ROUTLEDGE INTERNATIONAL STUDIES IN BUSINESS HISTORY

Organizing Global Technology Flows

Institutions, Actors, and Processes

Edited by
Pierre-Yves Donzé and
Shigehiro Nishimura

"This book deals with an important but understudied topic of technology flows across national boundaries. Both communities of business history and history of technology will benefit from having available a set of in-depth case studies on this topic."

—Hyungsub Choi, Seoul National University, Korea

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Organizing Global Technology Flows

Research on the international transfer of technology in economics and management literature has primarily focused on the role of countries and that of companies, in particular multinational enterprises (MNEs). Similarly, economic and business historians have tended to view international technology transfer as a way for economically "backward" countries to acquire new technologies in order to catch up with more developed economies. This volume provides a more in-depth understanding of how the international transfer of technologies is organized and, in particular, challenges the core-periphery model that is still dominant in the extant literature.

By looking beyond national systems of innovation and statistics on foreign trade, patent registration and foreign direct investment, the book sheds more light on the variety of actors involved in the transfer process (including engineers, entrepreneurs, governments, public bodies, firms, etc.) and on how they make use of a broad set of national and international institutions facilitating technology transfer. Put differently, the volume offers a better understanding of the complexity of global technology flows by examining the role and actions of the different actors involved. By bringing together a number of original case studies covering many different countries over the period from the late 19th to the 21st century, the book demonstrates how technology is being transferred through complex processes, involving a variety of actors from several countries using the national and international institutional frameworks.

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Foreword

This is an important book on an important topic. Technology and innovation are central to understanding the historical drivers of the patterns of wealth and poverty which characterize our contemporary global world. From the 18th century the ability of certain firms and regions, especially in Europe and the United States, and later in Japan, to innovate, and to learn from innovations elsewhere, has behind the epic growth of incomes and improvements in longevity. Equally, the stickiness of much of this innovation, and its slower diffusion to other geographical regions, has presented a fundamental challenge to catching up.

As the editors of this volume make clear in their perceptive introduction, the issue of technology transfer has attracted the attention of leading scholars across a range of disciplines. This is entirely appropriate as such an important topic demands multiple skills and methodologies. We now know a great deal about the diffusion of innovation across borders, as well as the lack of diffusion and the persistent clustering of innovation in certain hubs and cities. It is equally clear that a great deal remains to be understood about the complexities of the process.

Business history has played a distinctive role to this unfolding understanding of innovation and its diffusion. Alfred D. Chandler, the doyen of business historians, showed the link between the growth of large and professional managed firms and the high levels of innovation seen in the American economy from the 19th century. Subsequent researchers have explored the organizational routines and cultures which evolved over time within particular firms, which encouraged creative thinking and innovative renewal, as well as the embedding of those firms within networks and clusters, which encouraged innovation. Historians of international business and their colleagues in the history of technology have shown how technological diffusion across borders, either within firms or between firms, has been a cumulative process deeply embedded within and shaped by multiple institutions. It is clear that this diffusion can best be understood by looking longitudinally, and within a broad economic, social and political context.

This is the task to which the contributors of this book have set themselves, and their work makes a significant contribution to the literature on global

technology flows on several dimensions. It provides rich new empirical evidence on actors in the diffusion process which have received less attention than they deserve. There is an ongoing debate in the economics and other literatures about the role of patent systems in innovation, and the chapters in the volume add to this literature by looking specifically at the international patent system. Cartels, the subject of the second section, have been hugely important in global business over the last hundred years, yet they have been unfairly seen primarily as growth-retarding institutions designed to exploit consumers. New research has challenged such a view, and the chapters in this volume add to this revisionist interpretation by exploring how cartels were channels for technological diffusion. The third section takes a new perspective on the role of firms in innovation transfer, exploring mutual learning rather than one-way flows. The final section on engineers explores the deeply underexplored role of professional networks in technology transfer. The examination of these issues using case studies based on deep historical research brings nuance and authority.

An important contribution of the volume is the range of settings of the studies. In a literature in which English-language studies have been preeminent and the experiences of the English-speaking countries have often held center stage, not least because of the importance of the United States and its firms as a center of technological innovation in the 20th century, the chapters in this volume provide access to a much broader range of experiences in Asia, Europe and Latin America. This rich empirical evidence provides an opportunity to study technological diffusion across different chronological, geographical, developmental and cultural settings. Confronting such diversity is a crucial step to generating generalizable propositions concerning the lessons of history about global technology flows.

There are few tasks more important in the agenda of business history than documenting the past of technology transfer and providing convincing explanations for the patterns revealed. Historical research on the diffusion of innovation is crucial to fully understanding the Great Divergence in wealth between the West and the Rest over recent centuries. Going forward, this historical evidence can provide crucial insights into how particular institutions, actors and processes have been important in the past in facilitating diffusion, and so provide guidance for policy makers and managers to make the right decisions going forward.

—Geoffrey Jones
Harvard Business School

Preface

The take-off point for this book was the "Technology Transfer in the 20th Century: Institutions and Actors" session at the XVth World Economic History Congress, held at Utrecht University in the Netherlands on August 6, 2009. A preliminary session, organized by Shigehiro Nishimura and Pierre-Yves Donzé in Kyoto in 2008 to gather business and economic historians residing in Japan, provided the first opportunity to exchange ideas on global technology transfer and raise the necessity of conducting more research and discussions on the basis and channels of this phenomenon with scholars from all over the world. The project took its first real step in Utrecht, where European and Asian business and economic historians came together to discuss various perspectives. Joining Nishimura (from Japan) and Donzé (from Switzerland) in Utrecht were Cédric Humair (Switzerland), Pierre Lamard (France), Zejian Li (China), Yuki Nakajima (Japan) and Julia Yongue (United States). Kristine Bruland (Norway), Takafumi Kurosawa (Japan) and Margrit Mueller (Switzerland) also agreed to participate in the session as session chairs and discussants. This fruitful discussion with a worldwide audience encouraged us to broaden our perspective and disseminate our collective, global academic knowledge through a book. Harald Degner (Germany), Jochen Streb (Germany), Patricio Sáiz (Spain), David Pretel (Spain), Valerio Cerretano (Italy), Marco Bertilorenzi (France), María Inés Barbero (Argentina), Stephen B. Adams (United States) and Paul J. Miranti (United States) kindly joined the team. The contribution of Valerio Cerretano, "European Cartels and Technology Transfer: The Experience of the Rayon Industry, 1920 to 1940," has already been published in *Zeitschrift für Unternehmensgeschichte—Journal of Business History* 56/2 (2011): 206–224. We would like to acknowledge the publisher for granting us the right to republish it in this book. Finally, we would like to thank Geoffrey Jones and Takafumi Kurosawa for accepting the tasks of writing the opening and closing sections of the book, respectively; their expositions emphasize the importance of technologies in understanding global competitiveness of industries and in the making of a global world. We thank all the distinguished business and economic historians actively involved on the front lines of their academic field for their valuable contributions. Furthermore,

we would like to express our deepest gratitude to Ray Stokes and Matthias Kipping for their patient and considerate help preparing the manuscript of this book.

—Pierre-Yves Donzé and Shigehiro Nishimura
Kyoto/Osaka, March 2013

Introduction

Pierre-Yves Donzé and Shigehiro Nishimura

Research on the international transfer of technology in economic history, economics and management literature has primarily focused on the role of countries and that of companies, in particular multinational enterprises (MNEs).[1] This process has been widely approached as a vertical and a core-periphery phenomenon, where technologies and knowledge flow from the developed, industrialized countries to the less developed ones, thus supporting the industrialization of the latter and the move forward of the former, close to the "flying geese theory" developed by Kaname Akamatsu in the 1930s and recently popularized by Terutomo Ozawa.[2] Moreover, most of the research highlights the role of MNEs and national institutions as key actors in the transfer process. Yet the actual role of these actors remains rather vague, given that many of the studies rely on statistical data and analysis (regarding patents, trade and foreign direct investment) rather than examining the transfer processes in depth. Accordingly, the papers gathered in this volume aim at giving a fresher view of the history of international technology transfer from the late 19th to the early 21st century, thereby contributing to a better understanding of this phenomenon itself. By looking behind rough statistical data and opening the black box of *multinational enterprise, national system of innovation* and *foreign direct investment,* these 12 chapters show how technology has been transferred through complex processes, involving a variety of actors from several countries using the national and international institutional frameworks.

TECHNOLOGY TRANSFERS IN ECONOMICS

Technology transfer in the past tended to be approached as a vertical phenomenon, flowing down from industrial countries to underdeveloped countries, and as a crucial vehicle for industrialization and catching up. It became a key issue in economics during the 1960s. One of the most representative works of this decade was the product cycle theory, which introduced into classical theory the notion that multinational enterprises, by moving facilities abroad, help transfer technologies and knowledge to other countries.

Its most representative author is no doubt Raymond Vernon, who, from a classical perspective, explains the transfer of production facilities to another country as the result of comparative advantages for the multinational enterprise.[3] In such cases, technology transfer reflects a desire to enter new markets, as with the example of direct investments in the textile industry in East Asia at the end of the 19th century, or can occur when a technology reaches maturity in its home country, becoming financially easy to access for other countries, as with the case of elevators in skyscrapers. Vernon thus inserts technology transfer into international trade, yet he does not mention the question of adapting technologies to local economies or the process of the transfer itself.

The product cycle theory is, however, a crucial step for research on technology transfers in economics. While technology was generally considered until then as an immaterial factor without real significance, it became an issue factored into the classical economic approach. Since then, a great deal of research has been conducted on technology transfer from this perspective, as for example with the work done by James Quinn on technology transfers by American and European MNEs towards developing countries.[4] Based on some 400 interviews conducted in the second half of the 1960s, this article provides an overview of technology transfer as it was seen then by managers of MNEs, emphasizing that it takes many forms (export of products, flow of capital, copy and imitation, etc.) and contributes to the economic growth of developing countries. As for Farok J. Contractor and Sagafi-Nejad Tagi, they stressed the different policies adopted by states for encouraging the import of technologies.[5] They emerged as key actors in developing countries in the 1960s and 1970s and had a significant impact on the way MNEs could invest in a country. While foreign direct investment (FDI) was the norm in high-tech industry where it was hard to find domestic firms that had the ability to collaborate with the foreign MNE, in some regions, especially in South America and in communist countries, the State tended to promote licensing agreements between MNEs and local partners, following the example of Japan in the 1950s. Finally, one should also mention the work of Bruce Kogut on joint ventures as an essential vector of technology transfer.[6] Focusing on the case of American MNEs that went overseas through joint ventures in the 1960s and 1970s, Kogut shows that this particular form of investment can be explained by strategic reasons rather than transaction cost considerations. It was sometimes a condition of local governments to authorize the FDI but also a strategy to use local resources, especially in marketing and R&D, for supporting expansion into a new market. These are some examples of numerous cases of research on technology transfer conducted by economists and deeply influenced by the product cycle theory, as they consider technology transfer as a vertical flow, going down from industrial to developing countries through MNEs. Technology transfer then gave birth to several new theories, leading to the emergence of a new field with its own journal (the *Journal of Technology Transfer,* since 1977). The

product cycle theory, which dates back to the mid-1960s, has since been reappraised by some economists and historians, especially Philippe Gugler and John H. Dunning, who emphasize the role of transnational corporations (companies organized on the global scale) rather than MNEs (headquarters in a country and branches or joint ventures abroad) in transferring technologies since the 1980s.[7] According to their model, the new trend is technological convergence which makes innovation possible. Two firms active in different sectors collaborate to create new technologies, as was the case, for example, with AT&T (telecommunication), IBM and Olivetti (IT) in creating information networks. As for John Cantwell, he used US patents during the 20th century to analyze the technological strategy of MNEs and showed that, rather than being a one-way flow from the US headquarters to foreign branches, technologies can also take the opposite route, as he observed above all in the chemical industry as early as the 1920s.[8] Despite these sometimes fundamental reevaluations of the product cycle theory, economic research into technology transfer has remained largely focused on MNEs as the main actors and FDI as the main vector.

Interest in technology transfer was also whetted during the 1960s and 1970s by the United Nations and its agencies, which then adopted a development policy for the southern hemisphere countries characterized by industrialization driven by large investment in heavy industry, especially by MNEs. Numerous UN studies and works at the time accorded a central role to MNEs and FDI, which were supposed to allow economic development through technology transfer.[9] In Japan as well, a great deal of research on technology transfer has been conducted since the end of the 1980s as a result of growing FDI from Japanese companies towards Southeast Asia. This work is undeniably influenced by the theory on MNEs and by the idea of a contribution to development through the emergence of regional integration in East Asia as a consequence of FDI and technology transfer from Japan.[10]

In addition to the works on MNEs, a second field of economics has also attached great importance to technology transfer, that of innovation management, and more specifically the theories around the so-called National System of Innovation (NSI).[11] Authors like Lundval or Freeman argue that, despite globalization and the worldwide organization of MNEs, spatial localization still matters for technological and knowledge issues. Economic development and thus the growth of any country relies on local institutions, such as R&D facilities, technical education and public policies, which are a source of domestic innovation and give nations their competitive advantage.[12] However, NSIs are not closed systems but are rather open to outside technology and knowledge, incorporating them into the domestic innovation system under various patterns. The interrelationships between NSIs and technology transfer can indeed take several forms, a deep integration of foreign technologies into the domestic institutions (enterprises, R&D centers) contributing to innovation, as it was in Japan during the 1950s–1970s and in East Asia in the 1980s–1990s, whereas weak integration, as

was the case in the USSR and Latin America in the second half of the 20th century, has little impact on innovation at the corporate level.[13] Thus, both NSIs and technology transfer can contribute to the competitiveness of firms and nations. The innovation strategy adopted by MNEs also stems from considerations about the abilities of different NSIs to contribute to their own development, with Freeman arguing that most of their R&D activities "are still overwhelmingly conducted in the domestic base of the company and are heavily influenced by the local national system of innovation."[14] This does not mean that the flow of technologies within a MNE always runs from headquarters to foreign subsidiaries—in a way close to Vernon's product cycle theory. In some cases, a reverse transfer can be observed, with headquarters benefiting from R&D and innovation carried out in a foreign subsidiary, Geoffrey Jones asserting that "firms sought to access geographically-based knowledge to develop technologies which are distinct from, but complementary to, those created by their parent companies."[15] For example, John Cantwell and Lucia Piscitello have shown, using US patents granted to the world's largest firms from 1969 to 1995, that MNEs developed their international organization following a strategy of opening subsidiaries in specific European regions (Germany, Italy, United Kingdom) in order to access local knowledge. Thus, global firms "tap into specialised sources of local expertise, and so differentiate their technological capability, by exploiting geographically separate and hence distinct streams of innovative potential."[16]

TECHNOLOGY TRANSFER TACKLED BY HISTORIANS

This new theoretical background led historians to focus as well on technology transfer from a long-term perspective. Research on the history of technology transfer appeared in distinct fields, primarily in the history of technology and in business history. In the 1970s and the 1980s, historians began to get involved in research on industrialization and economic growth tackled from the angle of technology transfer, either by using the general theoretical framework on MNEs or by adopting a more practical approach. Nevertheless, the overwhelming majority of these works also viewed technology transfer as a vertical phenomenon. It was used as a tool to understand industrialization in latecomers' countries and the catching-up process with the United Kingdom then other developed nations. These many efforts led to several important syntheses published by David J. Jeremy in the first part of the 1990s.[17] These works are crucial for better understanding technology transfer itself as an economic and social process and for ensuring that technology transfer is regarded as a significant factor in industrial history.

On the basis of publications in business and economic history since the 1970s, we can distinguish two main periods in the history of technology transfer thinking in the long run (18th–20th centuries).[18] The first phase

relates to the period from the beginning of the Industrial Revolution up until the middle of the 19th century. It is marked by the overwhelming domination of Great Britain as the major source for technologies transferred elsewhere in the world. The period 1700–1850 indeed shows a general trend of technologies moving from the United Kingdom to other parts of the world, for example, the United States,[19] Germany,[20] France,[21] Norway[22] and China.[23] The characteristics of technology transfer during these years are the importance of textile and machines as the main sectors, as well as the role of persons (engineers, merchants, immigrants, etc.) and objects (commercial goods, machines, blueprints, etc.) as principal vectors.[24] Shannon Brown summarizes this general trend by asserting that "the transfer of technology is simply the transfer of knowledge, usually embodied in men or machines."[25] This focus on individuals as key actors in technology transfer is for example well illustrated in Kristine Bruland's book on Norwegian industrialization. She underscores the decisive role of Norwegian engineers going to United Kingdom in the mid-19th century and bringing back machines, but also information which was then diffused domestically through associations of technicians and scientific literature.[26] The weight of individuals in transferring technologies during this period became even more crucial in the United Kingdom, where the authorities tried to put a stop to the flow of technology from Britain to the rest of the world. At the beginning of the 1780s, the British government forbade the emigration of qualified artisans in many industries such as textile, machines, paper, watch- and clock-making, and so on, and punished them by depriving them of their nationality, while the agents who helped them emigrate were liable to a fine of 500 pounds and 12 months' imprisonment. However, this law proved difficult to apply, and emigration was finally liberalized in 1824.[27] Yet this dominant approach in historiography, which attaches importance to the United Kingdom as the center of diffusion of technologies to the rest of the world, may be too exclusive, as technologies have also been exchanged between other countries since the 18th century. In continental Europe, technologies were also transferred over borders, as for example between France and Switzerland in the textile industry.[28] In Asia, the case of Japan during the Edo era (1603–1868) and the so-called closed country policy reflects the permanence of relationships and exchanges with other Asian countries, mainly China. There were more than a thousand Chinese residents in Nagasaki at the end of the 17th century, and they played a key role in the influx of technologies into Japan, notably in the textile industry.[29]

The second period, which starts in the mid-19th century and runs up into the present, is that of the multipolarization of flows as a consequence of the spread of industrialization and the appearance of new innovation centres (USA, Europe and Japan). Works published on this period, undoubtedly marked by economic theory, emphasize the crucial role played by MNEs and FDI.[30] Capital became the main vector of technology transfer. In a breathtaking article, Mira Wilkins emphasizes "the role of private business as a

vehicle for the diffusion of technology."[31] In particular, she shows that successful technology transfer in the long term implies its adoption by local firms, and that MNEs were the most effective actor for this purpose. This does not mean that individuals stopped playing a key role after the so-called second Industrial Revolution. Rather, research published on Finland[32] and Japan, for example, points to a continuation of their significant role. According to Hoshimi Uchida, the Japanese electrical appliances industry, a sector typical of the second Industrial Revolution, benefitted from numerous engineers trained in American companies. After returning to Japan, they took over some domestic enterprises whose technological development they supervised. Most of this cases occurred within the framework of joint ventures between American (General Electric, Western Electric, Westinghouse) and German (Siemens, AEG) MNEs, on the one hand, and Japanese firms, on the other hand.[33] This implies that MNEs did set up a framework for transferring technologies, through joint ventures, patents agreements or licensing contracts, and that the concrete process was driven by individuals, such as engineers or technicians, usually related to the MNEs. Thus, organizations, for example, companies, MNEs or universities, and institutions, such as the international agreements or pacts which set up new global norms, were instrumental in reshaping the framework within technologies moved, while, from a micro-viewpoint, they appear to have been driven mainly by individuals as before. Other studies stress the growing importance of governments and public administrations in organizing the import of new technologies, especially in Asia and Latin America.[34] Nevertheless, historiography tends to focus on the role of MNEs as the main actors and FDI as the main vector for the period since the end of the 19th century. And finally, despite the emergence of MNEs as new actors, the dominant perspective is still the approach of the vertical flow of technology.

Yet the publication of new works since the end of the 1990s, particularly in the field of the history of technology, makes it possible to break away from the traditional approach and adopt new perspectives. Among these numerous publications, the typological essay written by Kristine Bruland on the basis of her research on Scandinavia should be mentioned.[35] While integrating technology transfer within the general context of a learning process, she thus largely contributed to the construction of a general theoretical framework whose lack was the principal weakness of the synthesis published up to that point. Even if her work appears as a case study of a catching-up process through technology transfer, she adopts an analytical approach which gives pride of place to organizations and institutions and helps highlight the importance of actors other than MNEs and individuals. In the same way, the work of Joel Mokyr can be read as an invitation to view the question of technology transfers within the broader context of "useful knowledge."[36] The "elite networks," in which useful knowledge is constructed and exchanged, presented by Mokyr as the main source of the early industrialization of Europe since 1800, spread as of the end of the

19th century to the whole world, giving birth to a global scientific community, whose analysis from the point of view of technology transfer appears promising. The circulation of "useful knowledge" on a worldwide scale, and especially its supply from Asia to European manufacturers, merchants and scientists, appears to be a key element in the global organization of Western business.[37] Lastly, the challenging view proposed by David Edgerton should also be underlined here, as he points out that technologies circulate especially between rich countries themselves and that technology transfer during the 20th century did more to bring developed countries closer together than to support a policy of catching up on behalf of poor countries.[38] David J. Jeremy had already affirmed that, from a long-term perspective, the circulation of technology is not a one-way street, taking the example of Japan, which industrialized thanks to the importation of technologies in the late 19th and early 20th centuries, and has established herself as an innovating nation exporting technology since the 1980s.[39] Edgerton goes further, arguing that the flow of technology is not driven by different levels of development between nations. These few examples show that the question of technology transfers should be reconsidered and analyzed again from a new point of view, and the global business history perspective offers precisely such an opportunity.

TECHNOLOGY TRANSFER IN THE 20TH CENTURY: INSTITUTIONALIZATION AND NEW ACTORS

The period since the 1880s can be viewed as that of the institutionalization of technology transfer, which breaks with the previous era marked by a more informal framework. Although traditional forms of technology transfer still exist today, especially in the consumer goods industry, globalized institutions and norms, on the one hand, and new actors, on the other hand, have emerged and have a dramatic influence.

The birth of a globalized economy at the end of the 19th century comes with the emergence of new institutions which influence the organization of markets and which, for this reason, have an important impact on the nature and the function of technology transfers. The concept of *institution* should be understood here as defined by Douglass C. North. It does not mean *organization,* such as MNEs, universities or public bodies, but rather what North calls the "rules of the game in a society" or some "humanly devised constraints that shape human interaction."[40] Since the late 19th century, the spread of global norms and institutions has provided a new framework in which technology transfer occurs.

There are firstly many new institutions that have been set up and adopted worldwide from the mid-19th century onwards. They have led to new global norms and rules which drive technologies. For instance, this is the case of the International Telegraph Convention (1865),[41] the Paris Convention for the Protection of Industrial Property (1883)[42] or the World

Time Conference of Washington which set the prime meridian from which longitude would be measured, at Greenwich Observatory (1884).[43] These institutions helped unify the diverse national economies in a global system and then facilitated exchanges. The international patent system is a good example of this process.[44] It clearly shows how the global flow of technologies was influenced by an organizational shift and the introduction of a new global norm. The protection of invention was not inexistent prior to 1883; rather, it was based on national or local legislation which granted industrial and commercial operating monopolies for various products and manufacturing processes on the domestic market.[45] They did not aim at facilitating or organizing the transfer of technologies, but rather at avoiding it and guaranteeing a competitive advantage to patent holders on the domestic market. Consequently, the major change introduced by the Paris Convention was that the unification of national legislation henceforth made it possible to protect inventions and marks on a global scale, providing a guarantee for actors—primarily multinationals—operating in several countries. For such firms as Singer Manufacturing[46] or General Electric,[47] the institutionalization of the intellectual property system helped drive their expansion worldwide. Their patent management policies enabled them to sew up the market for innovation by suing rivals who copied them, and open joint ventures and branches abroad without risk. The Paris Convention was signed in 1883 by 11 countries, including eight European nations (Belgium, France, Italy, Netherlands, Portugal, Serbia, Spain and Switzerland) and three South American countries (Brazil, El Salvador and Guatemala). They were soon joined by Great Britain (1884), Norway (1885), Denmark (1894), the United States (1897), Japan (1899), Germany (1903), Australia (1907) and Austria (1909).[48] Researchers generally view the Paris Convention as an essential phase in "global patent-system integration."[49] It allowed a globalized technology market to emerge, insofar as patents were no longer solely attached to monopolies for the industrial exploitation of inventions but became goods tradable worldwide. As such, they primarily benefited multinationals, facilitating their policies of expansion and international division of labour. For business historians, however, the issue remains that of looking at the way actors made use of this new framework.

For inventors, entrepreneurs and firms, this new global system provided a means of facilitating the global flow of technology. Moreover, the spread of the gold standard, while stabilizing exchange rates, limited the risk of investing abroad and subsequently facilitated the establishment of industrial facilities by MNEs in other countries through FDI. The spread of new global institutions is not the specific characteristic of the second half of the 19th century but continues and becomes more pronounced after World War II, following a phase of deglobalization during the interwar period.[50] The Bretton Woods Agreements (1944) and the creation in 1947 of the International Organization for Standardization (ISO) are other examples of global institutions which influence the transfer of technology. However, we must

not cling to an idealized vision whereby the making of new institutions is expected to lead to the advent of a globalized and fluid world. The adoption of standardized norms on a global scale is a matter of power, sometimes leads to conflict and does not always work, the most famous example being the metric system, which is not used in the United Kingdom and the United States; however, this is also the case with electrical standards or mobile telephony, where systems differ in different parts of the world. Thus, there were various institutions competing with each other, which could have slowed down the exchange of technologies or on the contrary allowed latecomers to make a name for themselves in a competitive environment. In the Japanese precision machine industry, for example, the lack of a global standardized norm for measures posed many practical problems. It delayed the transfer of technologies in some sectors such as watchmaking, where firms used both the metric system for parts imported from Switzerland and the inch system for American machine tools until 1923.[51]

The second characteristic of technology transfer since the end of the 19th century is the emergence of new actors. Obviously, traditional actors such as individuals or firms have not disappeared; however, they are becoming less important due to the emergence of actors who were less present before. First of all, there are of course MNEs, whose importance has been largely emphasized by research carried out by economists and historians on this period. Besides, MNEs may be the actors which benefit the most from the spread of new global institutions. Nevertheless, the technology transfer that resulted from the action of MNEs not only took the form of vertical flows towards less developed countries, as emphasized in economics literature. The technology transfer organized by a firm must be understood within a general investment strategy conceived on a global scale. MNEs did invest abroad for many reasons, and they did so in many other industrial countries.[52] The case of General Electric Co. (GE) perfectly embodies this assertion.[53] Resulting from the merger in 1892 of two American electric appliances manufacturers (Thomson-Houston and Edison General Electric), GE soon adopted a global expansion strategy in which technology transfer, through licensing, was a key element. Between 1892 and 1918, GE signed seven licensing agreements with foreign firms, enabling domestic production of its goods in Canada, the United Kingdom, France, Germany, Russia and Japan.[54] In some cases, such as Russia and Japan, it obviously contributed to the development of a domestic electrical appliance industry, while in others, like the United Kingdom and Germany, where such an industry already existed, the inflow of GE's technologies resulted from its global expansion strategy.

Close to MNEs are business associations and other private bodies which encourage exchanges and contacts between firms at an international level. International organizations are another category of actors which played a key role in transferring technologies during the 20th century, as they provided valuable platforms for engineers and scientists to gather and exchange experience and knowledge. NATO is a case in point, which French military

engineers used in the 1950s as a platform for acquiring technology, knowledge and training in modern warfare from the United States.[55] In addition, governments and public bodies are other major actors for technology transfer, especially through policies introduced to encourage and facilitate the acquisition of techniques and knowledge. The industrialization policy pursued in the USSR by Stalin is an eloquent illustration of the use of foreign technology by a government to develop a country.[56] Japan provides another good example of the role of authorities from the perspective of importing technologies, with the famous Ministry of International Trade and Industry (MITI), its main tool for rebuilding the industry after the war through the acquisition of foreign technology.[57] Lastly, there are international cartels. By establishing internal rules, they tend to control the flow of technologies which are the source of their comparative advantages.[58]

STRUCTURE OF THE BOOK

Thus, to provide a better understanding of the processes by which technology transfer occurs, the chapters in this volume focus on the actors involved in technology transfer and their use of the institutional framework. In terms of the time period covered, the chapters range from the late 19th to the early 21st century—a period marked by the first global economy, followed by retrenchment and renewed globalization since the 1980s.[59] In terms of geographical coverage, the chapters focus on technology transfers between the major regions of the world: North America, Latin America, Europe, Japan and the BRICS (Brazil, Russia, India, China, South Africa). The United States is omnipresent in the book, with American engineers, companies and official bodies forming part of the story in nearly every chapter, reflecting America's strong economic and technological influence in the 20th century. Europe is examined in all of its diversity through early industrializers (United Kingdom, France), latecomers (Germany), small open economies (Switzerland) and the so-called backward economies (Spain, Italy, Yugoslavia, USSR). Beyond the West, attention is also paid to Argentina and to Japan, which occupies a key position in the history of technology transfer as it embodies the role of a country that succeeded in industrializing via imported foreign technology, becoming an exporter of technologies in the last third of the 20th century. Finally, the volume looks at China today, making it possible to extend and broaden the scope of this volume to the present and to examine the current technological development of the BRICS from an historical perspective. Most importantly, it should be stressed here that countries are never discussed in isolation. Rather, all chapters examine cases involving two or usually more countries.

The chapters in the volume are subdivided into four parts. The first section deals with the international patent system, which has been identified by past research as an institution with a major impact on technology transfer.