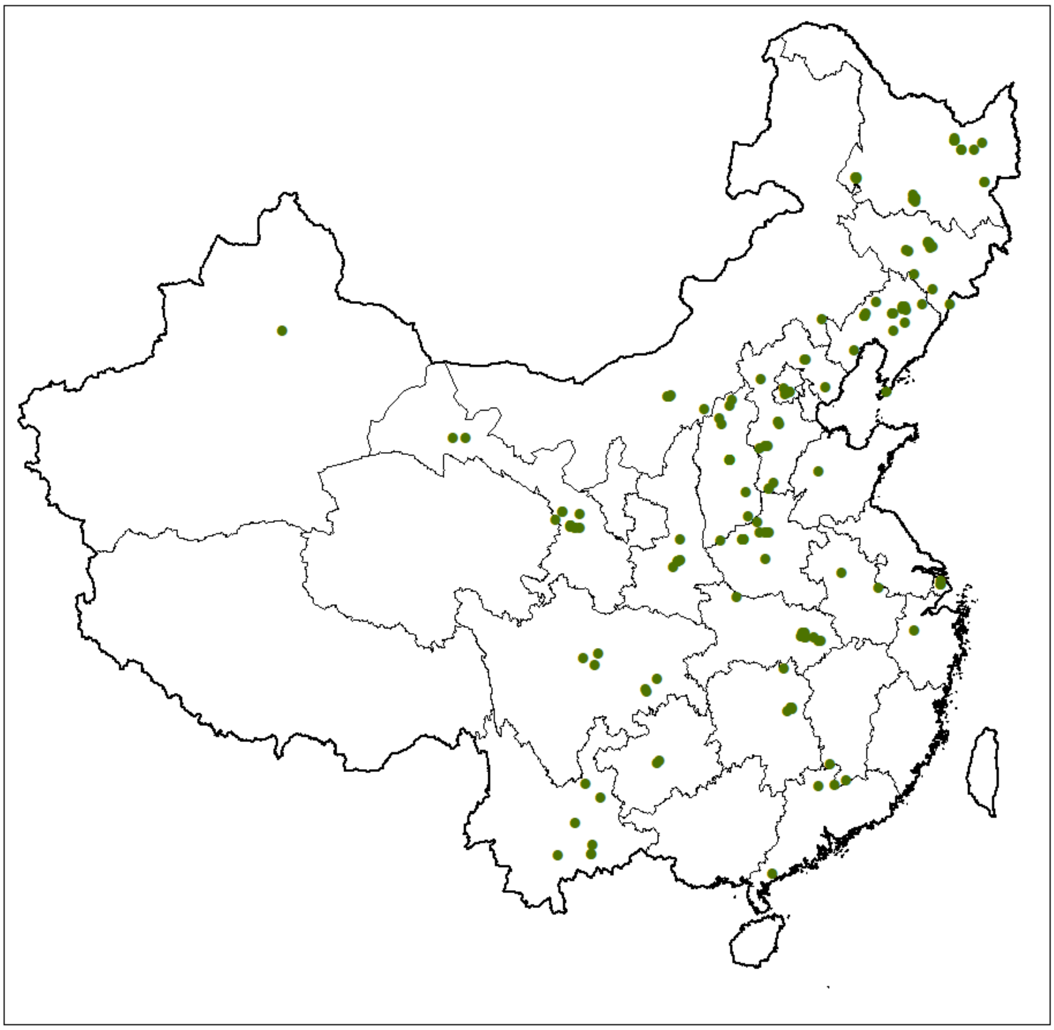
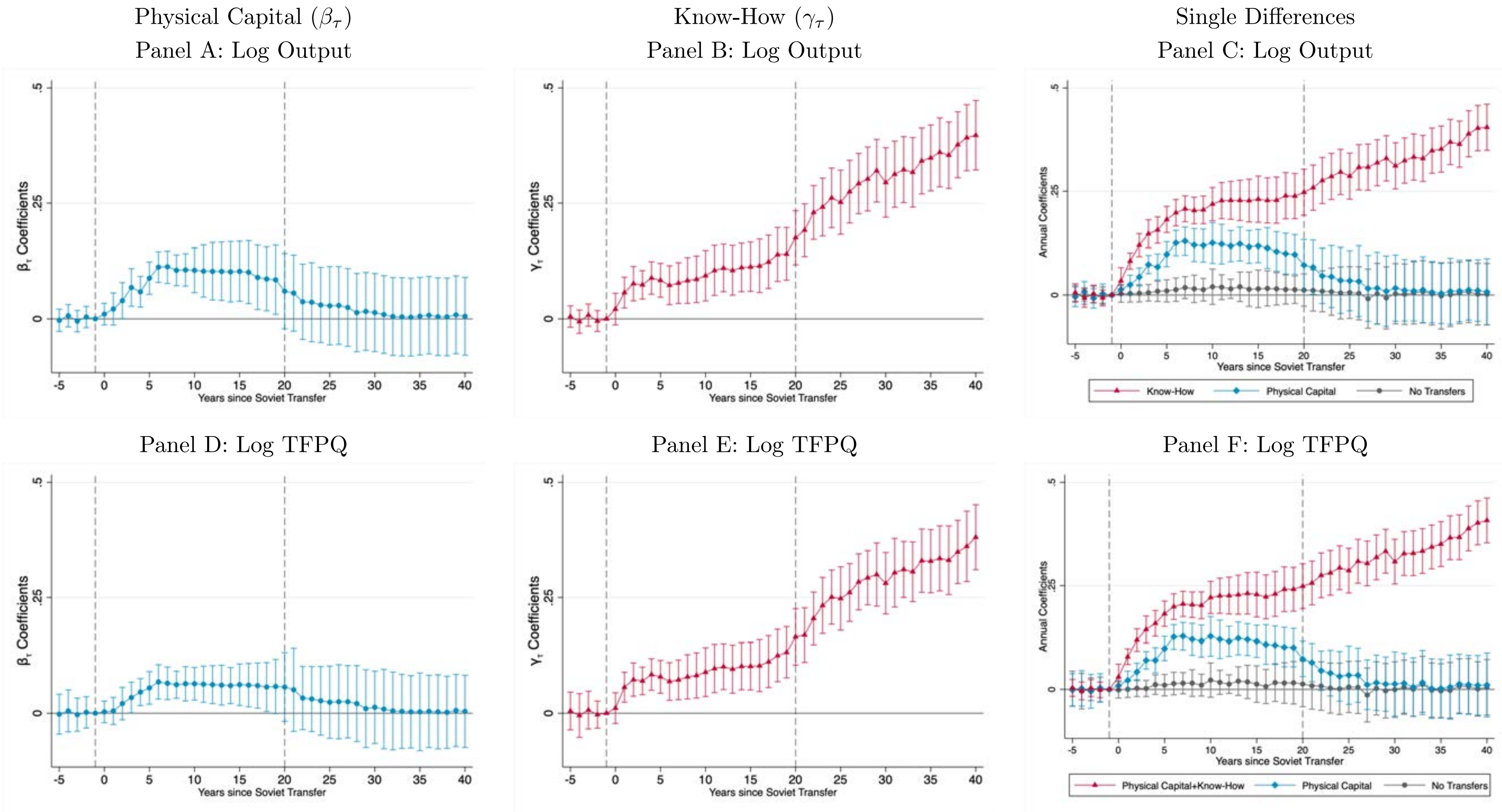
Figures and Tables

Figure 1: Distribution of the 156 Projects



Notes. 139 approved projects between 1952 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 the 304 Steel Plants' Production and Productivity



Notes. Annual β_τ coefficients (physical capital, Panels A and D) and γ_τ coefficients (know-how, Panels B and E) from Equation 1, and single differences (Panels C and F) for the 304 steel plants belonging to the 156 Projects. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Output* is logged quantities (in million tons) of steel. *Log TFPQ* is logged total factory productivity quantity, computed as the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects. 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.

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 Length	5.64	1.39	3	9
Expected Physical Capital Delivery Year	1957.87	3.06	1954	1963
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
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 Length	6.12	0.72	5	9
Expected Physical Capital Delivery Year	1957.26	2.96	1954	1963
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
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. *Approval* and *Start Year* are the approval and start year of each project; *Expected Length* is the expected number of years to complete project construction; *Expected Physical Capital Delivery* is the project average expected year of Soviet physical capital delivery; *Expected Soviet Experts Arrival* is the project average expected year of Soviet experts arrival; *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 project was expecting 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(k)* is number of employees per project, in thousands; *Number of Plants* is number of plants per project.

Table 2: Pre-Soviet Intervention Difference in Time Trends Among the 304 Steel Plants

	Log Steel	Log Crude Steel	Log Pig Iron	Log Capital
	(1)	(2)	(3)	(4)
Physical Capital * Trend	-0.002	0.007	-0.004	-0.002
	(0.002)	(0.009)	(0.004)	(0.005)
Know-How * Trend	0.003	0.004	-0.005	-0.004
	(0.005)	(0.003)	(0.007)	(0.007)
Time Trend	-0.008	-0.005	-0.004	0.002
	(0.011)	(0.007)	(0.006)	(0.005)
Physical Capital	0.004	-0.002	0.006	-0.003
	(0.006)	(0.004)	(0.011)	(0.004)
Know-How	0.007	-0.010	-0.011	-0.004
	(0.008)	(0.012)	(0.015)	(0.008)
	Log Sales	Log Value Added	Log TFPQ	Log Employees
Physical Capital * Trend	-0.004	0.004	-0.002	-0.004
	(0.005)	(0.005)	(0.003)	(0.006)
Know-How * Trend	0.004	0.001	-0.007	0.005
	(0.005)	(0.002)	(0.008)	(0.007)
Time Trend	0.002	-0.002	-0.004	-0.002
	(0.003)	(0.001)	(0.005)	(0.005)
Physical Capital	-0.005	-0.004	-0.003	0.010
	(0.017)	(0.009)	(0.007)	(0.011)
Know-How	-0.005	0.004	-0.008	0.007
	(0.006)	(0.009)	(0.007)	(0.010)
	Log Engineers	Log High-Skilled	Log Loans	Log Transfers
Physical Capital * Trend	0.004	0.003	-0.003	0.003
	(0.005)	(0.005)	(0.005)	(0.004)
Know-How * Trend	-0.003	0.005	-0.006	0.005
	(0.007)	(0.005)	(0.012)	(0.010)
Time Trend	-0.004	-0.002	0.004	-0.004
	(0.008)	(0.004)	(0.007)	(0.006)
Physical Capital	-0.005	-0.010	0.008	0.003
	(0.007)	(0.012)	(0.009)	(0.006)
Know-How	0.008	-0.011	0.004	0.003
	(0.010)	(0.012)	(0.007)	(0.005)
Observations	1,520	1,520	1,520	1,520

Notes. OLS regressions predicting plant outcomes before the Soviet transfer. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. 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 know-how transfers. *Steel, Crude Steel* and *Pig Iron* are logged quantities (in million tons) of steel, crude steel and pig iron. *Capital* is logged capital stock, calculated using the perpetual inventory method (PIM, see Table B.1). *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 the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects; *Employees, Engineers,* and *High-Skilled Technicians* are, respectively, logged thousands of employees, engineers, and high-skilled technicians; *Loans* and *Transfers* are, respectively, logged 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 3: Balancing Tests for the 304 Steel Plants, Panel A: Plant Characteristics and Outcomes

	Mean (1–3)			Tests for Mean Equality (4–8)				
	Know-How + Capital	Capital	No Transfer	Col. 1 vs. 2		Col. 2 vs. 3		All
				Mean Diff.	*p*-value	Mean Diff.	*p*-value	*p*-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Expected Physical Capital Year	1957.31	1957.44	1957.08	-0.13	0.731	0.36	0.610	0.581
	(3.45)	(3.59)	(3.12)	(0.27)		(0.32)		
Expected Soviet Experts Year	1958.56	1958.78	1958.21	-0.22	0.689	0.57	0.572	0.532
	(2.96)	(2.71)	(2.88)	(0.24)		(0.49)		
Steel Production (m tons)	602.06	604.24	602.85	-2.18	0.689	1.39	0.623	0.655
	(19.43)	(18.67)	(23.67)	(1.79)		(1.46)		
Crude Steel Production (m tons)	153.49	152.82	154.62	0.67	0.569	-1.80	0.486	0.642
	(13.98)	(14.18)	(14.23)	(1.18)		(1.23)		
Pig Iron Production (m tons)	96.08	101.04	99.31	-4.96	0.254	1.73	0.761	0.555
	(15.18)	(15.70)	(15.12)	(3.87)		(1.25)		
Capital Stock (m)	57.92	58.18	58.40	-0.24	0.608	-0.22	0.624	0.516
	(8.04)	(7.81)	(7.54)	(0.31)		(0.37)		
Annual Sales (m)	17.83	17.18	18.04	0.65	0.489	-0.86	0.380	0.452
	(3.30)	(3.56)	(2.45)	(0.52)		(0.69)		
Value Added (m)	2.59	2.53	2.51	0.06	0.628	0.02	0.639	0.720
	(0.16)	(0.27)	(0.20)	(0.08)		(0.04)		
Productivity (log TFPQ)	1.21	1.28	1.25	-0.07	0.578	0.03	0.651	0.678
	(0.32)	(0.55)	(0.25)	(0.06)		(0.04)		
Employees (k)	3.49	3.60	3.44	-0.11	0.453	0.16	0.532	0.492
	(1.03)	(0.72)	0.83	(0.08)		(0.13)		
Engineers (k)	0.38	0.36	0.37	0.02	0.801	-0.01	0.853	0.827
	(0.04)	(0.05)	(0.05)	(0.02)		(0.02)		
High-Skilled Technicians (k)	0.51	0.57	0.52	-0.06	0.497	0.05	0.563	0.647
	(0.14)	(0.36)	(0.33)	(0.04)		(0.05)		
Unskilled Workers (k)	2.60	2.64	2.62	-0.04	0.578	0.02	0.489	0.542
	(1.05)	(0.75)	(0.91)	(0.03)		(0.02)		
Loans	5.24	5.43	5.09	-0.19	0.347	0.34	0.401	0.398
	(0.96)	(1.86)	(2.18)	(0.15)		(0.29)		
Transfers	4.10	4.37	3.96	-0.27	0.423	0.41	0.398	0.512
	(1.05)	(2.15)	(2.12)	(0.24)		(0.36)		
Observations	98	91	115	189	189	206	206	304

(continues)

Table 3: Balancing Tests for the 304 Steel Plants, Panel B: Geographical Location and Natural Resources – Continued

	Mean (1–3)			Tests for Mean Equality (4–8)				
	Know-How + Capital	Capital	No Transfer	Col. 1 vs. 2		Col. 2 vs. 3		All
				Mean Diff.	*p*-value	Mean Diff.	*p*-value	*p*-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance Border (km)	231.60	230.44	229.45	1.16	0.510	0.99	0.616	0.552
	(61.34)	(62.15)	(65.74)	(0.89)		(0.81)		
Distance Province (km)	67.32	68.25	68.18	-0.93	0.526	0.07	0.488	0.582
	(17.89)	(16.58)	(18.01)	(0.88)		(0.10)		
Distance Coast (km)	515.64	517.76	514.28	-2.12	0.683	3.48	0.537	0.562
	(54.39)	(58.71)	(56.32)	(1.79)		(3.12)		
Distance Treated Ports (km)	581.30	582.83	580.93	-1.53	0.706	1.90	0.762	0.609
	(41.32)	(43.98)	(42.72)	(1.11)		(1.51)		
Distance Highway (km)	38.11	37.65	38.42	0.46	0.526	-0.77	0.711	0.654
	(12.43)	(11.57)	(13.42)	(0.38)		(0.61)		
Distance Railway (km)	63.49	62.55	62.31	0.94	0.572	0.24	0.521	0.522
	(21.19)	(22.40)	(19.87)	(0.79)		(0.15)		
Distance Coal Deposits (km)	5.77	6.03	5.82	-0.26	0.663	0.21	0.560	0.549
	(2.58)	(2.41)	(2.98)	(0.22)		(0.18)		
Distance Coke Deposits (km)	7.59	7.68	7.21	-0.09	0.504	0.47	0.556	0.499
	(3.48)	(3.87)	(3.09)	(0.07)		(0.31)		
Observations	98	91	115	189	189	206	206	304

Notes. Balancing tests for the 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 know-how and physical capital transfers from the Soviet Union (column 1), 91 plants that received only a physical capital transfer from the Soviet Union (column 2), and 115 plants that eventually received no Soviet transfers (column 3). Columns 4 and 6 report the mean differences of columns 1 and 2 and 2 and 3, respectively, with standard errors in parentheses. Columns 5 and 7 report the *p*-value of testing mean equality between columns 1 and 2 and columns 2 and 3, respectively. Column 8 reports the *p*-value of testing jointly the mean equality of columns 1, 2 and 3. *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 quantities (in million tons) of steel, crude steel, and pig iron; *Capital Stock* is plant capital stock, calculated using the perpetual inventory method (PIM, see Table B.1). *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 the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects; *Employees, Engineers, High-Skilled Technicians*, and *Unskilled Workers* are, respectively, thousands of employees, engineers, high-skilled technicians, and unskilled workers employed in a plant; *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 in 1952, and coal and coke deposits.

Table 4: Effects of Soviet Transfer on Firms Upgrading Before 1978

	Crude Steel (1)	Pig Iron (2)	Scrapped Output (3)	Converters (4)	Casting (5)	High-Skilled (6)	Unskilled (7)
Physical Capital * Year 1	0.011	-0.018	0.002	0.006	0.005	0.002	-0.003
	(0.011)	(0.020)	(0.004)	(0.005)	(0.009)	(0.003)	(0.005)
Physical Capital * Year 5	0.112**	-0.106***	0.005	0.009	0.007	0.005	0.003
	(0.051)	(0.047)	(0.006)	(0.010)	(0.008)	(0.006)	(0.005)
Physical Capital * Year 10	0.082*	-0.076*	0.010	0.009	0.006	0.013	0.015
	(0.044)	(0.041)	(0.014)	(0.010)	(0.008)	(0.015)	(0.020)
Physical Capital * Year 20	0.021	-0.028	0.008	0.007	0.010	0.011	0.011
	(0.047)	(0.049)	(0.009)	(0.009)	(0.014)	(0.013)	(0.010)
Know-How * Year 1	0.004	-0.032	0.005	0.003	0.008	0.004	0.005
	(0.035)	(0.030)	(0.007)	(0.010)	(0.011)	(0.006)	(0.008)
Know-How * Year 5	0.055***	-0.048***	-0.075***	0.252***	0.019	0.026***	-0.025***
	(0.015)	(0.012)	(0.012)	(0.041)	(0.013)	(0.007)	(0.004)
Know-How * Year 10	0.178***	-0.138***	-0.151***	0.345***	0.267***	0.053***	-0.060***
	(0.046)	(0.044)	(0.045)	(0.053)	(0.051)	(0.007)	(0.007)
Know-How * Year 20	0.209***	-0.189***	-0.178***	0.651***	0.784***	0.068***	-0.071***
	(0.049)	(0.048)	(0.043)	(0.151)	(0.143)	(0.007)	(0.006)
Observations	7,904	7,904	7,904	7,904	7,904	7,904	7,904

Notes. Selected annual β_τ and γ_τ coefficients from Equation 1. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. Data are provided at the plant level from Steel Association Reports from 1949 to 2000. *Crude Steel, Pig Iron,* and *Scrapped Output* are logged quantities (in million tons) of crude steel, pig iron, and output scrapped due to low quality. *Converters* and *Casting* are indicators for plants using the basic oxygen converters and the continuous casting furnaces. *High-Skilled* and *Unskilled* are logged thousands of engineers and production supervisors, 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 5: Trade With The Western World After 1978

	Substitute Capital (1)	Complementary Equipment (2)	Exports (3)	Int. Stand. (4)
Physical Capital	0.012	0.013	0.014	0.010
	(0.009)	(0.010)	(0.018)	(0.012)
Know-How	-0.159***	0.186***	0.292***	0.278***
	(0.048)	(0.051)	(0.041)	(0.043)
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 Soviet know-how. Data are provided at the plant level from the from Steel Association Reports from 1949 to 2000 and from the Chinese Ministry of Commerce and the Ministry of Industry and Information Technology from 1970 to 2000. *Substitute Capital, Complementary Equipment, Exports,* and *Int. Stand.* are logged values of foreign imported capital used to replace Soviet capital, foreign equipment complementary with plant physical capital, exports, and quantity of steel that met 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 6: Effects of Soviet Transfer on Complementary Firms

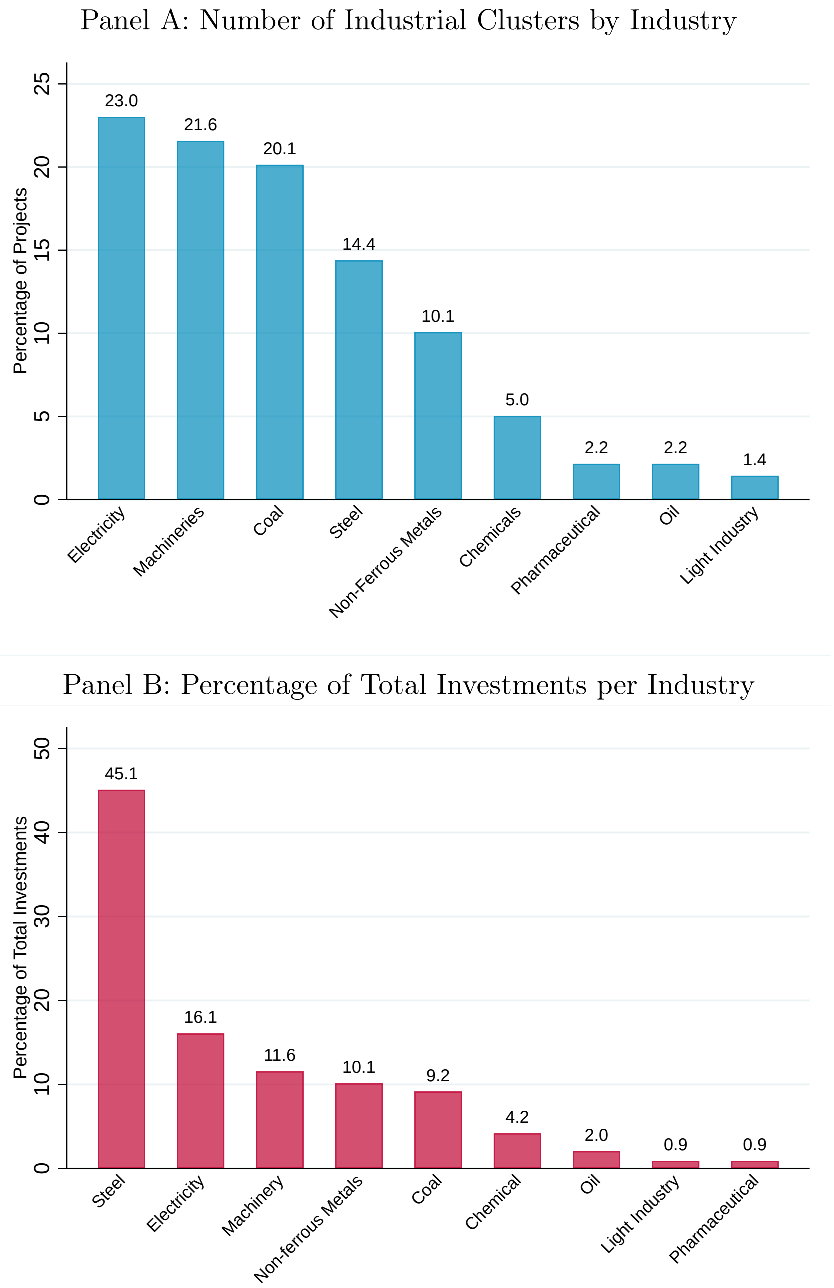
	Log Output	Log TFPQ	Tech. Upgrade	Subs. Capital	Compl. Equipment	Log Exports
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Capital	-0.008	-0.009	0.003	0.006	0.005	0.009
	(0.015)	(0.014)	(0.005)	(0.011)	(0.008)	(0.012)
Know-How	0.006	0.005	0.006	-0.088***	0.077***	0.164***
	(0.010)	(0.011)	(0.008)	(0.021)	(0.019)	(0.035)
Physical Capital * Post	0.095***	0.012	0.009			
	(0.028)	(0.014)	(0.010)			
Know-How * Post	0.185***	0.176***	0.322***			
	(0.035)	(0.033)	(0.106)			
Observations	27,360	27,360	27,360	13,680	13,680	13,680

Notes. *Physical Capital* is an indicator for complementary plants with linkages with plants that received Soviet physical capital. *Know-How* is an indicator for complementary plants with linkages with plants that also received Soviet know-how. Data are provided at the plant level from the from Steel Association Reports from 1949 to 2000 and from the Chinese Ministry of Commerce and the Ministry of Industry and Information Technology from 1970 to 2000. *Post* is an indicator for years after receiving the Soviet transfers; *Log Output* is logged quantities (in million tons) of steel; *Log TFPQ* is logged total factor productivity quantity, computed as the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects; *Tech. Upgrade* is an indicator for plants that adopt a new technology or production technique, or develop a new product or a new process; *Subs. Capital, Compl. Equipment,* and *Log Exports* are logged values of foreign imported capital used to replace existing capital, foreign equipment complementary with plant physical capital, and exports. 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

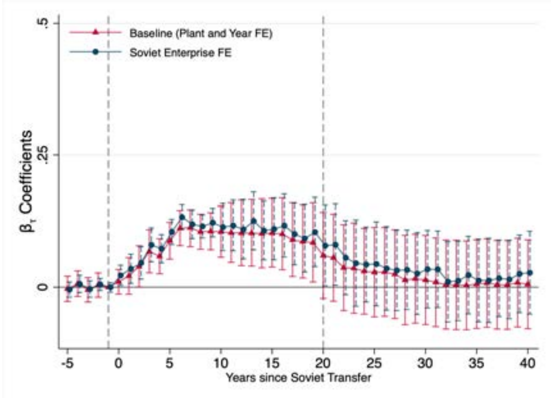


Notes. Distribution of the 139 civilian industrial clusters, known as the 156 Projects. Panel A reports the number of projects by industry. Panel B reports the percentage of total investments by industry. Data are provided at the project level from the National Archives Administration of China.

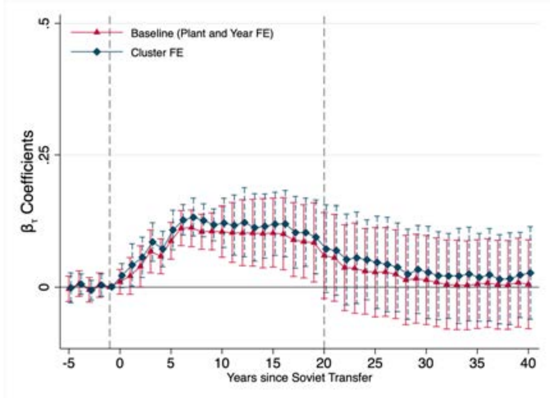
Figure A.2: Robustness Check on the Effects of Soviet Physical and Know-How Transfers on the 304 Steel Plants' Production – Alternative Fixed Effects, Output

Log Output, Physical Capital (β_τ)

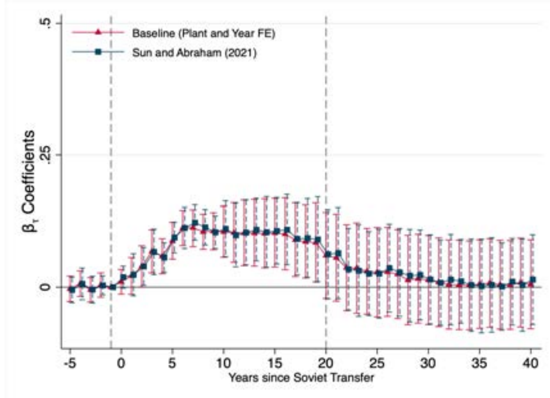
Panel A: Soviet Enterprise FE



Panel B: Industrial Cluster FE

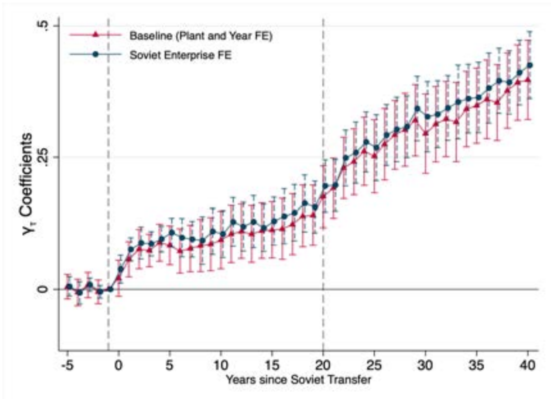


Panel C: Sun and Abraham (2021)

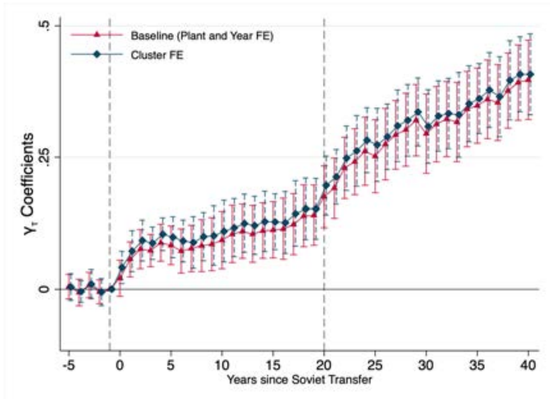


Log Output, Know-How (γ_τ)

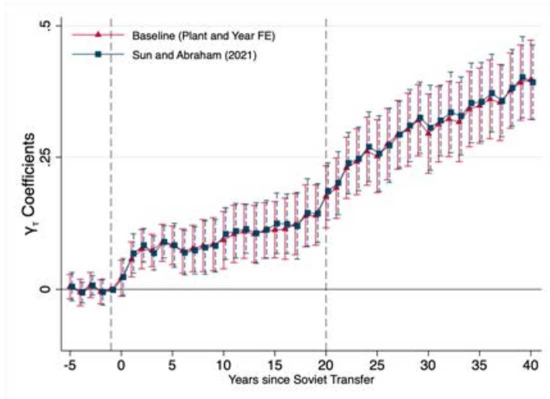
Panel D: Soviet Enterprise FE



Panel E: Industrial Cluster FE



Panel F: Sun and Abraham (2021)

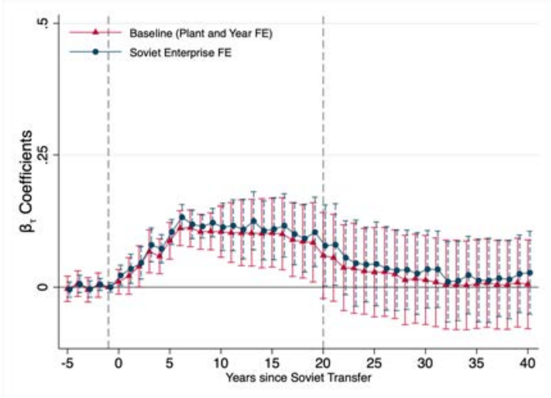


Notes. Annual β_τ coefficients (Panels A–C) and γ_τ coefficients (Panels D–F) from Equation 1 for the 304 steel plants belonging to the 156 Projects, controlling for Soviet enterprises that Chinese plants were supposed to duplicate fixed effects (Panels A and D), industrial cluster fixed effects (Panels B and E), and estimating weights underlying two-way fixed effects regressions based on Sun and Abraham (2021)'s method, using the Stata command `eventstudyweights`. Each panel also reports the baseline specification from Equation 1, which includes plant and year fixed effects. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Output* is logged quantities (in million tons) of steel. 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.

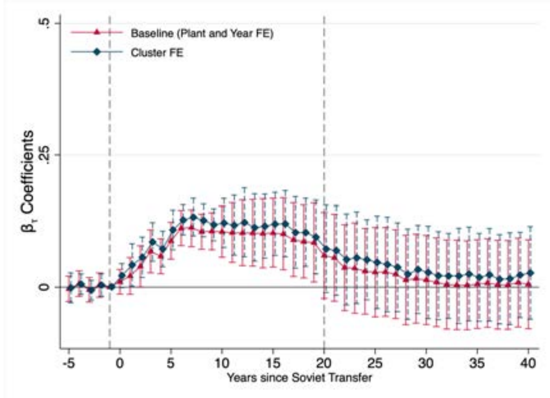
Figure A.3: Robustness Check on the Effects of Soviet Physical and Know-How Transfers on the 304 Steel Plants' Productivity – Alternative Fixed Effects, TFP

Log TFPQ, Physical Capital (β_τ)

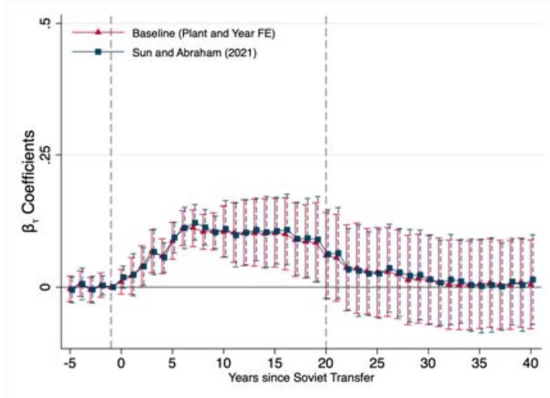
Panel A: Soviet Enterprise FE



Panel B: Industrial Cluster FE

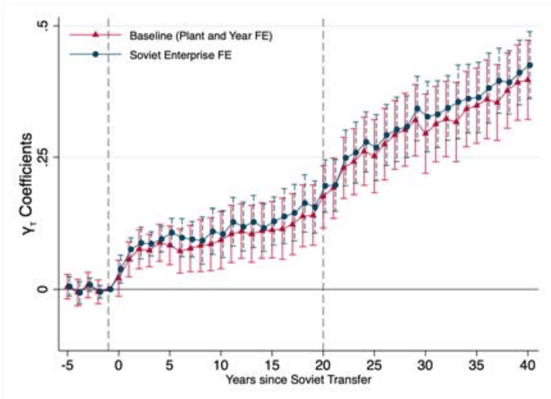


Panel C: Sun and Abraham (2021)

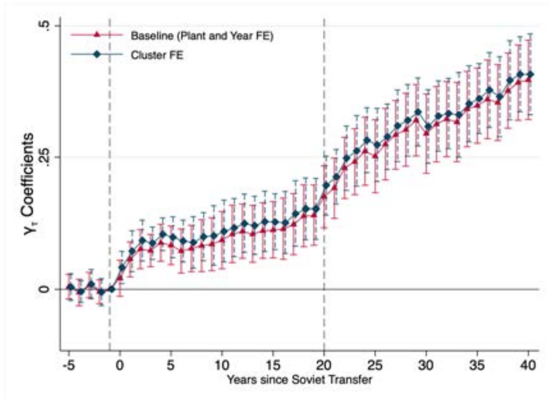


Log TFPQ, Know-How (γ_τ)

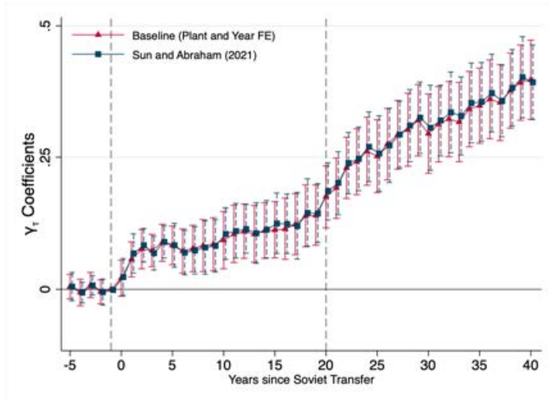
Panel D: Soviet Enterprise FE



Panel E: Industrial Cluster FE



Panel F: Sun and Abraham (2021)

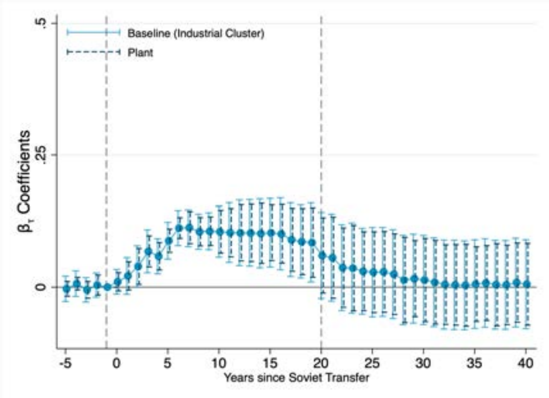


Notes. Annual β_τ coefficients (Panels A—C) and γ_τ coefficients (Panels D–F) from Equation 1 for the 304 steel plants belonging to the 156 Projects, controlling for Soviet enterprises that Chinese plants were supposed to duplicate fixed effects (Panels A and D), industrial cluster fixed effects (Panels B and E), and estimating weights underlying two-way fixed effects regressions based on Sun and Abraham (2021)'s method, using the Stata command `eventstudyweights`. Each also panel reports the baseline specification from Equation 1, which includes plant and year fixed effects. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log TFPQ* is logged total factory productivity quantity, computed as the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects. 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.

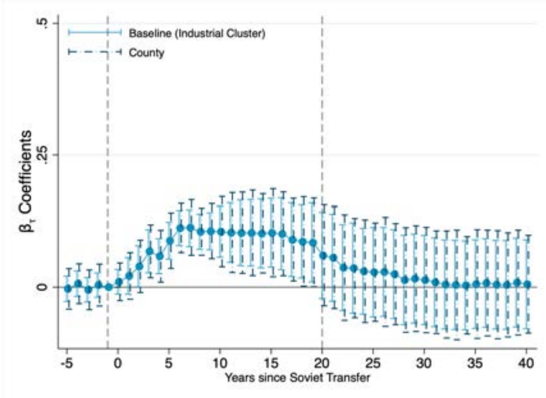
Figure A.4: Robustness Check on the Effects of Soviet Physical and Know-How Transfers on the 304 Steel Plants' Production – Alternative Clustering Level, Output

Log Output, Physical Capital (β_τ)

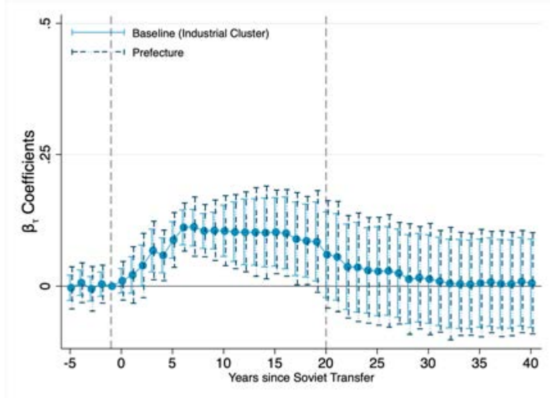
Panel A: Plant Level



Panel B: County Level

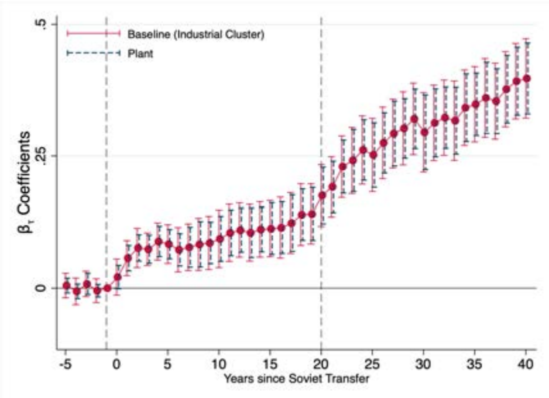


Panel C: Prefecture Level

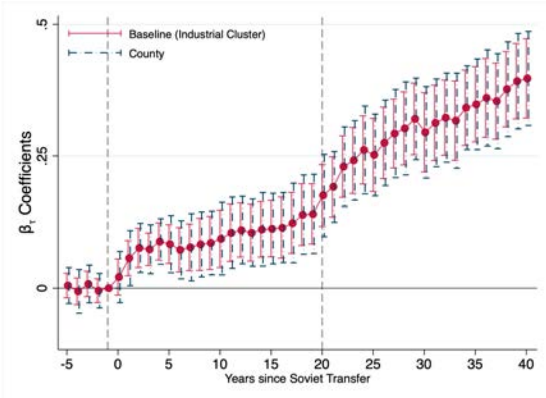


Log Output, Know-How (γ_τ)

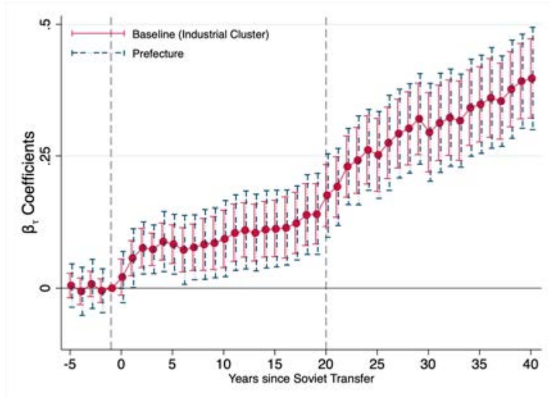
Panel D: Plant Level



Panel E:County Level



Panel F: Prefecture Level

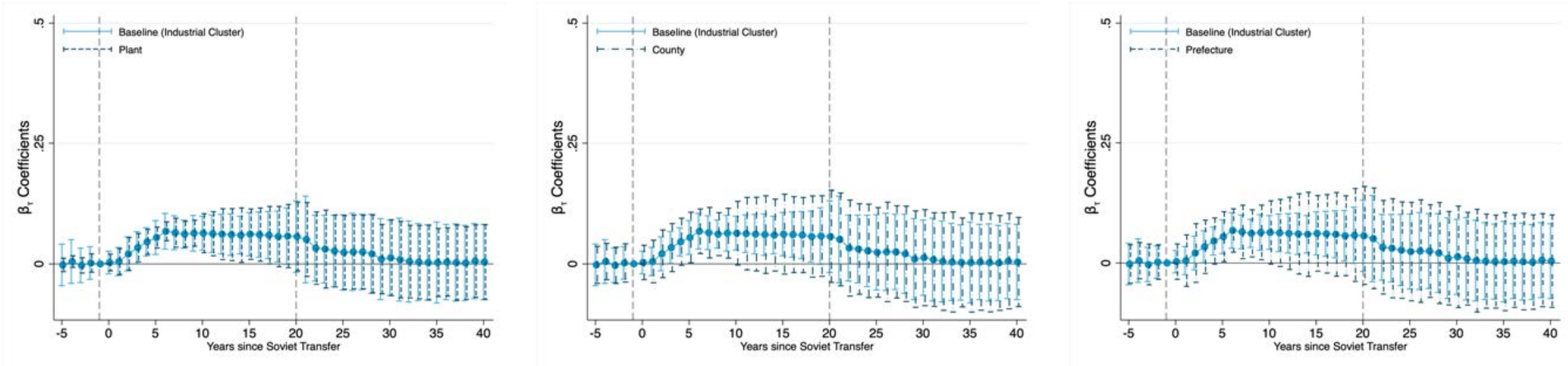


Notes. Annual β_τ coefficients and γ_τ coefficients from Equation 1 with standard errors clustered at the plant level (Panels A and D), the county level (Panels B and E) and the prefecture level (Panels C and F). Each also panel reports the baseline specification from Equation 1, with standard errors block-bootstrapped at the industrial cluster level with 1,000 replications. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Output* is logged quantities (in million tons) of steel.

Figure A.5: Robustness Check on the Effects of Soviet Physical and Know-How Transfers on 304 Steel Plants' Productivity – Alternative Clustering Level, TFP

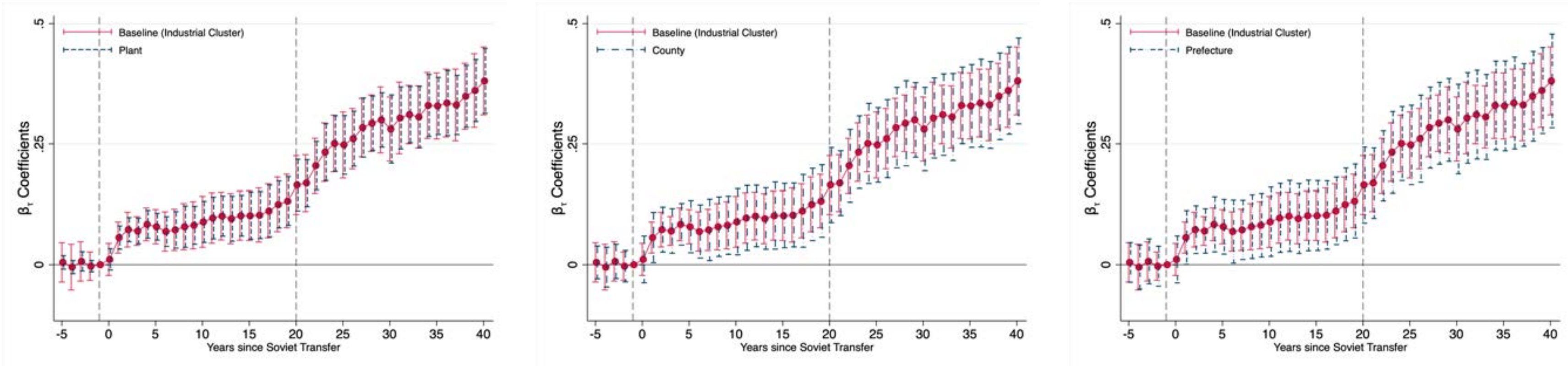
Log TFPQ, Physical Capital (β_τ)

Panel A: Plant Level | Panel B: County Level | Panel C: Prefecture Level



Log TFPQ, Know-How (γ_τ)

Panel D: Plant Level | Panel E:County Level | Panel F: Prefecture Level



Notes. Annual β_τ coefficients and γ_τ coefficients from Equation 1 with standard errors clustered at the plant level (Panels A and D), the county level (Panels B and E) and the prefecture level (Panels C and F). Each panel also reports the baseline specification from Equation 1, with standard errors block-bootstrapped at the industrial cluster level with 1,000 replications. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log TFPQ* is logged total factory productivity quantity, computed as the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects.

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

	Log Steel	Log Crude Steel	Log Pig Iron	Log Capital
	(1)	(2)	(3)	(4)
Physical Capital * (t-2)	0.002	-0.006	0.008	-0.002
	(0.005)	(0.010)	(0.011)	(0.003)
Physical Capital * (t-3)	0.007	-0.010	-0.005	-0.004
	(0.009)	(0.011)	(0.007)	(0.005)
Physical Capital * (t-4)	0.004	-0.005	0.008	-0.003
	(0.006)	(0.006)	(0.011)	(0.006)
Physical Capital * (t-5)	-0.003	-0.008	-0.010	-0.002
	(0.004)	(0.010)	(0.011)	(0.007)
Know-How * (t-2)	0.003	-0.003	0.003	-0.005
	(0.005)	(0.004)	(0.005)	(0.009)
Know-How * (t-3)	0.006	-0.006	-0.004	-0.003
	(0.009)	(0.011)	(0.006)	(0.005)
Know-How * (t-4)	0.004	-0.010	0.007	-0.005
	(0.010)	(0.009)	(0.009)	(0.007)
Know-How * (t-5)	0.005	-0.005	-0.005	-0.004
	(0.006)	(0.007)	(0.005)	(0.005)
Observations	1,520	1,520	1,520	1,520
F-statistics	0.477	0.461	0.352	0.583

	Log Sales	Log Value Added	Log TFPQ	Log Employees
Physical Capital * (t-2)	-0.007	-0.010	-0.004	0.004
	(0.009)	(0.011)	(0.009)	(0.007)
Physical Capital * (t-3)	-0.010	0.006	-0.003	-0.005
	(0.011)	(0.007)	(0.004)	(0.009)
Physical Capital * (t-4)	-0.006	-0.008	-0.006	0.011
	(0.009)	(0.009)	(0.008)	(0.010)
Physical Capital * (t-5)	-0.005	0.010	0.005	0.009
	(0.010)	(0.008)	(0.007)	(0.010)
Know-How * (t-2)	0.005	-0.007	-0.008	0.006
	(0.006)	(0.008)	(0.011)	(0.009)
Know-How * (t-3)	0.004	0.005	-0.005	0.004
	(0.005)	(0.006)	(0.006)	(0.006)
Know-How * (t-4)	-0.008	-0.003	-0.005	0.002
	(0.010)	(0.006)	(0.007)	(0.004)
Know-How * (t-5)	0.008	0.002	-0.004	0.003
	(0.007)	(0.006)	(0.007)	(0.005)
Observations	1,520	1,520	1,520	1,520
F-statistics	0.512	0.498	0.389	0.555

(continues)

Table A.1: 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)	-0.005	-0.005	-0.009	-0.005
	(0.011)	(0.011)	(0.010)	(0.009)
Physical Capital * (t-3)	0.007	-0.004	0.008	0.010
	(0.008)	(0.006)	(0.010)	(0.011)
Physical Capital * (t-4)	-0.011	-0.010	0.005	0.004
	(0.012)	(0.011)	(0.007)	(0.005)
Physical Capital * (t-5)	0.006	-0.008	0.004	0.006
	(0.008)	(0.012)	(0.008)	(0.009)
Know-How * (t-2)	-0.011	-0.006	0.002	0.006
	(0.010)	(0.008)	(0.009)	(0.007)
Know-How * (t-3)	0.007	-0.009	0.011	0.005
	(0.008)	(0.010)	(0.012)	(0.009)
Know-How * (t-4)	-0.005	-0.004	0.009	0.011
	(0.009)	(0.006)	(0.010)	(0.010)
Know-How * (t-5)	0.006	-0.007	0.005	0.004
	(0.007)	(0.009)	(0.008)	(0.006)
Observations	1,520	1,520	1,520	1,520
F-statistics	0.439	0.421	0.457	0.390

Notes. OLS regressions predicting plant outcomes before in the five years before receiving the Soviet transfer. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. Data are provided at plant level from the Steel Association Reports. The trend is allowed to vary freely for each year before the Soviet intervention for plants that received Soviet physical capital and know-how transfers. 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* are logged quantities (in million tons) of steel, crude steel and pig iron. *Capital* is logged capital stock, calculated using the perpetual inventory method (PIM, see Table B.1). *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 the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects; *Employees, Engineers,* and *High-Skilled Technicians* are, respectively, logged thousands of employees, engineers, and high-skilled technicians; *Loans* and *Transfers* are, respectively, logged 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. The F-statistics test whether all the interaction terms between physical capital and know-how and the year indicators are jointly zero. 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: 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
	(0.010)	(0.011)	
Start Year	-0.015	0.003	0.767
	(0.018)	(0.006)	
Expected Length	0.003	0.002	0.538
	(0.004)	(0.005)	
Expected Physical Capital Delivery Year	0.005	-0.004	0.426
	(0.007)	(0.006)	
Expected Soviet Experts Arrival Year	-0.007	0.003	0.552
	(0.010)	(0.005)	
Planned Investment (m)	-0.019	0.011	0.861
	(0.023)	(0.015)	
Actual Investment (m)	0.011	-0.005	0.619
	(0.013)	(0.007)	
Expected Equipment Value (m)	0.013	-0.006	0.561
	(0.016)	(0.009)	
Number of Workers (k)	-0.009	0.010	0.667
	(0.010)	(0.012)	
Number of Plants	-0.008	0.005	0.522
	(0.010)	(0.007)	
Observations	304	304	304

Notes. Coefficients from regressing project characteristics each plant belonged to on an indicator for plants that received the Soviet physical capital transfer and an indicator for plants that also received the Soviet know-how transfer. 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 project; *Expected Length* is the expected years to complete project construction; *Expected Physical Capital Delivery Year* is the project average expected year of Soviet physical capital delivery; *Expected Soviet Experts Arrival Year* is the project average expected year of Soviet experts arrival; *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 project 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* is number of employees per project, in thousands; *Number of Plants* is the number of plants per project. 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.3: Differences in Counties Hosting the 304 Steel Plants in 1953

	Physical Capital (1)	Know-How (2)	p-value (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 characteristics of the county each plant belonged to on an indicator for plants that received the Soviet physical capital transfer and an indicator for plants that also received the Soviet know-how transfer. 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.4: Effects of Soviet Physical and Know-How Transfers on the 304 Steel Plants' Production and Productivity

	Log Output	Log TFPQ		Log Output	Log TFPQ
	(1)	(2)		(3)	(4)
Phys. Cap. * Year -5	-0.003	-0.002	Phys. Cap. * Year 19	0.085**	0.058*
	(0.012)	(0.022)		(0.038)	(0.030)
Phys. Cap. * Year -4	0.007	0.005	Phys. Cap. * Year 20	0.060	0.057
	(0.013)	(0.023)		(0.042)	(0.038)
Phys. Cap. * Year -3	-0.005	-0.003	Phys. Cap. * Year 21	0.056	0.051
	(0.011)	(0.018)		(0.041)	(0.046)
Phys. Cap. * Year -2	0.004	0.002	Phys. Cap. * Year 22	0.037	0.033
	(0.012)	(0.017)		(0.042)	(0.035)
Phys. Cap. * Year 0	0.010	0.003	Phys. Cap. * Year 23	0.036	0.031
	(0.011)	(0.012)		(0.044)	(0.036)
Phys. Cap. * Year 1	0.021	0.005	Phys. Cap. * Year 24	0.030	0.027
	(0.018)	(0.015)		(0.042)	(0.038)
Phys. Cap. * Year 2	0.039*	0.021	Phys. Cap. * Year 25	0.028	0.024
	(0.020)	(0.018)		(0.043)	(0.040)
Phys. Cap. * Year 3	0.068***	0.034**	Phys. Cap. * Year 26	0.029	0.025
	(0.021)	(0.017)		(0.043)	(0.041)
Phys. Cap. * Year 4	0.059***	0.046***	Phys. Cap. * Year 27	0.025	0.025
	(0.017)	(0.015)		(0.040)	(0.040)
Phys. Cap. * Year 5	0.088***	0.055***	Phys. Cap. * Year 28	0.014	0.021
	(0.018)	(0.018)		(0.041)	(0.042)
Phys. Cap. * Year 6	0.112***	0.068***	Phys. Cap. * Year 29	0.016	0.010
	(0.017)	(0.019)		(0.042)	(0.043)
Phys. Cap. * Year 7	0.113***	0.065***	Phys. Cap. * Year 30	0.014	0.013
	(0.018)	(0.018)		(0.041)	(0.040)
Phys. Cap. * Year 8	0.105***	0.062***	Phys. Cap. * Year 31	0.009	0.009
	(0.017)	(0.015)		(0.040)	(0.044)
Phys. Cap. * Year 9	0.106***	0.064***	Phys. Cap. * Year 32	0.005	0.005
	(0.016)	(0.019)		(0.041)	(0.043)
Phys. Cap. * Year 10	0.105***	0.064***	Phys. Cap. * Year 33	0.004	0.004
	(0.025)	(0.018)		(0.042)	(0.041)
Phys. Cap. * Year 11	0.103***	0.063***	Phys. Cap. * Year 34	0.004	0.003
	(0.029)	(0.020)		(0.041)	(0.040)
Phys. Cap. * Year 12	0.102***	0.062***	Phys. Cap. * Year 35	0.006	0.003
	(0.032)	(0.021)		(0.040)	(0.043)
Phys. Cap. * Year 13	0.103***	0.061***	Phys. Cap. * Year 36	0.008	0.004
	(0.033)	(0.022)		(0.042)	(0.040)
Phys. Cap. * Year 14	0.103***	0.060***	Phys. Cap. * Year 37	0.005	0.003
	(0.032)	(0.020)		(0.040)	(0.041)
Phys. Cap. * Year 15	0.103***	0.062***	Phys. Cap. * Year 38	0.004	0.002
	(0.033)	(0.023)		(0.041)	(0.040)
Phys. Cap. * Year 16	0.101***	0.061***	Phys. Cap. * Year 39	0.009	0.006
	(0.025)	(0.024)		(0.041)	(0.040)
Phys. Cap. * Year 17	0.090**	0.060**	Phys. Cap. * Year 40	0.006	0.004
	(0.036)	(0.025)		(0.040)	(0.040)
Phys. Cap. * Year 18	0.086**	0.057**			
	(0.035)	(0.027)			
Observations	13,984	13,984		13,984	13,984

(continues)

Table A.4: Effects of Soviet Physical and Know-How Transfers on the 304 Steel Plants' Production and Productivity – Continued

	Log Output	Log TFPQ		Log Output	Log TFPQ
	(1)	(2)		(3)	(4)
Know-How * Year -5	0.005	0.005	Know-How * Year 19	0.141***	0.132***
	(0.012)	(0.021)		(0.029)	(0.028)
Know-How * Year -4	-0.006	-0.005	Know-How * Year 20	0.175***	0.165***
	(0.013)	(0.024)		(0.030)	(0.031)
Know-How * Year -3	0.008	0.007	Know-How * Year 21	0.192***	0.169***
	(0.012)	(0.021)		(0.029)	(0.030)
Know-How * Year -2	-0.004	-0.003	Know-How * Year 22	0.230***	0.205***
	(0.012)	(0.015)		(0.030)	(0.029)
Know-How * Year 0	0.021	0.011	Know-How * Year 23	0.242***	0.233***
	(0.018)	(0.017)		(0.032)	(0.031)
Know-How * Year 1	0.057***	0.056***	Know-How * Year 24	0.262***	0.251***
	(0.017)	(0.016)		(0.033)	(0.030)
Know-How * Year 2	0.076***	0.073***	Know-How * Year 25	0.251***	0.248***
	(0.019)	(0.018)		(0.035)	(0.035)
Know-How * Year 3	0.074***	0.070***	Know-How * Year 26	0.275***	0.261***
	(0.016)	(0.015)		(0.035)	(0.032)
Know-How * Year 4	0.089***	0.079***	Know-How * Year 27	0.293***	0.284***
	(0.018)	(0.017)		(0.033)	(0.031)
Know-How * Year 5	0.084***	0.078***	Know-How * Year 28	0.302***	0.293***
	(0.019)	(0.018)		(0.035)	(0.030)
Know-How * Year 6	0.073***	0.069***	Know-How * Year 29	0.321***	0.300***
	(0.021)	(0.021)		(0.036)	(0.035)
Know-How * Year 7	0.078***	0.072***	Know-How * Year 30	0.295***	0.281***
	(0.023)	(0.022)		(0.038)	(0.034)
Know-How * Year 8	0.083***	0.079***	Know-How * Year 31	0.313***	0.304***
	(0.025)	(0.024)		(0.037)	(0.038)
Know-How * Year 9	0.086***	0.082***	Know-How * Year 32	0.323***	0.311***
	(0.026)	(0.025)		(0.036)	(0.031)
Know-How * Year 10	0.094***	0.089***	Know-How * Year 33	0.317***	0.306***
	(0.028)	(0.027)		(0.038)	(0.033)
Know-How * Year 11	0.105***	0.097***	Know-How * Year 34	0.342***	0.330***
	(0.028)	(0.027)		(0.037)	(0.035)
Know-How * Year 12	0.110***	0.101***	Know-How * Year 35	0.348***	0.329***
	(0.026)	(0.025)		(0.036)	(0.035)
Know-How * Year 13	0.105***	0.096***	Know-How * Year 36	0.360***	0.335***
	(0.027)	(0.027)		(0.038)	(0.036)
Know-How * Year 14	0.111***	0.102***	Know-How * Year 37	0.354***	0.331***
	(0.027)	(0.026)		(0.037)	(0.038)
Know-How * Year 15	0.113***	0.102***	Know-How * Year 38	0.377***	0.349***
	(0.027)	(0.026)		(0.036)	(0.035)
Know-How * Year 16	0.115***	0.103***	Know-How * Year 39	0.392***	0.361***
	(0.029)	(0.029)		(0.037)	(0.039)
Know-How * Year 17	0.123***	0.112***	Know-How * Year 40	0.397***	0.381***
	(0.029)	(0.028)		(0.038)	(0.036)
Know-How * Year 18	0.139***	0.125***			
	(0.030)	(0.029)			
Observations	13,984	13,984		13,984	13,984

Notes. Annual β_τ and γ_τ coefficients from Equation 1 for the 304 steel plants belonging to the 156 Projects. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Output* is logged quantities (in million tons) of steel. *Log TFPQ* is logged total factory productivity quantity, computed as the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects. 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.5: Effects of the Soviet Intervention on Number of Workers and Inputs in the 304 Steel Plants

	Log Workers (1)	Log Coke (2)	Log Iron (3)	Log Capital (4)
Physical Capital * Year 1	-0.009	0.005	-0.008	0.151***
	(0.008)	(0.007)	(0.012)	(0.039)
Physical Capital * Year 5	0.005	0.004	-0.002	0.152***
	(0.006)	(0.006)	(0.005)	(0.036)
Physical Capital * Year 10	-0.003	0.003	0.004	0.109***
	(0.004)	(0.007)	(0.006)	(0.028)
Physical Capital * Year 20	-0.008	0.006	-0.005	0.033**
	(0.010)	(0.005)	(0.009)	(0.016)
Physical Capital * Year 30	0.004	0.007	0.009	0.021
	(0.007)	(0.007)	(0.011)	(0.018)
Physical Capital * Year 40	0.005	-0.005	0.003	0.005
	(0.007)	(0.006)	(0.004)	(0.007)
Know-How * Year 1	-0.006	-0.003	-0.002	-0.002
	(0.008)	(0.005)	(0.003)	(0.010)
Know-How * Year 5	0.002	-0.002	-0.003	0.005
	(0.003)	(0.004)	(0.007)	(0.006)
Know-How * Year 10	-0.001	0.004	-0.005	0.020**
	(0.003)	(0.006)	(0.008)	(0.010)
Know-How * Year 20	-0.008	-0.002	0.007	0.075***
	(0.011)	(0.011)	(0.012)	(0.025)
Know-How * Year 30	0.005	0.003	-0.002	0.092***
	(0.007)	(0.004)	(0.003)	(0.028)
Know-How * Year 40	0.008	0.006	-0.004	0.112***
	(0.010)	(0.009)	(0.005)	(0.031)
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	13,984	13,984	13,984	13,984

Notes. Selected annual β_τ and γ_τ coefficients estimated from Equation 1 for the 304 steel plants belonging to the 156 Projects. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Workers* is logged thousands of employees per plant; *Log Coke* and *Log Iron* are logged quantities (in million tons) of coke and iron. *Log Capital* is logged capital stock, calculated using the perpetual inventory method (PIM, see Table B.1). 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: Effects of the Soviet Intervention on Government-Imposed Quotas in the 304 Steel Plants

	Log Steel	Log Crude Steel	Log Pig Iron
	(1)	(2)	(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)
Plant FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	13,984	13,984	13,984

Notes. Selected annual β_τ and γ_τ coefficients estimated from Equation 1. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Steel, Log Crude Steel,* and *Log 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.7: 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)
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	13,984	13,984	13,984	13,984

Notes. Selected annual β_τ and γ_τ coefficients from Equation 1. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. 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. Road* and *Log Dist. Railroad* measure the logged distance in km from the closest road and railroad 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.8: 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)
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. *Physical Capital* is an indicator for counties where plants that received the Soviet physical capital transfer were located. *Know-How* is an indicator for counties where plants that also received the Soviet know-how transfer were located. *Log Investment* is logged government investment in all industries, in steel industries, and in 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. *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.9: Correlation Between Plants That Received No 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 received no 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 factory productivity quantity, computed as the residuals of OLS regression of plant logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects. *Log Workers* is logged number of workers. *Prob. Ox* 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.10: Political Connections

	Secretaries (1–4)				Mayors (5–6)			
	Rotations	Term length	Education	Experience	Rotations	Term length	Education	Experience
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Physical Capital * Year 1	0.006	0.002	-0.004	-0.006	-0.003	-0.004	-0.008	-0.007
	(0.008)	(0.004)	(0.008)	(0.008)	(0.005)	(0.006)	(0.009)	(0.011)
Physical Capital * Year 5	-0.004	0.001	-0.001	-0.004	-0.002	0.001	-0.010	-0.002
	(0.005)	(0.003)	(0.003)	(0.004)	(0.003)	(0.00)	(0.011)	(0.006)
Physical Capital * Year 10	-0.006	-0.004	-0.005	-0.005	-0.005	0.002	-0.006	-0.004
	(0.010)	(0.005)	(0.008)	(0.007)	(0.007)	(0.004)	(0.007)	(0.005)
Physical Capital * Year 20	0.001	-0.002	-0.004	0.001	-0.003	0.003	-0.008	0.003
	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.011)	(0.008)
Physical Capital * Year 30	-0.001	-0.002	-0.008	0.003	-0.005	0.004	-0.010	0.001
	(0.004)	(0.003)	(0.012)	(0.006)	(0.007)	(0.006)	(0.010)	(0.003)
Physical Capital * Year 40	0.002	0.004	-0.005	0.003	-0.002	-0.001	-0.008	-0.005
	(0.007)	(0.006)	(0.006)	(0.003)	(0.006)	(0.004)	(0.011)	(0.010)
Know-How * Year 1	-0.005	0.001	-0.003	0.002	0.001	-0.003	-0.009	-0.004
	(0.005)	(0.003)	(0.005)	(0.004)	(0.005)	(0.005)	(0.010)	(0.006)
Know-How * Year 5	-0.001	-0.002	-0.002	-0.003	0.003	0.002	-0.008	-0.010
	(0.006)	(0.002)	(0.006)	(0.005)	(0.004)	(0.004)	(0.011)	(0.011)
Know-How * Year 10	0.003	0.003	-0.002	0.003	-0.005	0.001	-0.011	-0.007
	(0.005)	(0.004)	(0.003)	(0.005)	(0.009)	(0.002)	(0.014)	(0.012)
Know-How * Year 20	0.001	0.001	-0.002	0.004	0.003	0.003	-0.009	-0.007
	(0.003)	(0.005)	(0.002)	(0.006)	(0.003)	(0.005)	(0.008)	(0.010)
Know-How * Year 30	-0.004	-0.002	-0.005	0.002	-0.002	0.003	-0.007	-0.005
	(0.008)	(0.004)	(0.006)	(0.006)	(0.004)	(0.004)	(0.009)	(0.006)
Know-How * Year 40	-0.002	0.003	-0.007	-0.007	0.004	0.001	-0.011	-0.008
	(0.007)	(0.007)	(0.008)	(0.010)	(0.007)	(0.003)	(0.013)	(0.010)
Plant FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,984	13,984	13,984	13,984	13,984	13,984	13,984	13,984

Notes. Selected annual β_τ and γ_τ coefficients from Equation 1 for the 304 steel plants belonging to the 156 Projects. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. *Rotations* is logged number of rotations at the prefecture level. *Term Length* is logged average length of politicians' terms before being rotated. *Education* and *Experience* are, respectively, logged number of years of education and of experience in previous appointments. Data are provided at the prefecture-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.11: 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)
Know-How	-0.022	0.009
	(0.023)	(0.003)
Observations	81	81

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

Table A.12: 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 2. *Physical Capital* is an indicator for plants that received Soviet physical capital. *Know-How* is an indicator for plants that also received Soviet know-how. 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 as the residuals of OLS regression of plant logged value added on logged workers, capital stock and inputs, and plant and year fixed effects; *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.13: 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. *Know-How* is an indicator for firms related to plants that also received Soviet know-how. *Private* is an indicator for non-state-owned firms. *New* is an indicator 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 as the residuals of OLS regression of plant logged value added on logged workers, capital stock and inputs, and plant and year fixed effects. 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.14: 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 Output* is the per county share of output produced by privately owned firms. *Related* includes firms in the same, upstream, or downstream industry of the 304 steel plants; *Unrelated* 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.15: 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 per county offering a STEM degree. *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.

Appendix B: Data Appendix

In this appendix, we provide a detailed description of our primary data sources and how we assembled the dataset. We also describe how we constructed the key variables used in our analysis, whose definitions and sources are reported in Table B.1.

B1. The 156 Projects

The first step of our data collection aimed to retrieve the list of the 156 Projects approved under the Sino-Soviet Alliance. To do so, we relied on the official signed agreements between the Soviet Union and China signed between 1950 and 1957, collected from the National Archives Administration of China, whose access is restricted and was occasionally granted for this paper. For each project, we recorded information on name, location, industry, total investments, capacity, number of workers, and name and number of plants. For each plant, we retrieved records indicating whether the Soviet transfers were eventually received.

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, which 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 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 (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 project information, beyond that contained in our data.

We next collected data on both the accidents suffered by the Soviet physical capital planned to be delivered to Chinese steel plants and the delays experienced by Soviet experts traveling to China. We retrieved 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 for 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. These data allow us to match accidents and delays on the Soviet side to the 304 steel plants. Physical capital may have suffered the following accidents: fires and floods in Soviet factories that completely destroyed machinery and equipment destined for Chinese plants, and train derailments during the transportation to China that caused similar damages. Given that the average time to rebuild steel machinery and equipment spanned from two to three years, such accidents represented a major obstacle to completing the 156 Projects (Filatov, 1980).

Moreover, only one railway connected the Soviet Union to China in the 1950s, making it impossible to use alternative routes after trains derailed, which further delayed machinery delivery and experts' visits. There were 115 accidents: 48 were fires (41.7%), 30 were floods (26.1%), and 37 were train derailments (32.8%).

Soviet experts' trips to China could be delayed for three reasons. First, if machinery they had to learn to use got destroyed, they needed to wait for it to be rebuilt before learning how to use it. Second, these experts could have been retained to deal with unexpected breakdowns or machinery repairs in their own factories. Third, translators assigned to their trips often needed more time to learn Chinese. Of the 109 planned Soviet experts' trips to China, 87% were delayed: 40 (42.1%) due to physical capital accidents, 37 due to urgent matters in Soviet factories (38.9%), and 18 due to translators' issues (19.0%).

B2. Plant-Level and Firm-Level Data

We then constructed a panel dataset of plant performance, gathering data from several archives.

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. Using the plant name, location, county, and province, we manually and uniquely matched the 304 plants belonging to the 20 steel industrial clusters to their performance data.

Second Industrial Survey (1985). In the early 1980s, the Chinese government began implementing several reforms on market liberalization. Until then, stretching back to the PRC'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 the early 1990s.[1] The firm-level-data portion of the survey, though still confidential today, has been declassified for this project; it covers the 7,592 largest firms operating in China in 1985.[2] For each of them, the Survey gathered data on output, sales, profits, fixed assets, raw materials, total wages, number of employees, finished product inventory, main products, production equipment, and year of establishment, which we manually collected and digitized. We have also manually collected and digitized the county-level and prefecture-level industrial production data reported in the survey (which is stored internally at Statistics China, in Beijing).

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

We complement this data with 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 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.

Table B.1 includes the definition of all the variables in our analysis, along with their aggregation level and time-period coverage, and sources are reported.

Geolocation 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 we found how the addresses changed from 1984 and the corresponding current addresses. In this way, we were able to obtain the geographic locations of all the firms based on the current addresses.[3]

Between 1998 and 2013, the China Industrial Enterprises database records the firm name only. We searched firms by their name in Tianyancha, a comprehensive database on all registered Chinese firms, which

[1] The First Industrial Survey was conducted in 1950, right after the PRC was founded. Its goal was estimating the "lay of the land" regarding the national industrial and mining enterprises, a basis for the recovery from the Civil War and subsequent development. However, this survey contains no firm-level data, and it predates the construction of treated and comparison plants. For this reason, we cannot employ it in our paper.

[2] The Second Industrial Survey reported that in 1985 there were 437,200 firms operating in China and that it collected firm-level data for the 7,592 largest ones, but the official survey guidelines 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.

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

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.

Identification of Firms Economically Related to the 304 Plants. We reconstructed the backward and forward linkages between the 304 steel plants and the 684 other complementary plants not eligible to receive the Soviet transfers, as follows. First, we retrieved each firm's three-digit industry code from the Steel Association Reports, as we observe the firm products. We then 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 304 steel plants. If products were neither upstream nor downstream, we consider these firms not economically related to the 304 plants. The National Bureau of Statistics of China (NBS) began compiling its input-output tables in 1987, and did so every five years (in the years ending with 2 and 7).

B3. Checking the Accuracy of Plant-Level Data

While dealing with plant-level data, one always has to consider the possibility that the outcomes provided by the plants may not be accurate. This issue is even more salient in command-driven economies, where the risk of data manipulation is higher. First, until the 1990s, Chinese statistical institutes were highly decentralized, with consequent variation in the quality and methodologies employed to compute the official statistics, which undermines their internal validity of such data (Koch-Weser, 2013). Second, authoritarian regimes usually provide little transparency on how key economic outcomes are computed, and systematic misreporting or data falsification are employed, especially in periods of economic instability or to hide government policy failures (Koch-Weser, 2013). Third, focusing specifically on the 304 steel plants, their managers may have had incentives to report better-than-actual outcomes, for example in an attempt to meet the production goals set by the central government.

While not completely exempt by these potential issues, the Steel Association Reports offer advantages relative to official statistics. First, these reports were used internally and not to compile official statistics. Therefore, they were highly monitored and checked by industry peers, which strongly limited the possibility of manipulation. Moreover, the fact that they reported quantities of steel produced further reduced the risk of manipulation, since these products were sold to other state-owned firms, which could cross check their production information. Conversely, the aggregate production data were complied by Statistics China, a different and independent source. Manipulations were more likely to occur in the latter than in the former reports since those were the officially released data.

Chinese economic historians have acknowledged the much higher quality and reliability of data for internal use relative to those of data for public release (Zeitz, 2011; Zhang, 2015; Hirata, 2018; Wu and Yi, 2022), also underscoring how the former have a much wider, more comprehensive coverage than the latter. Moreover, data for internal use appear to be consistent with major historical trends. For instance, the construction of the 156 Projects implied a massive reallocation of labor from the agricultural to the heavy industrial sector, amounting to 40% of Chinese employment in the industrial sector in 1952. Consistently, the Steel Association Reports indicate a 45% jump of employment in the steel industry in the 1950s. Conversely, the publicly released compendium does not show any major changes in employment levels in the same years. Similar conclusions during the years of the Great Leap Forward were also reached by Zeitz (2011).

Also, 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 lowered 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 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 considerations, we compared the Steel Association Reports with plant internal digests, used to describe daily factory operations; these were even less subject to the direct government control. We were able to retrieve such information from the company historical archives for 98 of the 304 steel plants. The digests report quantity of steel production, including crude steel and pig iron, allowing us to compare the same quality of products. The comparison of the production volumes across the two data sources reveals that they are remarkably similar, with minor discrepancies that appear due to rounding or typos. Such discrepancies are never larger than 1%.

Next, we compared our data with the data collected by Clark (1995). As one of the leading experts on the economics of steel production in command economies, Clark visited and collected data on Chinese steel plants with a capacity of at least 100,000 tons in multiple trips between 1952 and 1993. Specifically, for each visited plant, he estimated the minimum and 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. While Clark collected his data independently, he was certainly able to visit these plants thanks to the help of the Chinese government, which very likely monitored his publication. Moreover, during his plant visits, Clark had access to plant production data, likely to be used to compile the Steel Association reports. These caveats limit the use of Clark (1995)'s data as an alternative data source. However, his work contains qualitative descriptions of the production process at the plant level, consistent with data on firm technological upgrade that we collected from Chinese Ministry of Commerce and the Ministry of Industry and Information Technology historical archives, sources that to the best of our knowledge were not available to Clark when he visited China.

Table B.1: 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	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, 1970-2000
Log Complementary Equipment	Logged values of foreign imported equipment complementary to domestic capital	Plant-year, Chinese Ministry of Commerce, 1970-2000
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	Plant-year, Steel Association, 1949–2000; China Industrial Enterprises, 1998–2013
Log Capital Stock	See table notes	Plant-year, Steel Association, 1949–2000; China Industrial Enterprises, 1998–2013
Log TFPR	Total Factor Productivity Revenue	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 we 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%, 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 1%, 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.

Appendix C: Sensitivity Checks

C1. IV Results

Since the probability of receiving the Soviet transfers before the Split depended on delays on the Soviet side, we also propose an instrumental variable (IV) approach, leveraging on the causes of such delays. Specifically, we instrument the probability of receiving Soviet physical capital with an indicator that equals one if capital to be delivered to a specific Chinese plant suffered any of the accidents described in Section B.1; the probability of receiving Soviet know-how with an indicator that equals one if experts supposed to visit a specific Chinese plant experienced any of the delays described in Section B.1. The exclusion restriction implies that such delays affected plant outcomes only through the transfers eventually received by the plant. While the exclusion restriction cannot be tested directly, we show that the two types of delays are not predicted by plant characteristics (Table C.1). However, they strongly predict whether 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 16.8%, with the chances being 19.6% lower according to the estimation of the marginal effects of a probit model (Table C.2, columns 1 and 2). Similarly, delays to the Soviet experts a plant was supposed to host reduce the plant's probability of receiving a know-how transfer before the Split by 18.1%, a result confirmed by the probit estimation, which indicates a 21.2% lower probability (Table C.2, columns 3 and 4).

Repeating our 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 11.0% and 10.4%, respectively, ten years after the intervention relative to plants that did not receive any Soviet transfers (Figure C.1, Panels A and C). 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 an 18.4% increase in output and a 17.8% increase in TFPQ 20 years after the intervention, with these numbers jumping to 47.3% and 46.3% after 40 years, relative to plants that received only the physical capital transfer (Figure C.1, Panels B and D). The similar magnitude of the estimates between OLS and IV specifications indicates that variations in the transfers eventually received by each plant largely depended on the accidents the Soviet machinery suffered or on experts' delays, rather than on their allocation to the most promising establishments.

C2. TFP Estimation and Robustness Checks[4]

In our main specification, we estimate total factor productivity quantity (TFPQ) as the residuals of an OLS regression of plant-level logged physical output, measured in million tons of steel, on logged workers, capital stock and quantities of inputs (coke and iron) employed in the production process, and plant and year fixed effects. A potential problem with this approach is that OLS could be biased due to the endogenous choice of inputs by the plants. However, this concern is attenuated in our context, since workers and inputs usage don't differentially change across the 304 plants, as shown in Table A.6. In other words, the estimated increase in TFPQ appears driven by higher output rather than a different input usage.

Observing gross output in an industry that produces relatively homogenous goods represents an advantage relative to the value-added TFP approaches, as explained by Gandhi et al. (2020). However, a potential concern with the OLS estimates is that using quantities of output and input may hide the fact that plants that received the Soviet transfers produced more high-quality steel relative to plants that did not receive any transfers (as shown in Table 3) or that they may have used the same quantity of better-quality inputs. To address this issue, we first compute plant value added and input costs, using product and input prices collected from the Steel Association Reports. Notably, these prices, although set by the government, did reflect quality differences. In 1985, for instance, Statistics China set the high-quality crude steel price at 320RMB (US$199.22 in 2020 figures) per ton, compared to 249RMB (US$154.95 in 2020 figures) per ton of lower-quality pig iron. All the nominal variables are deflated using the year-product-specific deflator provided by Statistics China, with 1980 as the base year. While using the same deflator for all the firms

[4] We would like to thank our discussant, Dimitrije Ruzic, Nick Bloom and Martin Rotemberg for insightful comments and suggestions on TFP estimation in a command economy.

cannot control for plant-specific price shocks (as explained by De Loecker and Warzynski, 2012), this is not an issue in our context. In fact, Chinese firms faced the same price for a given product in a given year. As a result, our estimates suffer no bias due to plant-specific variation in output or input prices. Second, we compute total factor productivity revenue (TFPR) by estimating the same regression as in our main specification, but replacing physical output with value added and input quantities with their costs. These productivity estimates are slightly larger than the baseline ones, indicating that neglecting to control for output composition downward-biases our results but does not change the overall interpretation of our findings (Table C.3, row 2, Panels A and B).

We next check the robustness of our TFPQ and TFPR measures to alternative estimation methods. First, instead of an OLS regression, we use factor shares. From Chinese national accounting, we retrieve a labor share of 0.60 and a capital share of 0.40, but we also use a labor share of 0.66 and a capital share of 0.33 (which are the values usually used by the literature, Bloom et al., 2013a), as well as 0.50 and 0.50 for robustness. We then compute TFPR using these values and retrieved TFPQ via the formula $\log \text{TFPQ}{=}\text{logTFPR-log } \widetilde{p}$, where $\widetilde{p}$ is the value-added weighted average of each plant product price. These productivity estimates are comparable to the OLS ones (Table C.3, rows 3-5, Panels A and B).

The use of prices in a command economy may generate the so-called quality bias (de Roux et al., 2020): the Chinese government may have set prices that were not reliable indicators of underlying input quality. We already noted that the Chinese government set higher prices for high-quality steel. Nevertheless, these prices may not fully reflect quality differences. Therefore, we test for the possibility of quality bias as follows. We impose to output and inputs the average annual U.S. prices reported by the American Iron and Steel Institute at the four-digit level, and we compute TFPR and TFPQ with these values, as described above. The estimates using U.S. prices are larger but comparable to those using Chinese prices (Table C.3, row 6, Panels A and B), confirming that also the latter incorporated at least to some extent quality differences.

In the last few decades, a growing body of research has proposed different methods to address the potential endogeneity of TFP estimation (see for instance, Olley and Pakes, 1996,OP; Levinsohn and Petrin, 2003, LP; and Gandhi et al., 2020, GNR). All these methods are based on a control-function approach that employs a "proxy variable," for instance an input, to learn about TFP variations. In particular, Gandhi et al. (2020) developed a nonparametric identification and estimation of gross-output production function, using as a proxy variable plant inputs. The fact that in our setting inputs appear uncorrelated with TFP variation limits the use of these methods, as we may incur in a weak instrument issue. Not surprisingly, using these TFP estimation methods leads to results virtually identical to the factor-share ones (Table C.3, rows 7-9, Panels A and B).

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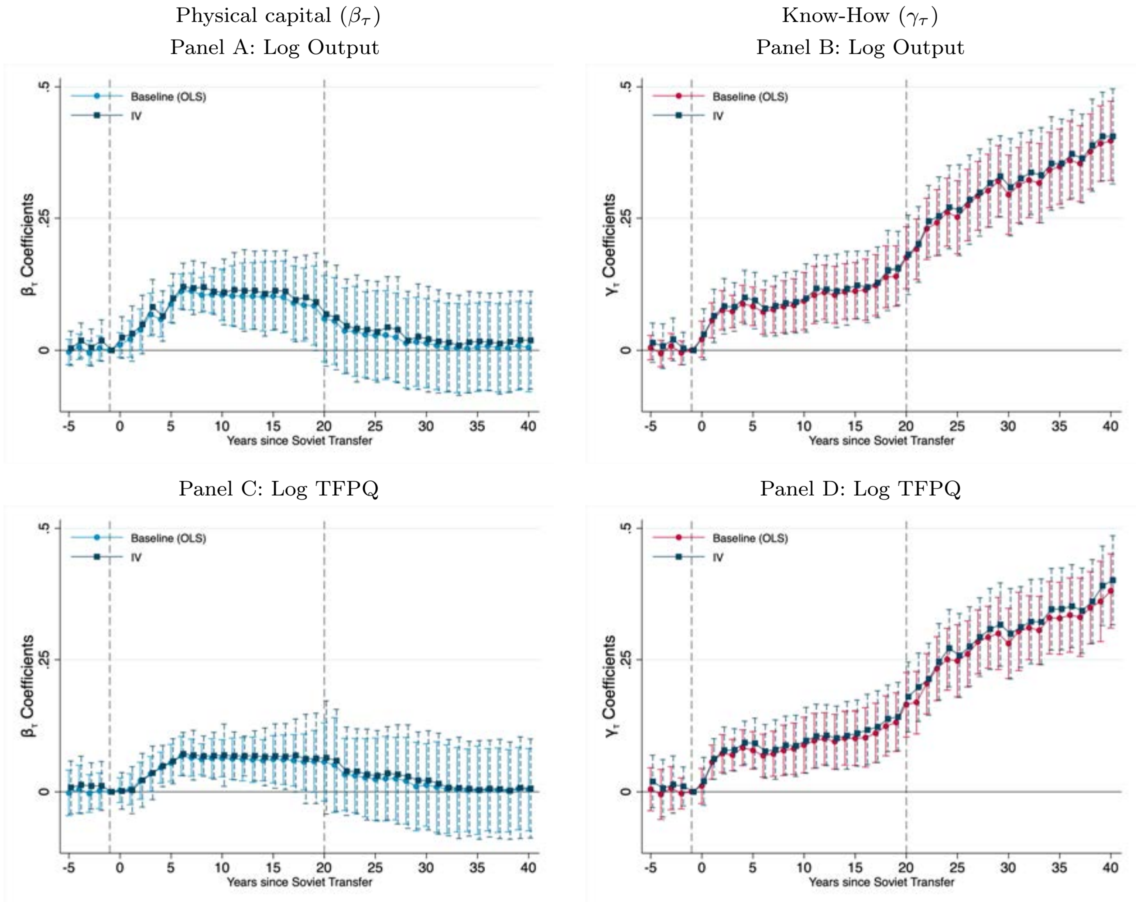
Figure C.1: Effects of Soviet Physical and Know-How Transfers on Plant Production and Productivity, OLS and IV Estimates



Notes. IV estimates of Equation 1 on the 304 steel plants belonging to the 156 Projects using accidents to Soviet machinery as an instrument for receiving Soviet physical capital transfer and accidents to Soviet experts as an instrument for receiving know-how transfer. Each panel also reports the baseline OLS specification. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *Log Output* is logged quantities (in million tons) of steel. *Log TFPQ* is logged total factor productivity quantity, computed as the residuals of OLS regression of logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects. Standard errors are block-bootstrapped at the industrial-cluster level with 1,000 replications.

Table C.1: Correlation Between Plant Characteristics and Probability of Machinery and Experts Accidents

	Pr Accident Physical Capital	Pr Experts Delays
	(1)	(2)
Steel Production (m tons)	-0.003	0.006
	(0.003)	(0.007)
Crude Steel Production (m tons)	-0.001	-0.005
	(0.003)	(0.006)
Pig Iron Production (m tons)	0.004	-0.004
	(0.005)	(0.008)
Value Added (m)	-0.003	0.004
	(0.008)	(0.004)
Productivity (log TFPQ)	-0.004	-0.008
	(0.008)	(0.009)
Employees per Plant (k)	0.002	-0.004
	(0.004)	(0.006)
Engineers (k)	0.003	0.003
	(0.004)	(0.005)
High-Skilled Technicians (k)	-0.002	-0.005
	(0.006)	(0.004)
Unskilled Workers (k)	0.003	0.005
	(0.004)	(0.008)
Loans	-0.006	-0.005
	(0.008)	(0.006)
Transfers	-0.004	0.006
	(0.009)	(0.009)
Distance Cole Deposits (km)	0.001	-0.006
	(0.005)	(0.009)
Distance Coke Deposits (km)	-0.005	-0.003
	(0.007)	(0.005)
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 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 (TFPQ), computed as OLS residuals of regressing plant-level logged physical output, in million tons of steel, on logged workers, capital stock, and quantities of inputs (coke and iron) employed in the production process, and plant and year fixed effects; *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 C.2: Soviet Accidents and Probability of Receiving Soviet Transfers

	Physical Capital		Know-How	
	(1)	(2)	(3)	(4)
Physical Capital Accidents	-0.168***	-0.196***		
	(0.020)	(0.023)		
Soviet Experts Delays			-0.181***	-0.212***
			(0.053)	(0.046)
Steel Production (m tons)	0.003	0.005	0.005	0.006
	(0.005)	(0.011)	(0.006)	(0.009)
Crude Steel Production (m tons)	-0.004	0.002	0.004	-0.005
	(0.009)	(0.003)	(0.005)	(0.006)
Pig Iron Production (m tons)	-0.004	-0.008	0.002	0.008
	(0.005)	(0.009)	(0.004)	(0.010)
Value Added (m)	0.008	0.005	0.011	0.010
	(0.009)	(0.007)	(0.011)	(0.015)
Productivity (log TFPQ)	-0.004	0.006	-0.002	-0.005
	(0.008)	(0.006)	(0.004)	(0.006)
Employees per Plant (k)	0.005	0.006	0.002	0.005
	(0.006)	(0.007)	(0.004)	(0.006)
Engineers (k)	0.005	0.008	0.005	0.010
	(0.006)	(0.009)	(0.008)	(0.009)
High-Skilled Technicians (k)	0.008	0.011	0.004	0.005
	(0.010)	(0.012)	(0.004)	(0.008)
Unskilled Workers (k)	-0.005	-0.009	0.005	0.007
	(0.008)	(0.010)	(0.008)	(0.009)
Loans	-0.004	-0.006	0.011	0.010
	(0.006)	(0.008)	(0.012)	(0.011)
Transfers	0.010	0.011	-0.006	-0.007
	(0.011)	(0.015)	(0.008)	(0.009)
Distance Cole Deposits (km)	0.004	0.003	0.004	0.005
	(0.005)	(0.005)	(0.008)	(0.007)
Distance Coke Deposits (km)	0.005	0.005	0.004	0.006
	(0.007)	(0.008)	(0.005)	(0.009)
Model	OLS	Probit	OLS	Probit
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 machinery suffered an accident on the Soviet side. *Soviet Experts Delays* is an indicator for Chinese plants whose Soviet experts' trips were delayed on the Soviet side. Data are provided at the 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; *Log TFPQ* is logged total factory productivity quantity, computed as the residuals of OLS regression of logged physical output on logged workers, capital stock and inputs, and plant and year fixed effects; *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 C.3: Robustness of TFP Estimations

	Year 1	Year 5	Year 10	Year 20	Year 30	Year 40
Panel A: Physical Capital (β_τ)						
TFPQ, OLS Baseline	0.005	0.055***	0.064***	0.057	0.013	0.004
	(0.015)	(0.018)	(0.018)	(0.038)	(0.041)	(0.040)
TFPR, OLS	0.004	0.062***	0.070***	0.063	0.016	0.006
	(0.020)	(0.016)	(0.025)	(0.050)	(0.040)	(0.039)
FS: LS = 0.60, CS = 0.40	0.003	0.065***	0.071***	0.065	0.018	0.005
	(0.021)	(0.018)	(0.026)	(0.055)	(0.039)	(0.041)
FS: LS = 0.66, CS = 0.33	0.003	0.069***	0.072***	0.066	0.017	0.005
	(0.020)	(0.020)	(0.025)	(0.052)	(0.042)	(0.039)
FS: LS = 0.50, CS = 0.50	0.003	0.068***	0.075***	0.068	0.019	0.004
	(0.019)	(0.019)	(0.026)	(0.055)	(0.040)	(0.041)
Using US Prices	0.002	0.067***	0.078***	0.065	0.019	0.005
	(0.020)	(0.021)	(0.025)	(0.056)	(0.041)	(0.039)
OP	0.004	0.054***	0.064***	0.056	0.015	0.005
	(0.018)	(0.020)	(0.024)	(0.051)	(0.038)	(0.040)
LP	0.004	0.055***	0.063***	0.058	0.017	0.006
	(0.019)	(0.021)	(0.025)	(0.052)	(0.040)	(0.041)
GNR	0.004	0.054***	0.064***	0.057	0.015	0.005
	(0.019)	(0.020)	(0.025)	(0.051)	(0.049)	(0.040)
Panel B: Know-How (γ_τ)						
TFPQ, OLS Baseline	0.056***	0.078***	0.089***	0.165***	0.281***	0.381***
	(0.016)	(0.018)	(0.027)	(0.029)	(0.037)	(0.037)
TFPR, OLS	0.060***	0.088***	0.096***	0.169***	0.301***	0.407***
	(0.018)	(0.022)	(0.028)	(0.034)	(0.040)	(0.045)
FS: LS = 0.60, CS = 0.40	0.061***	0.087***	0.098***	0.170***	0.298***	0.405***
	(0.020)	(0.021)	(0.030)	(0.032)	(0.041)	(0.047)
FS: LS = 0.66, CS = 0.33	0.059***	0.087***	0.097***	0.178***	0.299***	0.406***
	(0.019)	(0.025)	(0.031)	(0.031)	(0.039)	(0.046)
FS: LS = 0.50, CS = 0.50	0.058***	0.090***	0.095***	0.177***	0.300***	0.404***
	(0.020)	(0.022)	(0.029)	(0.035)	(0.042)	(0.048)
Using US Prices	0.064***	0.095***	0.108***	0.201***	0.312***	0.420***
	(0.019)	(0.021)	(0.030)	(0.032)	(0.045)	(0.046)
OP	0.061***	0.090***	0.096***	0.165***	0.282***	0.380***
	(0.019)	(0.022)	(0.029)	(0.033)	(0.041)	(0.044)
LP	0.062***	0.086***	0.095***	0.166***	0.281***	0.381***
	(0.019)	(0.021)	(0.028)	(0.034)	(0.040)	(0.044)
GNR	0.061***	0.087***	0.096***	0.164***	0.381***	0.379***
	(0.018)	(0.023)	(0.027)	(0.035)	(0.041)	(0.046)
Observations	13,984	13,984	13,984	13,984	13,984	13,984

Notes. Selected annual β_t (Panel A) and γ_t (Panel B) coefficients from Equation 1 estimated on the 304 steel plants belonging to the 156 Projects. Data are provided at the plant level from the Steel Association Reports from 1949 to 2000. *TFP* is estimated as total factor productivity quantity (TFPQ), computed as OLS residuals of regressing plant-level logged physical output, in million tons of steel, on logged workers, capital stock, and quantities of inputs (coke and iron) employed in the production process, and plant and year fixed effects (row 1), and as total factor productivity revenue (TFPR), substituting physical output with value added and quantities of inputs with their costs (row 2), using factor shares (FS) with a labor share (LS) of 0.60 and capital share (CS) of 0.40 (row 4); a labor share of 0.66 and a capital share of 0.33 (row 5); a labor share of 0.50 and a capital share of 0.50 (row 6); using U.S. instead of Chinese prices for steel products; using Olley and Pakes (1996)'s method (row 7); using Levinsohn and Petrin (2003)'s method (row 8); and using Gandhi et al. (2020)'s method (row 9). Standard errors are block-bootstrapped at the industrial-cluster level with 1,000 replications *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.