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Transfers of Technology and Management Practices: Evidence from the Twentieth Century

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Abstract

I discuss recent works that evaluate the effects of technology and knowledge transfers in the twentieth century. Less developed economies cyclically rely on such transfers to promote industrialization and close the gap with the most advanced countries. I focus on embodied technology transfers through capital goods; disembodied transfers via patents, licensing, and worker mobility; the diffusion of managerial know-how; and industrial policy interventions. The analysis highlights the central role of absorptive capacity—human capital, institutional quality, and organizational capability—in determining whether transfers yield lasting productivity gains.

1. INTRODUCTION

Technological advancements are key drivers of economic development, as they boost productivity, structural transformation, and GDP increases. To accelerate industrialization and enable latecomer economies to catch up with more advanced economies, technology transfer interventions have been widely employed during the twentieth century. Yet developing countries often face dual constraints: They lack not only critical technologies but also the industry-specific knowledge and know-how required to deploy them effectively, which has in turn motivated knowledge diffusion policies.

Despite the centrality of technology and knowledge transfer programs in the twentieth century, there is not a clear consensus among economists about which interventions work in fostering firm and industry development or which program components help countries move from adopting foreign technology to developing their own. Moreover, it is challenging to disentangle the effects of technology transfer from those of know-how diffusion and human capital training, as they often occur simultaneously.

This article discusses recent works that evaluate the effects of technology and knowledge transfers in the twentieth century. The twentieth century was a period of unprecedented economic transformation, characterized by rapid industrialization, global integration of production, and technological progress. Unlike earlier centuries, when the diffusion of technology occurred at a slower pace and on a more limited scale, the twentieth century saw a qualitative shift in both the scope and the complexity of these transfers. This shift was shaped by profound structural and institutional changes: the rise of multinational enterprises (MNEs) as transnational repositories of proprietary knowledge, advances in transportation and telecommunications, the increasing codification of technical and managerial knowledge, and the proliferation of formal trade and investment agreements.

Technology transfer during the past century took multiple forms. Embodied transfers occurred through the importation of advanced machinery, equipment, and intermediate goods, allowing recipient firms to directly integrate frontier technologies into their production processes. Disembodied transfers operated through intangible channels such as patents, licensing arrangements, worker mobility, and the diffusion of managerial practices. Both modes were influenced by the absorptive capacity of recipient economies—defined by the stock of human capital, institutional quality, and prior technological capabilities—as well as by global political and economic forces.

Major historical events, particularly the First and Second World Wars, created powerful shocks that both necessitated and facilitated large-scale transfers of technology and organizational practices. Wartime mobilization spurred innovations in aerospace engineering, telecommunications, synthetic chemistry, and atomic energy, while postwar reconstruction programs, notably the Marshall Plan, institutionalized mechanisms for disseminating technical knowledge, industrial standards, and management systems. A few decades later, industrial policy in newly industrializing economies such as Japan, South Korea, and Taiwan strategically imported and adapted foreign technologies, embedding them within national innovation systems to achieve rapid catch-up growth. Government-led initiatives and industrial policies also played a central role, from deliberate Big Push strategies in command economies to targeted sectoral interventions in market-oriented systems. In some cases, these policies successfully catalyzed technological upgrading, fostered innovation, and spurred long-term competitiveness; in others, weak institutions, inadequate absorptive capacity, or policy misalignment limited their effectiveness.

The rest of the article is organized as follows. In Section 2, I introduce a definition of technology transfer and discuss its economic motivation as well as the critiques. Section 3 focuses on the channels of technology transfer. Section 4 reviews the increasing body of work on the transfer of managerial practices. Section 5 discusses technology transfer related to industrial policy interventions. Section 6 offers some conclusive remarks.

2. TECHNOLOGY TRANSFER: DEFINITION, ECONOMIC RATIONALE, AND CRITIQUE

2.1. Definition

Technology transfer refers to the process by which an economic agent—such as a firm, an organization, or a country—acquires technology from another (Bessant & Rush 1993, Cummings & Teng 2003). This process may involve embodied forms, including machinery, equipment, and other capital goods, as well as disembodied forms, like patents, technical blueprints, or know-how (Mansfield 1985, Bell & Pavitt 1993). It encompasses both codified knowledge (patents, designs, software) and tacit knowledge (soft skills, production techniques, managerial practices).

Technology transfer can occur through a variety of formal channels, such as industrial policy, licensing agreements, joint ventures, foreign direct investment (FDI), and research collaborations (Narula & Zanfei 2005, Hoekman & Javorcik 2006), as well as informal channels, such as labor mobility, supplier–buyer linkages, and spillover effects (Mansfield 1985, Javorcik 2004). To what extent these mechanisms are successful depends on the recipient's absorptive capacity—the ability to recognize, assimilate, and apply external knowledge—which in turn relies on human capital, prior technological capabilities, and institutional quality (Cohen & Levinthal 1990, Keller 2004).

The twentieth century was characterized by a profound transformation in the scale and complexity of production systems, generating significant implications for the channels, intensity, and direction of international technology transfer. While cross-border diffusion of technological capabilities was a feature of earlier industrialization episodes of the late eighteenth and nineteenth centuries, the twentieth century witnessed a qualitatively distinct phase of global technological integration. This shift was underpinned by a confluence of structural and institutional drivers, including state-led industrial policy interventions, the rise and consolidation of MNEs as transnational repositories of proprietary knowledge, and substantial advances in transportation, telecommunications, and managerial coordination technologies (Rosenberg 1982, Mokyr 1990).

Specific historical events—most notably, the First and Second World Wars and their aftermath—further enhanced technological transfer. Large-scale wartime mobilization necessitated the rapid development and deployment of innovations in sectors such as aerospace engineering, telecommunications, synthetic chemistry, and atomic energy, while postwar reconstruction programs facilitated systematic and state-coordinated technology transfer across national boundaries. Initiatives such as the Marshall Plan did not merely restore productive capacity; they also institutionalized mechanisms for the dissemination of technical knowledge, organizational practices, and industrial standards that reshaped recipient economies' technological trajectories.

Furthermore, the mid-twentieth-century rise of MNEs provided a firm-internal governance structure (Williamson 1985) for cross-border technology transfer, allowing parent companies to allocate intangible assets—including design blueprints, process know-how, and managerial routines—across geographically dispersed subsidiaries. In parallel, newly industrializing economies such as Japan, South Korea, and Taiwan leveraged strategic latecomer advantages (Gerschenkron 1962) by selectively importing foreign technologies, adapting them to local conditions, and embedding them within national innovation systems.

In evaluating the economic and developmental impacts of technology transfer during this period, it is necessary to consider the historical and institutional context. While the definition of technology transfer used in this article is applicable to contemporary settings, the underlying drivers, constraints, and geopolitical configurations of the twentieth century may differ from those shaping current patterns of technological diffusion. Where needed, I explicitly address the external validity of the historical evidence presented.

2.2. The Economic Rationale for Twentieth-Century Technology Transfer

The motivation for technology transfer fundamentally lies in its potential to accelerate productivity growth, drive structural transformation, and facilitate economic convergence across economic agents (Grossman & Helpman 1991, Aghion & Howitt 1998).

Theoretically, technology transfer is conceptualized as a convergence mechanism within growth models, allowing economies below the technological frontier to expand their production possibility frontier through the assimilation of advanced techniques and knowledge, with consequent catch-up in terms of GDP per capita (Romer 1990, Aghion & Howitt 1998). Foundational growth models identify technology as a key driver of long-run economic performance. Solow's (1956) neoclassical growth model treated technological progress as an exogenous factor—an unexplained residual. Endogenous growth models emphasize the pivotal role of technology transfer in enabling catch-up growth: Lagging economies, under certain conditions, can achieve faster growth than frontier economies by absorbing, adapting, and diffusing existing technologies (Grossman & Helpman 1991, Barro & Sala-i-Martin 1997). Aghion & Howitt's (1998) Schumpeterian framework adds the process of creative destruction, framing technology transfer as the adoption of frontier innovations that accelerate follower economies' growth trajectories.

Another key theoretical advance is the concept of absorptive capacity, introduced by Cohen & Levinthal (1990). Although rooted in organizational theory, it has become central to economic modeling of technology flows. Absorptive capacity refers to the ability to recognize, assimilate, and apply external knowledge, which depends on prior related knowledge and R&D investments.

International trade and FDI models explicitly integrate technology transfer as a channel for diffusion. Grossman & Helpman (1991) highlight how trade in intermediate goods, learning-by-doing, and R&D spillovers transmit technology globally, with the magnitude of gains conditioned by factor endowments and knowledge diffusion rates. Helpman et al. (2004) further emphasize firm heterogeneity, showing that MNEs tend to be more productive and serve as conduits for superior technology transfer, although local impacts depend on domestic firms' absorptive capacities.

Keller (2004) synthesizes these insights by modeling technology diffusion as a process constrained by geographic and technological distance. Diffusion typically follows an S-curve, starting slowly due to initial learning barriers, accelerating as absorptive capacity builds, and eventually slowing as saturation approaches, underscoring the dynamic interplay between transfer mechanisms and recipient-side constraints.

2.3. Critique

Building up on these theoretical predictions, many developing countries have actively pursued technology transfer as a central element of their industrial and innovation strategies throughout the twentieth century. However, to what extent technology transfer is successful has been largely debated.

One fundamental critique regards the fact that technology transfer requires a certain baseline of absorptive capacity, such as skilled labor, effective institutions, and innovation systems, to internalize, adapt, and ultimately improve upon imported technologies. Cirera & Maloney (2017) highlight that many developing countries suffer from weaknesses precisely in these areas, arguing that the presence of advanced technology alone does not guarantee productivity improvements or technological catch-up. Moreover, the authors also critique the design and implementation of technology transfer policies. Many interventions focus heavily on attracting FDI or licensing agreements without simultaneously strengthening local innovation ecosystems or addressing institutional weaknesses. This supply-side orientation overlooks the importance of demand-side factors and of the systemic reforms essential for embedding new technologies in productive processes. Fagerberg et al. (2010) analyze the role of technology transfer and note that without domestic capacity to absorb foreign technologies, countries may face a technology gap trap: The dependence on foreign technology limits local innovation. These results are echoed by Branstetter & Saggi (2011), who argue that intellectual property protection and technology imports can sometimes inhibit local innovation if local firms become too reliant on foreign technologies and fail to innovate themselves. Criscuolo et al. (2019) discuss the limits of foreign technology when local absorptive capacities are lacking. Finally, technology transfer policies may be undermined by weak governance, corruption, or policy inconsistency in developing countries (Rodrik 2007). Without stable and transparent institutions, industrial policies aimed at facilitating technology transfer can be captured by vested interests or fail due to poor implementation.

This discussion highlights three points. First, technology transfer is an endogenous driver of growth in economic models, but its empirical effectiveness hinges on the specific conditions of the transfer and recipients. Second, the convergence predicted by growth models may be delayed by lack of absorptive capacity, institutional quality, or policy interventions, which can generate persistent productivity gaps. Third, the global governance of knowledge—through trade regimes, FDI regulations, and intellectual property right (IPR) enforcement—shapes both the quantity and the quality of technologies within and across countries.

3. MAIN CHANNELS OF TECHNOLOGY TRANSFER

In this section I examine four main channels of technology transfer: imports and exports, multinationals and FDIs, workers' flows, and patents and compulsory licensing. I will also discuss the barriers to technology transfer.

3.1. Imports and Exports

Several studies, especially in development and trade economics, have documented the importance of imports and exports as channels of technology transfer.

Early macro-level evidence comes from Coe & Helpman (1995) and Coe et al. (1997) and indicates that imports from R&D-intensive economies accelerate productivity growth in importing countries—a finding interpreted as the result of foreign R&D spillovers embodied in trade flows. More recently, a large body of firm-level evidence shows that imported capital goods from technologically advanced economies can significantly enhance the productivity, product quality, and innovative capacity of plants in developing markets. The central mechanism is that these goods embody advanced designs, precision engineering, and process innovations developed elsewhere, making them a tangible form of international technology transfer.

One of the most robust sets of findings comes from India. Topalova & Khandelwal (2011) show that reductions in input tariffs during the 1990s, particularly on capital and intermediate goods, enabled manufacturing firms to access higher-quality foreign equipment. This improved firm-level total factor productivity, with effects especially pronounced in industries that were more reliant on imported inputs. Goldberg et al. (2010) further show that lower tariffs on intermediate inputs give firms access to a wider variety and higher quality of inputs, enabling the introduction of new products.

Similar patterns have been documented in other contexts. Amiti & Konings (2007), studying Indonesia, find that input tariff reductions, which were driven by trade liberalization in the 1990s, led to substantial productivity gains at the firm level, especially for firms that imported their inputs. Halpern et al. (2015) use Hungarian manufacturing data to show that imported inputs raise productivity because they embody technologies unavailable domestically; their estimates suggest that more than half of the productivity premium from importing is attributable to quality differences in inputs. Fernandes (2007), using Colombian plant-level data, finds that access to imported machinery and equipment contributed to significant productivity improvements, with stronger effects for plants integrated into global markets.

Another strand of the literature has instead focused on exports (see De Loecker 2013 for more details). Seminal work by Atkin et al. (2017b) shows through a randomized experiment with Egyptian rug producers that exposure to high-income export markets can spur significant quality upgrading and adoption of more sophisticated production techniques. However, their findings also reveal that such upgrading is not automatic: Producers required intensive buyer feedback, repeated interactions, and learning-by-doing to meet foreign standards. The constraints were not simply financial but involved tacit knowledge gaps, difficulties in understanding new processes, and the need for hands-on guidance from experienced buyers. Garcia-Marin & Voigtlander (2019) add to these findings that within-plant gains from trade are substantially larger than previously thought, and they provide evidence of complementarities between exports and technology adoption. Artopoulos et al. (2013) add to this body of work by explaining why some firms in developing countries manage to export differentiated products to developed markets. Through four Argentine case studies—wine, TV programs, motorboats, and wooden furniture—the authors show that successful exporters adopt business practices that differ sharply from those common in their domestic markets. In most sectors, an export pioneer played a central role by introducing these new practices, drawing on tacit knowledge gained from prior involvement in foreign business communities. As these practices spread within each sector, broader export emergence followed. Overall, the study highlights foreign market knowledge, not production capabilities, as the main constraint to sustained exporting to developed countries.

Recent evidence from de Souza et al. (2024) adds a caveat to these findings, showing that trade liberalization may also reduce technology diffusion. Using Brazilian data, their paper shows that tariff reductions led to fewer technology transfers from foreign to domestic firms and to a decline in Brazilian firms' citations of foreign patents. The sharpest drop in citations occurred among firms located near previous technology recipients, driven largely by reduced citations of firms that had historically transferred technology to Brazil. Overall, the results suggest that lowering import tariffs can slow the spread of foreign knowledge by discouraging technology transfers.

González et al. (2025) evaluate a new export-consulting program implemented in Argentina through a randomized controlled trial (RCT). Designed to help producers of differentiated goods enter and succeed in export markets, the program taught a set of 20 "good exporting practices" (GEP) and provided firms in the food and beverage sector with more than 70 hours of individualized consulting. Overall, the program shows no measurable impact for all participating firms. However, for the subset of "good-selection firms"—those chosen without political or administrative interference—the program produces large, consistent, and significant increases in the likelihood of exporting. These findings highlight both the potential of targeted export-support interventions for small and medium enterprises and the importance of careful beneficiary selection in ensuring their effectiveness.

3.2. Multinationals and Foreign Direct Investments

Multinational corporations (MNCs) play a key role in promoting technology and knowledge transfers (Keller & Yeaple 2013b, Yeaple 2013). Less developed countries have cyclically relied on MNCs, based on the expectation that they can generate positive spillovers and knowledge diffusion.

Regarding spillover effects, previous research has found mixed results, in part due to measurement and identification issues (Alfaro-Urena et al. 2022). Javorcik (2004), studying Lithuanian manufacturing, also documents the absence of significant horizontal spillovers but finds strong evidence of vertical spillovers from foreign affiliates to local input suppliers. These results suggest that foreign firms are often reluctant to share technology with local competitors but have incentives to help suppliers improve product quality and efficiency. Alfaro-Urena et al. (2022) explore the impact of integrating local firms into multinational supply chains using detailed firm-to-firm linkage data. Their analysis shows that joining multinational supply chains leads to productivity improvements for domestic suppliers, driven by access to advanced technologies, management practices, and quality standards imposed by multinational clients. The study provides new evidence that such integration not only raises efficiency but also promotes innovation and upgrading within local firms, underscoring the role of MNCs in fostering industrial development through supply chain participation. In a related paper, Alfaro-Urena et al. (2022) examine how employment in multinational firms affects workers in Costa Rica. The authors find that working for MNCs improves wages and job stability compared to working for domestic firms, reflecting higher skill requirements and better working conditions. Additionally, workers in multinationals experience greater opportunities for skill development and knowledge acquisition, which can have positive spillover effects when these workers move to local firms. Their findings highlight the broader labor market benefits of multinational presence and its potential to enhance human capital in developing countries.

Regarding knowledge transfer, Antràs et al. (2008) argue that MNCs establish a layer of middle managers in host countries to lower the costs of transferring knowledge across borders. Burstein & Monge-Naranjo (2009) show how reallocating managerial expertise from developed to developing countries can yield significant aggregate economic benefits. However, as explained by Keller & Yeaple (2013a), since MNCs' knowledge is often tacit and difficult to codify, production abroad needs frequent communication between headquarters and foreign affiliates. In a related study, Debaere et al. (2013) examine how language differences influence the boundaries of multinational firms, using data from South Korea. Guillouet et al. (2024) find that potential employers value higher English proficiency and prior multinational experience, and an English language course treatment is shown to improve the English ability of domestic managers, increase their interactions with foreign managers, and increase their involvement in the management of company personnel.

Within this channel, FDI inflows themselves play a central role. As Chandra (2006) highlights, technology transfer and know-how diffusion generally occur simultaneously within multinational operations. For instance, when a multinational sets up a subsidiary in a host country, it often introduces both new machinery (technology) and management practices (know-how) at the same time. This simultaneity makes it empirically challenging to isolate the distinct effects of each process on productivity or innovation in the host economy. In the same vein, Mostafa & Klepper (2018) emphasize that know-how diffusion is frequently embedded in the very process of technology transfer. For example, acquiring foreign machinery might require extensive training and adaptation, during which tacit knowledge is shared and absorbed by local workers. These intertwined mechanisms reinforce each other but complicate attempts to measure their individual contributions. Another major channel of international technology transfer is represented by FDI, whose importance promoting a country's technological progress could hardly be understated.

FDI allows national economic agents to access foreign knowledge and absorb it into their production functions (Maskus 2004). Harrison & Rodríguez-Clare (2009) provide a comprehensive review of the evidence linking trade openness, FDI, and industrial policy in developing countries. The authors emphasize that while theory predicts significant gains from trade and FDI—through specialization, scale economies, and knowledge spillovers—the realization of positive effects depends on complementary domestic reforms, such as improving infrastructure, strengthening institutions, and building human capital. In the FDI context, they highlight that spillovers to domestic firms often require strong linkages with foreign affiliates and sufficient absorptive capacity and that industrial policy can play a role in facilitating these conditions by supporting upgrading and innovation.

Antràs & Chor (2013) complement this perspective by modeling how global production is organized across borders. Their sequential production framework shows that the location of different supply chain stages depends on contractual frictions, productivity differences, and input demand characteristics. In FDI terms, this implies that multinationals not only decide whether to invest abroad but also strategically choose which stages of production to locate in a given country—decisions that influence the complexity of domestic activities and the type of technology transferred. Buera & Oberfield (2016) add a dynamic dimension, demonstrating that firms, both domestic and foreign, learn from the most productive producers, with global linkages accelerating the diffusion of technology. From an FDI standpoint, this suggests that multinational entry can boost productivity growth in host countries through demonstration effects and competitive pressure. However, the magnitude of these benefits hinges on the host economy's ability to absorb and adapt the knowledge brought by foreign investors. Bilir & Morales (2016) provide empirical evidence that multinational firms often introduce new products into host markets, responding to trade costs and market opportunities. These product introductions can raise the technological frontier for domestic firms, stimulate supplier upgrading, and transfer skills through labor mobility. This micro-level channel reinforces the view that FDI's developmental benefits stem from more than just capital provision: They also hinge on how foreign firms interact with and influence the domestic production structure.

A substantial share of empirical work on the effects of FDI has relied on cross-industry variation in the extent of foreign presence to estimate spillover effects. Early influential studies include the one by Haddad & Harrison (1993), which uses Moroccan manufacturing data to examine whether sectors with greater foreign ownership experienced faster productivity growth among domestic firms. They found little evidence of positive horizontal spillovers and, in some cases, even negative effects, which are interpreted as possible competitive pressure from foreign entrants crowding out less efficient domestic producers.

Aitken & Harrison (1999) extend this approach in the context of Venezuelan manufacturing, confirming a lack of positive horizontal spillovers. Javorcik (2004) is among the first to emphasize the importance of distinguishing between spillovers within an industry (horizontal) and across industries via supply chains (vertical). Javorcik's analysis, drawing on firm-level data from Lithuania, provides evidence consistent with positive productivity spillovers from FDI occurring through interactions between foreign affiliates and their local upstream suppliers. These findings indicate that spillovers are particularly pronounced in projects with joint domestic and foreign ownership, whereas they are not observed in wholly foreign-owned investments.

Keller & Yeaple (2013a) add a cross-country perspective by examining US manufacturing plants and showing that productivity in domestic firms can rise following foreign entry in the same industry, particularly in technologically advanced sectors. Their results point to the role of absorptive capacity in determining the magnitude of FDI spillovers.

However, as the literature has acknowledged, industry-level correlations between foreign presence and domestic firm performance can be confounded by unobserved shocks. For example, rising global demand for a certain product might attract foreign investors while simultaneously boosting domestic firms' sales, leading to an overestimation of FDI spillovers. Similarly, government policy changes favoring a sector could simultaneously promote foreign entry and domestic performance, making it hard to isolate the causal effect of FDI. To address these concerns, more recent work has exploited plausibly exogenous shocks to foreign entry. McCaig et al. (2022) use tariff reforms in Vietnam as a natural experiment, where changes in trade policy differentially affected the attractiveness of industries to foreign investors. By using tariff cuts as an external source of variation, they were able to trace how foreign entry induced by trade liberalization affected domestic firms, reducing concerns that results could be driven by endogenous foreign firm location decisions. Other papers have focused on the Chinese automobile sector, which uses FDI as a tool of industrial policy. An example of this is represented by the quid-pro-quo approach requiring foreign firms to form joint ventures with domestic automakers. More specifically, Bai et al. (2020), by exploiting data on detailed vehicle quality measures and relying on within-product variation across quality dimensions, document that affiliated domestic automakers adopt the quality strengths of their joint venture partners, consistent with knowledge spillover.

Taken together, this body of evidence underscores that while FDI can be a powerful vehicle for international technology transfer, its transformative potential depends critically on the institutional environment, absorptive capacity, and the nature of linkages forged between foreign and domestic firms.

3.3. Worker Flows

A significant body of research highlights the critical role that worker mobility plays in facilitating knowledge spillovers across firms. When employees move from one company to another, they carry valuable tacit knowledge, skills, and industry-specific know-how, which can significantly influence productivity and innovation at their new workplace.

Stoyanov & Zubanov (2012) use matched firm–worker data from Danish manufacturing and firm-to-firm worker movements to find that firms that hired workers from more productive firms experienced productivity gains one year after the hiring. Maliranta et al. (2009) study whether the movement of workers across firms is a channel of unintended R&D diffusion. Hiring employees directly from other firms' R&D departments into one's own R&D activities does not appear to constitute a significant channel for spillovers. In contrast, recruiting former R&D workers into non-R&D positions is associated with notable gains in both productivity and profitability. Boschma et al. (2009) add a geographic perspective, demonstrating that regional labor markets facilitate these spillovers by providing channels for frequent worker movements among related firms.

Extending this analysis to MNEs, several studies investigate how worker mobility between foreign multinationals and domestic firms fosters technological upgrading and learning in host countries. Balsvik (2011) finds that worker flows from foreign firms to local companies in Norway lead to increased domestic productivity, highlighting the positive externalities of foreign presence. Poole (2013) explores the US context, emphasizing how employees moving between multinational affiliates and domestic firms facilitate the diffusion of advanced technologies and management practices. Fosfuri et al. (2001) further enrich this literature by analyzing how knowledge transferred through worker mobility complements formal technology licensing and enhances the absorptive capacity of domestic firms.

Collectively, these studies illustrate that worker flows serve as a crucial, often informal, mechanism by which knowledge and innovations diffuse across firms and industries. This channel is especially important in the context of FDI, where foreign multinationals act as knowledge hubs and the movement of skilled workers enables domestic firms to assimilate advanced technologies and practices, thereby promoting industrial upgrading and economic development.

3.4. Patents and Compulsory Licensing

In the study of international technology transfer, patent data have emerged as an important channel for knowledge and innovation diffusion across countries' borders. Patents provide detailed and quantifiable evidence of innovative activity and allow researchers to trace the origins and diffusion of new technologies on a global scale.

Historically, the international protection of IPRs was formally established with the 1883 Paris Convention. Before this agreement, inventors faced significant obstacles in licensing their patents abroad (Bilir et al. 2011), which discouraged the cross-border exchange of knowledge. The Convention enabled inventors from any signatory country to register their patents internationally, thereby promoting technology transfer by providing legal protection for foreign inventions and facilitating international licensing arrangements. Moser (2005) shows that countries without formal patent protection generated as many, if not more, high-quality innovations as those with such protection. Nevertheless, patent systems shaped the sectoral direction of inventive activity: In the absence of patents, innovation tended to concentrate in industries where secrecy could serve as an effective alternative appropriation mechanism. By contrast, Hanlon & Jaworski (2022), examining the introduction of airframe design protection in the United States during the 1920s, find that stronger IPRs stimulated innovation in the protected domain but simultaneously reduced innovation in complementary sectors, such as aero-engine development. IPRs also include copyright protection of creative goods ranging from literature and science to images, film, and music. Giorcelli & Moser (2020) exploit exogenous variation in the adoption of basic copyrights as a result of the timing of Napoleon's military victories in Italy to investigate the effects of copyrights on creativity. Comparing changes in the creation of new operas across Italian states with and without copyrights, the authors document that the adoption of basic copyrights encouraged the creation of new work. Copyrights also changed the quality of creative output by encouraging composers to produce more popular and durable works. However, the extension of copyright beyond basic protection was associated with negative effects on creativity.

Several recent contributions have leveraged patent records to explore cross-country technology spillovers. Donges & Selgert (2019) utilize patent citation networks to examine how innovations patented in one country influence technological developments abroad. Their work emphasizes that patents are not only legal instruments protecting inventions but also markers of knowledge flows. By analyzing citation patterns, they identify how ideas and inventions disseminate internationally, revealing clusters of technological exchange and the influence of geographical proximity, trade relationships, and institutional environments. This approach uncovers the channels through which technology transfer occurs, including direct licensing, spillovers from MNEs, and collaborative research across borders. The authors also highlight the barriers to knowledge diffusion, such as intellectual property protection regimes and trade costs, which can either facilitate or hinder the effective transfer of patented technologies.

Nuvolari et al. (2020) offer a valuable historical dimension to the study of international technology transfer by analyzing patent data from the nineteenth and early twentieth centuries. Their work sheds light on the diffusion of industrial technologies during the first globalization wave and the role that patents played in protecting and transmitting knowledge internationally.

By examining patent filings, citations, and legal disputes, they uncover how technological leadership shifted among countries and industries over time. Their historical analysis reveals patterns of convergence, where lagging countries adopted and adapted innovations from technological leaders, as well as patterns of divergence driven by differences in institutional development and economic strategies. This study illustrates how patent systems and international agreements influenced the pace and direction of technology transfer historically, offering lessons relevant for contemporary policy debates.

Collectively, these studies demonstrate that patents are not only indicators of domestic innovation but also crucial instruments in the global diffusion of technology. Patent citation data provide a unique window into the international spillovers that drive productivity growth, industrial upgrading, and economic development. By mapping how patented technologies spread and are adopted across countries, researchers can better understand the determinants of successful technology transfer, including the roles of multinational firms, trade policies, intellectual property regimes, and local absorptive capacities.

Moreover, this literature highlights important policy implications. Countries aiming to harness foreign technologies for development must balance the protection of IPRs with policies that facilitate technology access and learning. Strengthening domestic innovation systems and investing in skills and infrastructure are essential to maximize the benefits of foreign patented technologies. Additionally, fostering international collaboration and encouraging FDI can accelerate the diffusion of knowledge embedded in patents, further supporting industrial upgrading and economic growth.

In examining the effects of IPRs on technology diffusion, compulsory licensing deserves a separate discussion. Under compulsory licensing, a government grants a third party—often a domestic firm—the right to produce a patented product or use a patented process without the consent of the patent holder. While compulsory licensing is most frequently used under the flexibilities of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in the context of pharmaceuticals, its relevance extends to a broader set of industries, including chemicals, machinery, and electronics, where it can serve as a deliberate industrial upgrading strategy.

Compulsory licensing has been used as a wartime and postwar policy tool to accelerate domestic technological capacity building. Moser (2012) uses evidence from World War I, when the US Trading with the Enemy Act made all German-owned patents available for licensing to US firms. An analysis of nearly 130,000 chemical inventions suggests that compulsory licensing increased domestic invention by 20%. Compulsory licensing not only reallocated existing technological advantages but also stimulated domestic inventive capacity by enabling firms to build directly on advanced foreign innovations. In a follow-up paper, Baten et al. (2017) study the effects of the same policy on domestic innovation. Firm-level data on German patents indicate that compulsory licensing was associated with a 30% increase in invention by German firms whose inventions were licensed.

3.5. Barriers to Technology Transfer

Despite the positive effects of foreign technology on countries' and firms' productivity, technology diffusion has often been slow and uneven across firms and sectors.

A first stream of research has shown that technology adoption lags behind invention due to multiple frictions. Griliches (1969) examined hybrid corn adoption in the United States and showed that diffusion could take many years, even when the productivity advantages were clear, emphasizing the role of learning, imitation, and adjustment costs. Mansfield (1985) analyzed several industrial innovations, documenting that technological change often spreads gradually, with adoption lagging behind invention due to factors such as capital costs, market uncertainty, and skill requirements. Rosenberg (1982) further argued that technology adoption is rarely automatic; the integration of new machinery often requires complementary organizational and process adjustments, making diffusion path-dependent. Hall (2004) revisited these patterns in the context of more recent innovation waves, demonstrating that adoption rates vary substantially depending on firm characteristics, industry structure, and regulatory or institutional constraints. Finally, Comin & Hobijn (2010) provided a macroeconomic perspective, showing that even generalized purpose technologies exhibit long, staggered adoption curves across countries, influenced by initial conditions, human capital, and institutional quality.

Historical evidence furthers micro-level insights into the sources of adoption delays. Squicciarini & Voigtlaender (2015) show that high-tail human capital was crucial in fostering industrial technology adoption in nineteenth-century France. Juhász et al. (2024c) provide firm-level evidence from the French mechanized cotton spinning industry, showing that early adopters initially operated with extremely low efficiency and diverse organizational practices. Over time, plants converged on best-practice layouts, highlighting the importance of learning-by-doing as a complementary factor in technology transfer.

More recent works have focused on the mechanisms behind the slow technology diffusion. Atkin et al. (2017a) examine technology adoption in Pakistani soccer ball manufacturing. The authors document that even when a cost-saving innovation was made freely available, firms were slow or reluctant to adopt. The reasons included coordination failures within the production process, uncertainty about performance in real-world conditions, and limited managerial capacity to reorganize workflows.

Taken together, these results show that the main obstacles to technology adoption are often embedded in capability constraints, coordination problems, and missing complementary inputs rather than in the mere absence of access to the technology itself. Overcoming these barriers typically requires interventions that go beyond lowering the purchase cost of the technology.

4. THE TRANSFER OF MANAGEMENT PRACTICES

While traditional discussions of technology transfer have focused on physical capital, machinery, and formalized production processes, recent research highlights the critical role of management practices as a key form of technology transfer. Management practices, ranging from structured human-resource protocols to systematic production monitoring, represent a distinct form of organizational know-how. They can be considered disembodied technologies, as they do not require new machinery but nonetheless embody productivity-enhancing knowledge. Empirical work over the last two decades has made substantial progress in measuring management practices and relating it to firm performance and productivity.

Management can affect firm productivity through three main channels: technology, efficiency, and human capital. Management capabilities can identify and adopt new production techniques and shape the investment, financial, and organizational practices to push firms as close as possible to the technological frontier. Therefore, management can be thought of as a technology, since it increases productivity (Bloom et al. 2016). Besides technological advancements, good management can allocate the firm resources more efficiently, for instance, through production planning and inventory control and by making fewer mistakes in the employment of physical capital. Finally, managers can make workers more productive by hiring and retaining the best workers, by providing performance-based incentives, and by allocating them to the most appropriate tasks.

Although the idea that managerial quality influences productivity can be traced back to Walker (1887), who argued that differences in managerial ability help explain firm heterogeneity, empirical research on the effects of management on firm performance has been scant until very recently. The persistent, unexplained productivity differences across seemingly similar firms—what Syverson (2011) calls the black box of productivity dispersion—were often attributed, indirectly, to management quality. Differences in managerial talent were, for instance, at the core of Leibenstein's (1966) *X*-inefficiency theory and Lucas's (1978) model of firm size.

Empirical research on the effects of management on firm performance has been limited until very recently for two reasons. First, management is a complex phenomenon, hard to define and to measure. Second, while the adoption of specific practices could improve firm outcomes, better-performing firms may simply adopt better management practices.

A substantial measurement and methodological advancement in this literature is represented by the World Management Survey (WMS), developed by Bloom & Reenen (2007). Recognizing that management is a broad and multidimensional concept, Bloom & Reenen (2007) focus on a set of specific, codified practices that could be systematically measured across firms and countries. These practices lie in three core areas of firm operations: (*a*) monitoring (how well firms collect and use performance data), (*b*) targets (the clarity and stretching of goals), and (*c*) incentives (how firms promote, reward, and retain talent). By using a structured telephone interview approach with double-blind scoring, the WMS created standardized management scores across firms, industries, and countries. The result was a globally comparable data set encompassing over 13,000 manufacturing firms, hospitals, and schools in more than 35 countries. These data revealed large and persistent differences in management practices, even within narrowly defined sectors and geographies. Notably, within-country variation in management closely mirrored productivity dispersion (Bloom & Reenen 2007).

The second methodological advancement in this literature concerns whether management has a causal effect on firm performance. In fact, while good management can make firms more productive, more productive firms can simply adopt the best managerial practices. Recent studies have solved this issue by using RCTs to evaluate the causal impact of management interventions. A pioneering example is provided by Bloom et al. (2013), who randomly offered free consulting on management practices to a set of textile firms in India. Treated firms not only adopted better management techniques but also experienced significant improvements in productivity, quality, inventory control, and profitability compared to control firms. These gains persisted over time, suggesting durable organizational changes (Bloom et al. 2020). Subsequent RCTs across various countries and sectors have reinforced these findings. Bruhn et al. (2018) provided consulting to small firms in Mexico, finding modest but significant improvements in productivity and sales and a substantial increase in employment. Iacovone et al. (2022) focus on scalability of management interventions in Colombia, demonstrating that group-based training programs, though less costly than intensive one-on-one consulting, produced improvements in management practices comparable in magnitude to individualized interventions. These studies collectively underscore not only the causal role of management practices but also the potential for designing cost-effective, scalable interventions to enhance firm performance.

Beyond RCTs, a growing body of work examines the role of managerial talent and individual characteristics in shaping firm outcomes. Lazear et al. (2015) and Hoffman & Tadelis (2021) show that managers with stronger interpersonal skills reduce employee attrition and turnover, thereby stabilizing the workforce and enhancing productivity. Similarly, Minni (2025) documents that effective managers optimize the allocation of workers to tasks and support career development, leading to higher worker efficiency and job satisfaction. Fenizia (2022) extends this line of inquiry to the public sector, demonstrating that managerial quality can significantly increase employee productivity even in nonmarket organizational contexts.

Recent evidence further highlights the micro-level impact of individual managers within organizations where overall practices are standardized. Metcalfe et al. (2023), for example, show that in the retail sector, store-level productivity varies substantially depending on the manager, even when management practices are set at the firm level. This finding illustrates that managerial effectiveness encompasses not only formal processes and routines but also the ability to motivate, coordinate, and adapt within established frameworks.

4.1. The Evolution of Management in the Twentieth Century

Despite their centrality in the modern debate, the concepts of management and managers developed fairly recently. Only when firms expanded in scale and complexity during the late nineteenth and early twentieth centuries did the coordination of labor, capital, and information demand not just entrepreneurial vision but also managerial expertise. This institutional shift from individual proprietorship to professional management was both reflected in and accelerated by the rise of business schools (Khurana 2010) and the emergence of scientific management (Taylor 1911, Gilbreth & Gilbreth 1917).

World War II arguably represented the major turning point in the evolution of US businesses and managerial practices. To cope with the war effort, the United States launched the so-called productivity drive, which stimulated substantial managerial advancements. One of the most important interventions in this respect was Training Within the Industry (TWI), which offered management consulting to US firms involved in war production. Until recently, most evidence about the productivity drive and its effect on productivity was qualitative (Dinero 2005). Bianchi & Giorcelli (2022) overcome this limitation by collecting new data on firms that got the TWI consulting and their performance for approximately 15 years. Leveraging newly assembled panel data encompassing all 11,575 firms that applied to the program, the authors find that TWI training generated significant and persistent improvements in firm performance, including heightened productivity and sales longevity. Crucially, their results highlight that the effects are not isolated; multiple training modules exhibited complementarities, and the benefits extended throughout the supply chain, indicating a broader diffusion of managerial best practices among nonparticipant firms connected via business networks. The implementation of TWI practices not only largely improved firm performance but also contributed to changing the firm structure in two ways. First, management training focused on changing firm operations, thanks to a better reallocation of existing resources. Second, it helped firms expand product scope and develop new marketing channels, which became fundamental in the postwar period.

At the same time, the US government aimed at training middle managers working in the facilities involved in the war effort. To do so, Engineering, Science, and Management War Training (ESMWT) was launched. Among other interventions, the program developed MBA-style programs targeted to middle managers and production supervisors employed at war industrial facilities. Through this program, more than 200,000 managers attending management courses were trained. Combining newly collected data on program attendance, manager career outcomes from reunion books, and a regression discontinuity design, Giorcelli (2023) shows that managers who attended ESMWT classes had better career outcomes than managers who did not, and they improved the productivity and performance of their plants. Moreover, this study highlights the value of peer networks: Exposure to a cohort of classmates from higher-performing firms increased both the likelihood of moving into such firms and the founding of ventures with fellow trainees, underscoring the role of social capital in managerial career mobility.

Perhaps the largest transfer of managerial knowledge across countries occurred in the aftermath of World War II under the Marshall Plan. The Marshall Plan was a US-led initiative launched in 1948 to provide economic aid for the reconstruction of Western Europe after the war. While the Marshall Plan was effective in increasing production (Bianchi & Giorcelli 2023), an increasing productivity gap between European and US businesses persisted. For this reason, since 1950, the US government introduced the United States Technical Assistance and Productivity Program (hereafter, Productivity Program). This program aimed at closing the productivity gap with the United States by diffusing US managerial practices in European plants. Giorcelli (2019) investigates the long-run effects of the Productivity Program in Italy. Exploiting an unexpected budget cut that excluded many eligible firms from the program, this paper documents that firms whose managers received management training increased productivity and other plant performance for at least 15 years. Moreover, management training was complementary to the import of US technologically advanced machines. Alongside performance improvements, firms displayed organizational changes such as better maintenance, human capital development, increased access to credit, and a shift toward professional management structures. These effects underscore the critical role of management capability in enhancing the productivity of both human and physical capital.

4.2. The Japanese Case

The US diffusion of managerial practices was not limited to Europe but reached Japan as well. In postwar Japan, US occupational authorities initially introduced elements of Western management, including quality control techniques and statistical methods, but Japanese firms adapted these practices to local constraints. Womack et al. (1990) discuss how Toyota's lean production system represents one of the most significant postwar management innovations. Constrained by scarce capital, limited domestic demand, and the need for export competitiveness, Toyota developed an integrated production philosophy emphasizing just-in-time inventory management, *jidoka* (empowering workers to stop the line to address defects), *kaizen* (continuous improvement), and multiskilled teams. The approach also transformed supplier relationships from adversarial contracting to collaborative, long-term partnerships.

The success of lean production demonstrated that managerial knowledge transfer is not a one-way flow from technologically advanced to catching-up economies; rather, Japan became a global exporter of management techniques, influencing manufacturers worldwide. By the 1980s, lean principles had been adopted in the United States and Europe, reshaping productivity debates and prompting organizational change across industries (Giorcelli 2021).

5. GOVERNMENT-INITIATED TECHNOLOGY TRANSFERS

This section examines industrial policy interventions as a central mechanism through which governments seek to influence economic development, structural transformation, and regional growth. By reallocating resources across sectors and locations, such policies shape firm behavior, labor demand, and long-run productivity. In recent years, industrial policy has returned to the forefront of economic debate and research, encompassing a wide range of interventions beyond the management transfers discussed in the previous section.

5.1. Industrial Policy Interventions

Governments could encourage technology transfers by using industrial policy tools. As explained by Juhász et al. (2024a), industrial policy can be defined as the set of "government policies that explicitly target the transformation of the structure of economic activity in pursuit of some public goal" (p. 216). Despite a long-standing discussion about the effectiveness of industrial policies in promoting technological advancements and economic development (see Juhász et al. 2024a for a comprehensive review), until recently rigorous economic research has been limited by a lack of systematic data and natural variation to estimate the causal impact of such policies. In fact, such interventions usually target areas or industries with an ex-ante higher probability of economic success.

Nevertheless, the last decade has seen a proliferation of empirical works evaluating the effects of industrial policies. This was largely possible thanks to access to micro-level archival data, easier digitization processes, and the employment of state-of-the-art econometric techniques. While a comprehensive overview of this literature goes beyond the purpose of this article, here I outline the most relevant contributions related to technology and knowledge transfers. Carlin et al. (2013) show that well-designed interventions—such as targeted subsidies, credit programs, and sector-specific infrastructure—can promote firm entry, encourage innovation, and facilitate upgrading. However, their findings also caution that poorly implemented policies risk locking firms into low-productivity equilibria. Complementary studies highlight the spatial dimension of technology transfer: Kline & Moretti (2014), for example, document how industrial clusters foster knowledge spillovers through labor mobility and interfirm linkages, illustrating how proximity to innovative firms accelerates learning and adoption. Liu (2019) reinforces this view in the context of developing countries, demonstrating that government investment in industrial sectors can catalyze private sector innovation and competitiveness, particularly when combined with market-enhancing reforms.

Historical and sector-specific case studies provide further empirical support: In the Chinese shipbuilding industry, Kalouptsidi (2018) and Barwick et al. (2023) argue that government support and industrial clustering facilitated innovation and competitiveness, while Hanlon (2020) finds that temporary protection in North American shipbuilding enabled technological transitions consistent with infant industry theory. In France, Juhász (2018) documents how the Napoleonic blockade enhanced mechanized cotton production. Using the rapid codification of technical knowledge in Meiji Japan as a natural experiment, Juhász et al. (2024b) find that the comparative advantage shifted to industries that could benefit from patents in countries and colonies that had access to codified technical knowledge but not in other regions. Evidence from South Korea in the 1970s illustrates the transformative potential of coordinated industrial policy: Choi & Levchenko (2025) and Lane (2025) show that the Heavy Chemicals and Industrial drive, through trade policy, preferential financing, and downstream investment, enhanced output, productivity, and structural transformation, while Kim et al. (2021) demonstrate that R&D subsidies and tax incentives improved technological capabilities and export performance. Finally, Zhou (2024) highlights the role of regulatory interventions in China's digital sector, showing how measures such as the Great Firewall act as industrial policy tools shaping domestic technological development.

Collectively, these studies suggest that strategically designed and effectively implemented industrial policies can accelerate technology transfer, foster innovation, and drive long-term industrial and economic transformation.

5.2. Unintended Technology Transfer

The analysis of colonial economies offers interesting cases of unintended technology transfer. While several papers have documented that extractive institutions set by colonizers have detrimental effects for economic development in both the short and the long run across countries (Acemoglu et al. 2001, 2002) and within countries (Dell 2010, Lowes & Montero 2021), a few notable exceptions are worth discussing. Dell & Olken (2020), in the context of the Dutch cultivation system—the integrated industrial and agricultural system for producing sugar in colonial Java—show that areas close to where the Dutch established sugar factories in the mid-nineteenth century are today more industrialized, have better infrastructure, are more educated, and are richer than nearby locations comparable in terms of suitability for colonial sugar factories. The railroad network designed and built by the British government in India dramatically changed the technology of trading, lowering interregional price gaps and increasing interregional and international trade as well as real income levels (Donaldson 2018). Mendez-Chacon & Van Patten (2022) show that areas in the concession of the United Fruit Company in Costa Rica had better living standards than nearby areas, thanks to the company's investments in local amenities, such as schools and hospitals. Similarly, the introduction of the printing press in twentieth-century sub-Saharan Africa by Protestant missions is associated with higher newspaper readership, trust, education, and political participation (Cage & Rueda 2016). Huillery (2009) shows that colonial investment in education rather than in health and infrastructures had large and long-lasting effects on the current economic outcomes of French-speaking West Africa.

5.3. Command Economies: Technology Transfer Under Constraint

One popular way to accelerate the process of industrialization in developing countries is relying on 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).

The Big Push theory was initially introduced by Rosenstein-Rodan (1943), who argued that large-scale, coordinated investment across multiple sectors is necessary to overcome structural barriers to industrialization in underdeveloped economies and allow them to escape the poverty trap. In fact, when countries are poor, demand may be too low to foster industrialization. Individual firms or sectors may underinvest because they do not expect complementary industries to emerge, leading to a suboptimal equilibrium. Moreover, large-scale investments and infrastructure projects require significant upfront capital that individual firms may not be able to afford alone or that financial markets cannot provide. As a result, isolated investments often fail to generate sustainable growth, because complementary sectors and infrastructure are absent or underdeveloped. By constructing all of the elements of an advanced economy simultaneously, such coordination problems may be solved and industrialization can be achieved. Murphy et al. (1989) model the Big Push as a coordination game in the context of an imperfectly competitive economy with aggregate demand spillovers, and they interpret the Big Push into industrialization as a move from a bad to a good equilibrium. Factual and counterfactual equilibria before and after the introduction of industrial policies have been highlighted in a recent contribution by Garg (2025). While counterfactual equilibria help identify whether the observed effects of industrial policy are driven by fundamentals or indeed solve a coordination problem, the application of this model to Indian industrial zones indicates that its presence increases the probability of escaping a low-industrialization equilibrium by 38%, with coordination effects explaining roughly one-third of the observed change in outcomes.

Big Push industrialization strategies have been largely pursued in command economies. In such settings, the state assumed direct control over resource allocation, investment decisions, and the diffusion of technology, seeking to achieve rapid industrialization through coordinated, top-down planning. Technology transfer was often orchestrated as part of these industrial drives, through state-to-state agreements, reverse engineering, or the mobilization of domestic scientific and engineering capacities toward imported blueprints. In such contexts, the command structure theoretically solved the coordination problem central to the Big Push framework: Planners could direct complementary investments across sectors and regions without relying on decentralized market incentives. This allowed for the synchronized introduction of new technologies in heavy industry, transport, and energy, creating the conditions for rapid capacity expansion. However, the same centralized control also introduced rigidity. Without competitive pressures or decentralized experimentation, technology transfer often resulted in mechanical replication rather than adaptive innovation, limiting long-run productivity growth.

Command economies offer an ideal setting to study the effectiveness of Big Push strategies. Allen (2011) explains that the Soviet Union's Big Push started in 1928 with the first Five Year Plan. It was based on four principles: (*a*) the channeling of investment into heavy industry and machinery production, (*b*) the use of demanding output targets to direct business operations, (*c*) agricultural collectivization, and (*d*) mass education. The Soviet Union also took advantage of the Great Depression to acquire technology and knowledge from the United States. Jiang & Weber (2025) provide evidence that US counties more exposed to financial distress in the 1930s were more likely to sell their technology to foreign competitors by signing technology transfer agreements with the Soviet Union.

Arguably, the largest combination of Big Push industrialization and technology and knowledge transfers to foster early stage industrialization was implemented in Communist China in the early 1950s. The Soviet Union sponsored the construction of the so-called 156 Projects: large-scale, capital-intensive industrial clusters built in China with Soviet aid. 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. Giorcelli & Li (2021) document 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 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.

However, despite these positive effects on firms involved in the transfer, counties that hosted the 156 Projects lost their productivity advantages over time. Heblich et al. (2022) document 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. Therefore, in evaluating the effects on industrial policies and related technology transfer, it is important to consider both partial and general equilibrium long-term effects.

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 US 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 as well as other states—for instance, India, Egypt, Ghana, and Turkey.

6. CONCLUSIONS

Technological advancements and international knowledge flows remain central drivers of economic development, particularly for countries seeking to catch up with more advanced economies. This article has highlighted the pivotal role of technology transfer interventions, emphasizing that less developed economies often face dual constraints: limited access to modern capital goods and insufficient industry-specific know-how. Knowledge transfer, especially tacit knowledge embodied in workers and organizational routines, emerges as a critical mechanism enabling firms to absorb foreign technology and enhance productivity.

Empirical evidence from technology and knowledge transfers in the twentieth century indicates that, while capital goods and technical innovations are important, their full productivity potential is realized only when firms possess the organizational and managerial capabilities to implement them effectively. The transfer of state-of-the-art management practices can have long-lasting effects on firm performance and productivity.

Finally, the twentieth-century experience offers important policy implications. Industrial policy, foreign investment incentives, and labor mobility programs can play complementary roles in promoting technological catch-up. Policymakers should recognize the multifaceted nature of knowledge diffusion, balancing investments in formal infrastructure with support for informal learning, training, and human capital development. Understanding the channels and conditions under which technology transfer translates into sustained industrial upgrading remains crucial for designing policies that foster long-term economic growth.

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