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INTERNATIONAL TECHNOLOGY TRANSFER CASE IN THE REFRACTORY INDUSTRY

Dissertation Thesis

2022 **Neha Jain, MA**

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Bratislava 2022

Neha Jain, MA

DECLARATION OF HONOUR

I hereby solemnly declare that this thesis represents my own work, and that all sources of information used in this study are listed in the references section of this thesis.

Date: Signature:

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My thanks are also due to the research participants who took their time to share with me their stories and experiences. It is their experience that set the foundation for this research to start with, and ultimately made this study possible. Respecting their request for anonymity, and to comply with the data protection regulations, I exercised care in compiling the results and refrained from including any details, e.g. names, interview transcripts, that may infringe this request for anonymity.

ABSTRACT

JAIN, Neha: International technology transfer case in the refractory industry. University of Economics in Bratislava. Faculty of international relations; Department of international law. Supervisor: Dr. habil. JUDr. Ing. Katarína Brocková, PhD. LL.M – Bratislava: FMV, 2022, 143 p.

The history of human civilization has been marked with development of new technologies. Even today, new technologies continue to emerge in different corners of the world. Technologies and knowledge, however, fail to justify the effort put into their creation if they are not commercialized and brought to the place of application. This is where technology transfer comes into play, bringing technologies from point of creation to point of application, facilitating commercialization of technologies, capacity building, and economic and industrial growth.

Following a qualitative grounded theory research methodology, this study aims to analyze technology transfer in the refractory industry. Refractories are products that are used in high temperature industrial applications like production of steel, cement, glass, etc. As these industries grow, boosted by the global demand for industrial materials, so does the refractory industry. Even though refractories are a fundamental pillar of heavy industries, there is a scarcity of literature on technology transfer in the refractory industry. Following an explorative approach, guided by the principles of the Glaserian grounded theory, this study analyzed cross-country technology transfer, using the refractory industry as a case study. Using open-ended interviews, data was collected on technology transfer between Austria, Brazil, China, Germany, India, Ireland, Norway, and United States of America. The main characteristics, challenges faced, and lessons learnt were then analyzed from the perspective of individuals involved directly in cross-country technology transfer.

The results could form a basis for studying and building technology transfer capabilities in multinational organizations across different industries. The study aims to facilitate a better understanding of international technological dialogue in multinational corporations and also aims to enable capability building for international technology transfer assignments.

Key words: international technology transfer, refractory, grounded theory, knowledge exchange

ABSTRAKT

JAIN, Neha: Medzinárodný transfer technológií v žiaruvzdornom priemysle. Ekonomická univerzita v Bratislave. Fakulta medzinárodných vzťahov; Katedra medzinárodného práva. Vedúci: prof: Dr. habil. JUDr. ing. Katarína Brocková, PhD. LL.M - Bratislava: FMV, 2022, 143 s.

Dejiny ľudskej civilizácie sú poznačené vývojom nových technológií. Aj v súčasnosti sa v rôznych kútoch sveta objavujú stále nové technológie. Technológie a poznatky však nedokážu ospravedlniť úsilie vynaložené na ich vytvorenie, ak nie sú komercializované a uvedené do praxe. Práve tu vstupuje do hry transfer technológií, ktorý prináša technológie z miesta ich vzniku do miesta ich použitia, uľahčuje komercializáciu technológií, budovanie kapacít a hospodársky a priemyselný rast.

Cieľom tejto štúdie je na základe kvalitatívnej výskumnej metodiky založenej na teórii analyzovať transfer technológií v žiaruvzdornom priemysle. Žiaromateriály sú výrobky, ktoré sa používajú v priemyselných aplikáciách pri vysokých teplotách, ako je výroba ocele, cementu, skla atď. S rastom týchto odvetví, ktorý je podporovaný globálnym dopytom po priemyselných materiáloch, rastie aj žiaruvzdorný priemysel. Napriek tomu, že žiaruvzdorné materiály sú základným pilierom ťažkého priemyslu, existuje nedostatok literatúry o transfere technológií v žiaruvzdornom priemysle. Na základe exploračného prístupu, ktorý sa riadil princípmi Glaserovej zakotvenej teórie, sa v tejto štúdii analyzoval transfer technológií medzi krajinami, pričom ako prípadová štúdia sa použil žiaruvzdorný priemysel. Pomocou otvorených rozhovorov sa zbierali údaje o transfere technológií medzi Rakúskom, Brazíliou, Čínou, Nemeckom, Indiou, Írskom, Nórskom a Spojenými štátmi americkými. Hlavné charakteristiky, výzvy, ktorým sa čelilo, a získané skúsenosti sa potom analyzovali z pohľadu osôb, ktoré sa priamo podieľali na transfere technológií medzi krajinami.

Výsledky by mohli tvoriť základ pre štúdium a budovanie kapacít transferu technológií v nadnárodných organizáciách v rôznych odvetviach. Cieľom štúdie je uľahčiť lepšie pochopenie medzinárodného technologického dialógu v nadnárodných korporáciách a tiež umožniť budovanie kapacít pre úlohy medzinárodného transferu technológií.

Kľúčové slová: medzinárodný transfer technológií, lom, zakotvená teória, výmena znalostí.

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List of Abbreviations

AACTE……………………….American Association of Colleges for Teacher Education

COVID-19…………………Coronavirus Disease detected in the year 2019

DDT………………………..Dichloro Diphenyl Trichloroethane

ESA………………………...European Space Agency

FDI…………………………Foreign Direct Investment

GAVI………………………Global Vaccine Alliance

GDP………………………..Gross Domestic Product

GLOBE…………………….Global Leadership and Organizational Behavior Effectiveness

ICT…………………………Information and Communication Technologies

IP…………………………...Intellectual Property

MNC……………………….Multinational Corporation

NASA………………………National Aeronautics and Space Administration

OECD……………………...Organisation for Economic Co-operation and Development

SARS-Cov-2……………….Severe Acute Respiratory Syndrome Coronavirus 2

SWOT……………………… Strength Weakness Opportunity Threat

TTO………………………...Technology Transfer Office

TLO………………………...Technology Licensing Office

UNCTAD…………………..United Nations Conference on Trade and Development

UTTO………………………University Technology Transfer Office

WIPO………………………World Intellectual Property Organization

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INTRODUCTION

Human history is marked with continuous evolution and creation of new knowledge and technologies. From securing food production for the growing global population to ensuring faster commute, often the aim of innovation and technological development has been to solve practical problems of human civilizations. Over the last decades the studies on technological dissemination have continued to catch the interest of the scientific community. With increasing globalization and increasing global investments in research and development, more and more organizations at national and international level aim at faster commercialization of new and existing technologies. This is where technology transfer comes in. Technology transfer aims at bringing the new and existing technologies from the point of creation to the point of application. Through technology transfer, the investments done in the development and creation of new knowledge and technologies could be justified, when they are eventually applied in solving practical problems of the human world.

Technology transfer in itself is not a new field of studies. The first part of this study, the literature review, reveals that multilateral technological dialogue has existed for several decades across the different civilizations spread across the globe. Over the years, from agricultural crops to irrigation techniques, from melting iron to building bridges, from electric bulbs to vaccines, technologies that once existed in a corner of the world have found their way in the heart of human civilization across the world. This could be made possible by different agents of technology transfer, like policy makers, financial and scientific institutions, and industries. International cross-country technology transfer, however, is not without its challenges. As the literature review further revealed, international technology transfers are affected by the global and local cultures and different cultural dimensions could be used to study such cultural differences.

The geographical and cultural distances are well-known barriers to technology transfer. But what requires more research and focus is how exactly do cultures impact technology transfer, whether a bigger cultural gap automatically implies a challenging technology transfer, whether there are some anomalies to the theories of cultural and geographical distance and what is their impact on international technology transfer. The literature review revealed some missing links in the scientific literature. These are the gap that this study aims to bridge. Taking over a decade of professional industrial experience in the steel and refractory industry as foundation, the author set out to address the cultural and geographical impact on technology transfer in the refractory industry.

Refractories are industrial products, used in high temperature industrial processes like production and treatment of steel, glass, cement, etc. Refractories are an essential product that enable the high temperature industries across the globe. As the human civilization grows and develops, boosting the demand for industrial materials like steel, glass, cement, and aluminium, it puts increasing pressure on the refractory industry for technological developments. This necessitates an international technological dialogue in the refractory industry for accelerated development of new technologies, as well as for faster commercialization of the existing and new technologies.

The aim of this study is to offer a comparative analysis of technology transfer in the refractory industry across different geographical regions, with the goal that the results could be used by multinational organizations for capability building and better preparation of technology transfer assignments. At the onset of this study several research methodologies were examined as to their suitability for this research. Finally qualitative Glaserian grounded theory methodology was selected for this study. Qualitative research offers the possibility of studying the research subject, be it an individual, a group of individuals, an event, or a location, in the natural surroundings of the subject. Also, qualitative research presents itself as a suitable method to conduct explorative research, where the research topic and subject is relatively new and unknown. As the literature review revealed a scarcity of literature in technology transfer on the refractory industry, an explorative project using qualitative research methodology was deemed suitable. Qualitative research, however, offers in turn several research possibilities, based on the research subject and the topic being studied. Out of these five qualitative research possibilities, namely, case study, ethnography, grounded theory, narrative study and phenomenology, grounded theory was selected for this study. Glaserian grounded theory methodology offers a unique combination – possibility to conduct an explorative study, high degree of flexibility in terms of data collection tools, letting the theory emerge from the data collected and all of this while avoiding forced quantification of data.

Once the research methodology was finalized, data was collected using semi-structured interviews. Convenience sampling followed by snowball sampling was used to identify the research participants who had direct experience in the field of international technology transfer in the refractory industry. The interviews were then analyzed to address the three research questions that guided the study.

Following the constant comparison method used for data analysis in the Glaserian grounded theory methodology, theoretical descriptions were then generated to address each of the research questions. These are discussed in detail in the analysis section and summarized in the results section of this study.

This study focuses on the human aspect of international cross-country technology transfer. This research shows that despite the fact that technology transfer has been known to the human civilization over the last several decades, there is no one solution or set of practices that fits all. The fact that all the research participants listed several similar challenges that they faced during international technology transfer, shows that the organizational and industrial best practices are still a work in progress. The analysis in this research focused on the human experience of individuals in the refractory industry, but the results resonate beyond the refractory industry. The author aims to add to the scientific literature on cross-country technology transfer. Furthermore, the author hopes to bring transparency and visibility in terms of challenges faced and lessons learnt by the industrial experts during their international technology transfer assignments. The results of this study could be used for capability building and improved planning of technology transfer assignments in multinational organizations. In order to extend this research to other industries beyond the refractory industry, the author recommends a deep dive into the results of this study together with the technology transfer experts in other industries – identifying the similarities and differences and adding new aspects that might be specific to other industries. This study could then form the foundation for building organizational best practices for international technology transfer for diverse industries.

1 THEORETICAL FRAMEWORK

In this section, first the evolution of international technological dialogue in the history of human civilization is highlighted. Covering the history of international technological dialogue spanning several centuries, the literature study leads to the technologies of the twenty-first century and the relevance of international technology transfer in the current times. Further, different agents which facilitate technology and knowledge exchange across borders are highlighted. International technology transfer is faced with several challenges and the barriers to international transfer have also been studied and discussed in later part of this section.

The second part of the literature study introduces the refractory products and highlights the relevance of refractory industry in a nation's economy owing to its strong link to heavy industries like steel and cement.

The third part of the theoretical framework offers an interim conclusion based on the literature study and identifies the missing links in the scientific literature that this study aims to bridge. These missing links then form the basis of the research constructs that guide the study in the following sections.

1.1 Technology Transfer

The European Commission (2022) defines technology transfer as ' *the process of conveying results stemming from scientific and technological research to the marketplace and to wider society, along with associated skills and procedures, and is as such an intrinsic part of the technological innovation process'.* This section starts with the evolution of international cross-border technology transfer over the last centuries. Moving to the twenty-first century, the continuously evolving landscape of the technologies and relevance of technology transfer in the current times has been discussed. International technology transfer occurs through different channels, facilitated by different national and international agents. Additionally, there are several barriers that hinder the flow of technology in the desired direction. These two aspects, namely, the channels of technology transfer, and the barriers to international technology transfer have been discussed in the latter part of this section. With relevance to the current study, the role of geographical and cultural distance on international technology transfer has been highlighted in the last part of this section.

1.1.1 Technology dialogue in the history of human civilization

The history of human civilization has been marked with inventions, discoveries, and a continuous evolution of knowledge. The invention of wheel or of paper, of gunpowder or of telegraph and satellites, the knowledge that once originated in one corner of the world has over time found itself well in use across borders and continents. What triggers this dialogue, this exchange of knowledge? Who needs it and who propagates it? The questions that come to a human mind at the first instance have been asked by several scholars over the span of human history. In modern times, the exchange of knowledge has been thought by many to be a unidirectional process, prominently by the west to the east or by the north to the south. This theory limits itself to a certain time and knowledge sphere as it fails to completely justify the continuous exchange of knowledge that happened for example across the Persian, Chinese, Indian, European, Incan civilizations over the span of human history. So strong has been the mystery and pull surrounding this continuous dissemination of human knowledge including discoveries and inventions, that knowledge dissemination studies have gained increasing importance over the last decades, with the view to learn from the history, understand the best practices and use this knowledge for facilitating faster and efficient knowledge exchange across countries and organizations when needed.

At the onset of this discussion and this study, it is essential to define what technology is and what is its link to knowledge in general. The word technology finds its essence in the Indo-Germanic word "tek" that was used to define the process of making houses by weaving wooden sticks together (Agar, 2020). This later evolved to the Greek word "techne" that came to mean the specialized know-how of making things that would otherwise not exist. This then found its existence as the root for the word "technologie" in the German speaking regions, depicting the systematic knowledge of industrial and handicrafts arts (Agar, 2020). In the latter half of the nineteenth century, the field of study "technik" in the German speaking world came to indicate practical arts, with emphasis on modern engineering and industry (Schatzberg, 2018). Today, Encyclopaedia Britannica defines technology as *the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased,* *to the change and manipulation of the human environment* (Britannica, 2021a). Looking at this definition, two concepts are visible - firstly, the link between technology and knowledge. Technology is essentially a field of knowledge. This is important to understand because during the course of this study, the question often arose, whether the ongoing research is limited exclusively to technology related to machines or instruments or covers a broader scope of knowledge related to products, processes, and persons. As will be seen later in this study, knowledge, and technology, especially when looking at their practical implications in the world and society, have several overlapping elements. At times the boundary between knowledge and technology is clear and it is easy to differentiate between knowledge related to machines from the rest. At other times, however, the boundary between knowledge and technology tends to be diffused, especially when the knowledge under discussion is linked to soft aspects like culture, emotions, etc. These, therefore, require a holistic approach rather than a segmented silo-thinking restricted to certain aspects of knowledge, technology, and their applications. The link between knowledge and technology also enables a symbiosis of the existing research, both in the field of knowledge transfer as well as technology transfer, which is especially relevant for the current study. When studying the exchange of knowledge and technology across borders, the concepts of knowledge flow, knowledge stickiness, knowledge-based organizations, to name a few, find some resonance in the technology transfer discipline (Sheng, Chang, Teo, & Lin, 2013; Wilhelm & Dolfsma, 2018).

The second concept visible from the definition of technology is that it deals with the application of the knowledge, putting it into operation in the real world. Thus, technology is not just collecting and assimilating knowledge, but necessarily putting it to use in solving practical problems, challenges, and limitations of the human world. This aspect makes technology a subset of knowledge, distinguishing technology from theoretical knowledge.

Treating technology as the knowledge to solve practical human problems over the course of human civilization, an intricate history of technology transfer can be mapped over the last centuries. Around the year 1000 AD technological innovations in the field of agriculture and metal processing have been documented in China and West Asia, extending to Europe (Pacey, 1991). Population growth was often a prime motivation factor, especially when trying to increase crop yield and building infrastructure. Such technologies are often referred to as survival technologies and may include developments related to agriculture, livestock, medical support, etc. Around 700 AD to 1000 AD, with a view of increasing and sustaining food production, a cluster of technologies were in use in the field of irrigation and hydraulic engineering with China being the center of innovation in this field (Pacey, 1991, p.7). An example of such transfer of survival technology can be found in the use of a quick-growing Champa rice from Vietnam that was transferred to South China around 1000 AD, that allowed for increased food production to meet the needs of the growing population (Pacey, 1991, p.5). From 800 AD to 1000 AD, China also led the world in terms of technology and innovation in the field of canal transport, textile production, iron making and design of bridges. The Chinese iron industry was leading the world in terms of production in these times and even pioneered the use of coke instead of wood or charcoal in the iron smelting (Pacey, 1991, p. 2). Much of the iron produced at that time went to the production of equipment for the armed forces, with the second major consumer being the Buddhist temples using cast iron bells. While China was leading the technology, the technology was percolating in the wider world. India played a pivotal role in these times, linking China to the Islamic world by transferring technologies related to agriculture and irrigation to Indonesia and Cambodia, medicinal herbs to West Asia, and itself accessing varieties of crops like sugarcane, cotton, oranges that were more suitable to the Indian climate (Pacey, 1991, p. 15). There was therefore already a technological dialogue underway between East and West Asia. This Asian technological dialogue was interrupted by a series of political upheaval in the regions from the conquest of the Saljuk Turks in Iran to the Mongol period in China. Till about 1150 AD, China, the Islamic countries, and western Europe were the forerunners in mechanical technology with China clearly leading the way. This situation saw a shift around 1450, when European technology gained momentum and developed faster than the other geographic regions (Pacey, 1991, p. 45). The Mongol invasion in China, on one side slowed down the technological development in China and on the other side accelerated the technological exchange between China and Europe via Russia, which is seen for example in the development of military goods like gunpowder and gun barrel design (Pacey, 1991, p. 46). Around 1200 AD, the art of paper making was transferred from China to Iraq (Hubbe & Bowden, 2009) and the art of glass making was transferred from Syria to Italian Venice (Al-Hassan, 2006). There are, however, examples in history that indicate that technologies can be developed independently around the same time in different geographic regions. Such is the case of the windmills that existed in Persia around 950 AD. The first windmills that developed in Europe around 1150 AD were quite different from their Persian counterparts and therefore were probably an independent innovation not resulting from a technology transfer (Pacey, 1991; Shepherd, 1990). Such independent developments are seen in human history every now and again, with the ones in the ancient times often linked to survival technologies where the basic human needs were similar across regions and the technological developments requiring less or few tools or complex engineering. Such examples highlight the need for caution when studying human technological developments by not overanalyzing and creating links where they are none.

Even before the European explorers reached America in the fifteenth century, there is evidence of interaction between America and the rest of the world in the earlier times. This is visible in similarities between the Chinese and Mayan calendars, rope suspension bridges in China and America and mulberry-bark paper used in Indonesia and Central America as early as 700 AD, which again hints at a technological dialogue between these regions separated by the ocean in the early times (Needham, 1974). The stronger link to America in the fifteenth century revealed the existence of crops that had been domesticated there regionally and had higher yield than any Asian or European crop in those times. Such crops are well known today in the form of maize, manioc, groundnut, and potato and have transformed the food habits of the global population. Products such as tobacco and cinchona - one the first known natural sources of quinine, also created a lot of political interest considering the future trade links between Europe and America (Meshnick & Dobson, 2001; Musk & De Klerk, 2003).

When looking at the chronology of the global technological development in world history, several periods of low technological growth are visible. Few such have been the collapse of the roman empire in Europe in the fifth century, the Mongol invasion in China in the thirteenth century and the bubonic plague in the fourteenth century. Such events are often followed by a state of political and social unrest, with the focus of the governments and people shifting more towards rebuilding and recovering rather than innovating and transferring technology. Such events also reveal the role that government institutions and the social situation plays in the technological development in a country. In times of growth, peace, and high trade the exchange across borders is strengthened thereby strengthening the technological dialogue.

Around the sixteenth century, the global shipbuilding industry was strengthening with increasing exploration campaigns and political activities requiring faster, durable, and more fuel-efficient ships. There is evidence of technology exchange between Portugal and Philippines, the latter transferring technology for building faster ships. Around the same time, a technological exchange between Great

Britain and India was evident for transferring the Indian teak-wood technology for building durable ships (Pacey, 1991, p. 67). The English ships using oak wood were susceptible to worms and the Indian teak wood, on the contrary, was more durable at sea. Another aspect was the increasing use of iron nails in the European and Chinese ships with the iron production having grown enough to meet the demands of ship building. This technology was later adopted by the Indian shipbuilders, however had to be modified further to prevent rusting of iron. During this period, there were further wide-reaching effects of global trade on technology transfer. The goods from China and Islamic world were in high demand, whereas the products from Europe, with few exceptions, were seldom suited to the needs of the remaining world (Pacey, 1991, p. 68). This meant that the European purchases in the East could not be traded in goods, but rather had to be paid often in gold and silver and this increased the European focus on mining activities in the Americas, especially in Peru and Mexico (Brading & Cross, 1972) and led to transfer of metal extraction technologies across the continents (Pacey, 1991, p.69). Shipbuilding, mining, and metallurgy, therefore, formed the three prime technology transfer clusters around this period.

The seventeenth century saw the dispersion of Chinese printing technology across East Asia, mainly in Japan and Korea (Pacey, 1991). The Chinese had developed and used paper printing already much earlier. This knowledge spread around the world in much earlier times. Even though the knowledge had dispersed, the application in other geographical regions was limited as duplication of documents by hand, instead of printing, was the common practice. Some printing presses had found their way already across Europe, Turkey and India but were used sparingly. Around the seventeenth century, Korea and Japan had similar written script as that of China and this facilitated a rapid technological exchange. Modern printing workshops were established which facilitated book-printing on topics ranging from classic Japanese secular literature to technical topics like metallurgy, navigation, and mathematics (Pacey, 1991). Meanwhile in Europe, another transformation was seen around this time - the use of machines as problem solving tools, be it textile spinning wheels, clocks, or weapons. This was setting the foundation for the increasing number of factories and for the soon to come industrial revolution.

The eighteenth century saw a technology transfer that transformed the industrial landscape of the world - namely the steam engine. This one invention included several technical concepts that were based on technological dialogue across decades between countries like Italy, Germany, France and

England (Britannica, 2021b). The steam engine revolutionized the manufacturing industries and had a lasting impact in the global manufacturing industry in the coming years. Another dialogue of commercial significance in these times was linked to the textile industry, the ability to produce finer cotton and silk cloth and with strong colors, that were a distinctive feature of the oriental textile technology (Pacey, 1991, p.119). Such products were of high commercial value in Europe but replicating the weaving and dyeing methods in Europe was too costly to be commercially viable. Italy, France, England, and Switzerland, were exchanging technologies to find cost-effective ways of producing high quality cloth as close to the oriental quality as possible. After several failed and moderately successful attempts, a breakthrough was achieved when the French, accompanied by Turkish experts, set up a dyeworks, which then had ripple effects across Europe, transferring finer aspects of the dyeing techniques across Europe. This example is of significance even today as it indicates two concepts of technology transfer that were used centuries ago and are still relevant. Firstly, the European manufacturers with interest in products manufactured in the developing countries and willing to manufacture these in Europe still face the challenge of high cost and lower cost-competitiveness (Drucker, 1999; Drucker, 2018; Kumar, Nirmalya & Puranam, 2012). Even if the technological knowledge is available, it is not always commercially viable to transfer this to the west, mainly because of intensive labor requirements. Over the last decades, this phenomenon has increasingly motivated multinational corporations to expand their operations across the globe, making the best of resources spread across the different regions. This is visible in the increasing trend within the multinational corporations and international organizations in creating research centers and state-of-the-art manufacturing hubs in the cost-effective countries like China, India, and former Eastern Bloc countries (Dodgson, Gann, & Phillips, 2013, p. 551). Secondly, this example highlights the role that technical experts from one country played in bringing the technology to the other country. Such professionally skilled migrant workers or expatriates, also known as expats in today's language, continue to be a key technology transfer agent in the global perspective (Kapur, 2001; Šušteršič & Kejžar, 2020).

The nineteenth century built upon the technological advances of the earlier times. The colonial empires across the world in this time worked as global knowledge exchange networks, fueled by political, strategic, and economic competitiveness (Headrick, 1988). Spanning across the length and breadth of the globe, a key challenge for the global political powers of that time was the speed of communication. Around the year 1840, it took nearly half a year for a letter to travel between Britain and India. The steam ships speeded up the transport, reducing the mail transport times to about 6 weeks (Headrick, 1988, p.97). The breakthrough was achieved in the year 1854 in the successful implementation of telegraph lines, which enabled communication within one day (Headrick, 1988, p.97). This spurred a series of technological dialogue and race for a faster, durable, and more widespread telegraph communication network. From Europe to Constantinople, Britain to India, France to Algeria, Alexandria to Suez, across Bavaria in Austria, to Baghdad and Karachi, in water and on land, the technology surrounding telegraphic communication was transferred across borders. This fast-paced international technology transfer once again shows the role governments and political organizations at regional and international level can play in accelerating technology transfer across borders by boosting the speed of exchange, providing financial backup, and mobilizing international resources (Headrick, 1988, pp. 100-101).

The next and perhaps the biggest transformational technological advancement of the nineteenth century came in the form of railways. Already in the beginning of the nineteenth century, the technological focus on the railroads started getting increasing interest. One interesting point was that railroad technology was not an isolated technology, but rather linked to several other technological developments like those in the iron and steel industry, construction of bridges, and machine building like steam power, boilers, and cylinders. The railroad development also needed the already in use telegraph technology for transmitting the arrival of trains.

The steam railroad was developed in Britain, but it soon saw increasing interest across the Atlantic in North America (Pacey, 1991, p. 138), with the first transcontinental railway built across North America around the year 1869 (Pacey, 1991, p. 150). The promising prospects of railway technology motivated European countries like France and Germany and Russia to increase their steel production as well as transfer the English technology across borders. Around the mid of the nineteenth century, Russia was expanding its railroad network. A technical and commercial dialogue was underway with the technical expertise coming in the form of bridge building knowledge of the American engineers and the financial resources western European countries. Some unfortunate lessons were to be learnt during this technological exchange as several bridges and related construction work failed as they were not able to meet the natural conditions in the Russian regions. This could later be attributed to the fact that the foreign engineers were not completely aware of the local conditions and therefore the attempts of simple geographical relocation of technology without deeper understanding of regional cultural aspects did not meet with complete success. This phenomenon resonates even today in the contemporary literature on the significance of cultural adaptation of technology (Dodgson et al., 2013; Jeremy, 1992). Geographical relocation versus cultural adaptation of technology transfer will also resonate through this study as a comparative study of technology transfer across multiple geographical borders will be discussed in the later sections. Coming back to the transfer of railroad technology in Russia, seeing the need of better understanding the local surrounding, including geographical terrain, steel production and technology level, a laboratory for locomotive design was set up in Kiev around 1882, in order to adapt the western technology to the Russian terrain (Pacey, 1991, p. 152). This concept of setting up research centers and laboratories in local surroundings and adapting the transferred technologies to the local needs also finds existence as well as acceptance in today's times (Chang, Chen, Wang, Chen, & Liao, 2014; Chunga, Ensink, Jenkins, & Brown, 2016).

The railroad developments resonated around the world, across India, Africa, Japan and even South America. India profited a lot from the technological dialogue that received a political boost by the colonial interest of the British Empire and by the beginning of the twentieth century, could boast of a dense railroad network spanning across the length and breadth of the country (Headrick, 1988, pp. 50-55). Another technological dialogue concerning railroad technology is the one in Japan around the last quarter of the nineteenth century that slowly found the railroad network expanding around Japan, China, and Korea. Here different modes of technology transfer were employed, namely, importing machinery, attracting skilled foreign technical experts, and expansion of the local offer of scientific and technical education. Till the end of the nineteenth century, the Japanese technical institutions reached a high level of expertise, barely requiring foreign teachers (Pacey, 1991, p. 155). This transforms into a significant concept in the study of technology transfer in today's times, namely the pivotal role of the scientific institutions and the scientific community in developing, dispersing, adapting technology across different levels of the society (Lee, 2020; Sanchez Preciado, Claes, & Rundquist, 2014; Vinig & Lips, 2015).

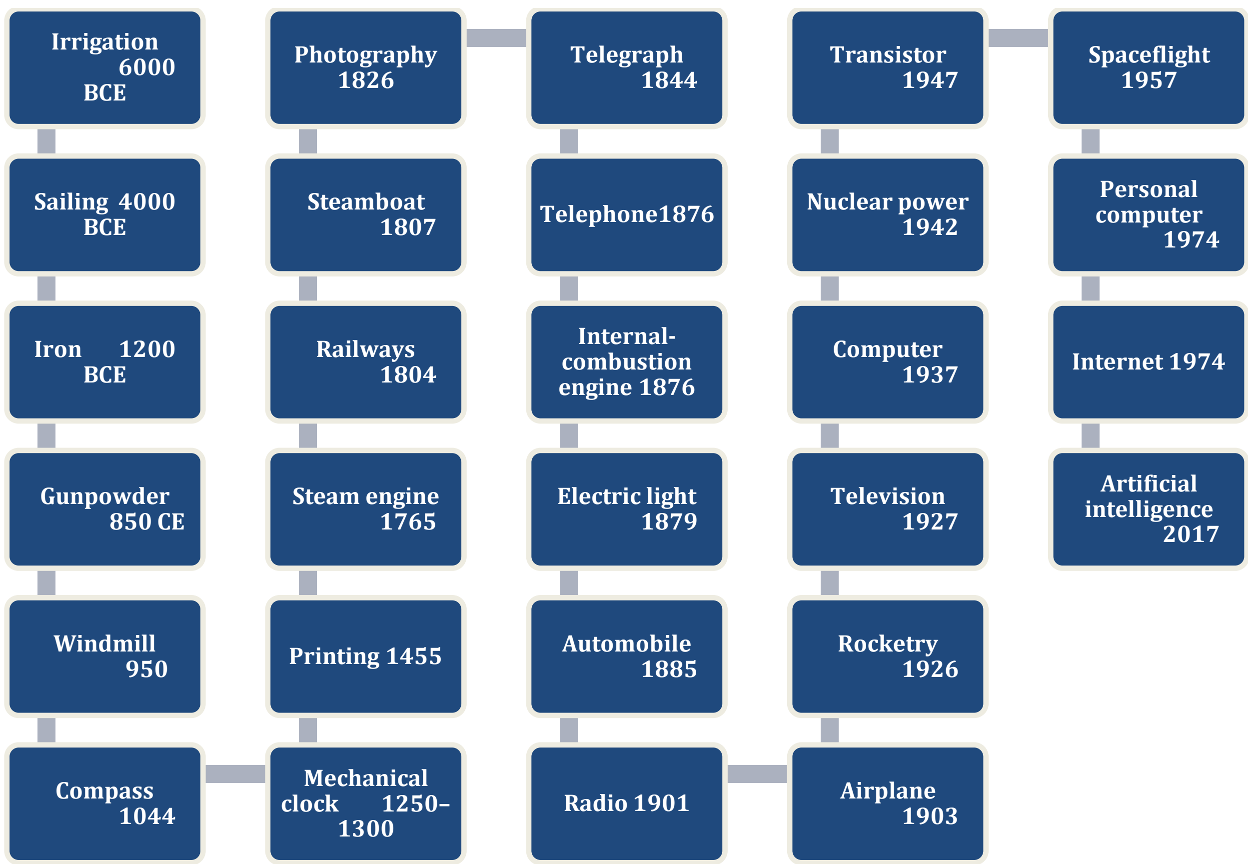
The following decades leading into the twentieth century saw complex innovations done around the globe, based on the accumulated knowledge and faster knowledge sharing. The use of electricity spread around as cheaper sources of electricity were discovered. Independent parallel invention of the electric bulb by Swan in England and Edison in America (Pacey, 1991, p. 168) brought more light to the world. A closer discourse between the scientific institutions in the western world worked on linking the theoretical and practical aspects of the technological developments (Pacey, 1991, pp. 168-169). In the later part of the twentieth century, the knowledge of nuclear energy was transferred from the West to the East (Pacey, 1991, p. 181). This technology, with its potential for energy generation as well as mass destruction, received a lot of political interest and the technological dialogue was motivated highly by politics. The increased speed of communication expedited the commercialization of technologies, leading to increased commercial motivation for technology transfer (Pacey, 1991, p.182). Be it electronics or chemicals, the twentieth century saw an increasing international technological dialogue. It is noteworthy that several of these technological advancements were based on the work done in the preceding years and decades.

Twentieth century was not only marked by complex technical developments but also by an increasing global knowledge exchange in survival technologies like increased food production, improved sanitation, reduced infant mortality rate, to name a few (Pacey, 1991). These were not always linked to the development of heavy machinery but with the role they played in uplifting the lives of the public, their significance remains worthy of mention here. Following the year 1945, when the world started rebuilding, a technological exchange was underway that focused on improving the general living conditions of the masses, including better access to health and a slow but steady improvement in the living conditions. The western technology played a pivotal role in technical developments in fields like electricity and aeronautics, but the developments in agriculture and public health incorporated a stronger dialogue between the East and the West. By the year 1980, with the increasing food production, China and India were nearly self-sufficient, despite the high population size (Pacey, 1991, p. 189). Around the 1940s, India was more open to a dialogue with the West than China and was fast in adopting technologies. One interesting example is seen in the fight of India and China against malaria disease, that is caused by a mosquito bite. India was fast in transferring technology from the West, that was mainly an insecticide DDT used in the agricultural practices. This technology was transferred without deeper consideration for the local conditions and fought only the symptoms without addressing the real problem, that was sanitation and hygiene. As a result, the number of malaria cases in India first decreased and then again increased. China, on the other hand, took a different path. Instead of simply relocating the technology from the West, they studied the root-causes of the disease and aimed to fight them with improved sanitation and living hygiene, also leading to the rapid commercialization of the biogas systems for the treatment of waste (Pacey, 1991, pp. 197-195).

A significant international dialogue in the twentieth century was the one linked to the Green Revolution – aimed at increasing food production using different varieties of grains, modified irrigation practices and increased use of insecticides. The transfer of high yielding crops from America to regions like Mexico and India, helped increase the food production in the next decades. It would, however, be incorrect to consider this as a unidirectional dialogue from the West to the East. The technologies from the West, especially considering the selection of the most suitable crop variant, had to be studied and tested in the local conditions, like geographic terrain, local pests, rain and irrigation, farm size, manpower and machine availability (Pacey, 1991, p. 193). This aspect of the Green Revolution entails lessons even for today's times. Not all technologies are universally transferable and adaptation of the technologies to the local conditions requires a dialogue between the experts from both, the transferring, and the receiving side (Chatterton & Chatterton, 1982; Parnas, 1998). Failures in technology transfer, especially when forcing the technologies in different conditions and geographical regions without understanding the local perimeters, were abundant during the agricultural dialogue between Europe and Africa. Around the late nineteenth century, the introduction of European breeds of cattle spread the deadly rinderpest disease to Africa (Dobson, Holdo, & Holt, 2011; Vogel, SW & Heyne, Heloise, 1996). The transfer of technologies from Europe to Africa, related to the use of tractors for increasing the food production in Africa around the later part of the twentieth century failed to bring the desired results as they disregarded the local terrain, weather and manpower skills and availability (Pessis, 2016) . Around the later part of the twentieth century, the concept of appropriateness of the transferred technologies to the local surroundings gained interest (Schumacher, 1985), that focused on creating intermediate technologies, the balance between the state-of-the-art technologies and the local conditions (Leonard, 2018; McRobie, 1979; Schumacher, 1985). Another noteworthy technological dialogue around this time was that between Africa and India - creating sheet metal gas stoves to come out of the firewood shortage that was a result of deforestation. In retrospect, although simple in nature, this transfer and assimilation of technology proved to be a survival tool for the African families and also created a new line of employment (Pacey, 1991, pp. 201-202).

The technological dialogue in the twenty first century shall be discussed in the following section, together with the relevance of the technology transfer in the current times. Looking back in history it can be said that over decades and centuries did technologies develop and spread around the world. Figure 1 shows the timeline of the developments of selected technologies in human history. Care needs to be exercised in studying this graphic, as it shows when the technologies were developed, meaning the concerned technologies were still probably in their nascent stage, limited to certain geographical locations, finding their place in the labs or small-scale production and had not yet reached the global population and neither had yet been commercialized to their full potential.

Figure 1 Timeline associated with the development of selected technologies in the history of human civilization



Source: Created by author, based on Gregersen, E. (2021). History of Technology Timeline. Encyclopedia Britannica.

Looking back at the technological dialogue in the history of human civilization, several lessons learnt remain relevant even for the current times. Table 1 shows the key takeaways from the discussion on the history of technological dialogue, that shall, to different extent, resonate in the later sections of this study.

Table 1 Key takeaways from the discussion on the history of international technological dialogue

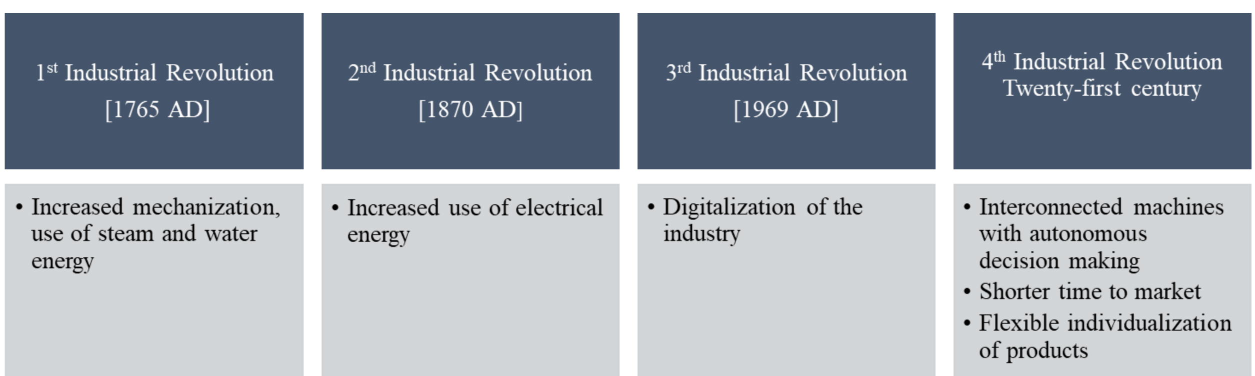
Concept	Example from the history
Link between knowledge and technology	Definition of technology as the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment (Britannica, 2021a)
Bilateral dialogue	Glassmaking dialogue between Syria and Venice, Railroad dialogue between Europe to India
Independent inventions	Windmill invention in Iran and Europe, invention of lightbulb in England and America
Role of governments and policies	International transfer of technologies related to telegraph, railroad, silver mining, etc. to meet the political needs of the colonial powers
Role of technical education & institutes	Importance put by Japan to promote the local development and sharing of knowledge by strengthening the universities and scientific institutions
Importance of intermediate technologies	Lessons learnt from the failures when transferring agricultural technologies from Europe to Africa without clear understanding of local situation
Role of foreign skilled workers	Setting up of textile dyeing unit in England with the help of Turkish experts
Role of communication speed	The rapid expansion of steamboats, telegraph, and railroad
Geographical relocation versus cultural adaptation of technology	Lessons learnt when building bridges with the American expertise in Russia

Source: Created by author

1.1.2 *International technology transfer in today's context*

Moving into the twenty-first century, a strong base of basic knowledge and infrastructure had already been built. This set the pace for a dynamic international technology exchange across the world. With the spread of technologies like the internet, mobile telecommunication, high volume data storage, developments in health, and education, the socio-economic fabric of the world has seen a transformation at a much higher speed compared to the previous decades (Yamin, 2019). Energy had been a critical political motivator in the earlier times, be it using coal, water, and wind. Increasing energy demands coupled with environmental concerns motivated a dynamic international technological dialogue in development and transfer of renewable energy sources like solar, wind and water (Haselip, Nygaard, Hansen, & Ackom, 2011; Wilkins, 2010). The need and expectations of the global market saw a shift. Faster and cheaper became the key driver of the manufacturing industry that started its way on the fourth industrial revolution, named Industry 4.0 (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014). Figure 2 shows the evolution of the industrial movements. These developments strengthened the technological dialogue across borders.

Figure 2 The four industrial revolutions



Created by author, based on (Lasi et al., 2014)

Access to internet and online tools saw a steep increase in the first two decades of the twenty-first century. At the onset of the new century, where only 7% of the world population had access to the internet, in 2020 more that 50% of the global population had access to the internet (Hillyer, 2020). This in turn led to the development of digital versions of traditional twentieth century industries, like online retailing, online video streaming, online banking, social networking, digital travel, and tourism support, to name a few (Karr, 2015).

At the onset of the twenty-first century, Peter Drucker (1998) highlighted that the coming age would be one of knowledge-based economies and knowledge-based companies - those that are able to identify, create, assimilate, and disseminate knowledge at a pace faster than ever before. This necessitated a transformation in the organizations, across geographies and industries. Knowledge based economies necessitated knowledge focused organizations (Drucker, 1998; Drucker, 1999). With the changing industrial landscape, the skill set required by the people, be it corporate employees, students, teachers, technical workers, or managers, has evolved drastically (Rotherham & Willingham, 2010). Instead of thinking in terms of regional segments, the skills had to be adapted to a global economy. Increased focus on public-private as well as industry-academia partnerships, diversity of cultural and linguistic, focus on experiments and practical learning and digital tools, marked the learning and teaching endeavors across schools and organizations and also gained acceptance at the policy level (AACTE, 2010).

The technologies that continue to gain pace in the twenty-first century differ from the earlier times. Table 2 shows the technologies that shape and transform the twenty-first century. Not only are there new technologies as compared to the earlier times, but there are also challenges that this century faces. Global inequality of food and water as well as education and infrastructure, food security for the growing population, global supply chain and their dependency on geopolitics, climate protection, ecosystem protection, promotion of low carbon energies, reduction and management of waste, management of natural disasters, are some of challenges faced by this generation (Royal Geographic Society, 2021). With the increased focus on innovation, policy makers, academic and research institutes, corporate organizations attempt to bring the technologies of the new age to meet the challenges of the human population. Innovation in turn requires right knowledge at the right place and time, and this role is played by technology transfer (Audretsch & Link, 2018; Tamer Cavusgil, Calantone, & Zhao, 2003). Knowledge exchange may be hindered by several barriers - cultural, political, financial, to name a few (Carlile, 2004; Tell et al., 2017). It is by understanding, addressing, and minimizing these knowledge barriers that the full potential of knowledge can be used for innovation (Abraham, Aier, & Winter, 2015; Carlile, 2002; Sheng et al., 2013; Wilhelm & Dolfsma, 2018).

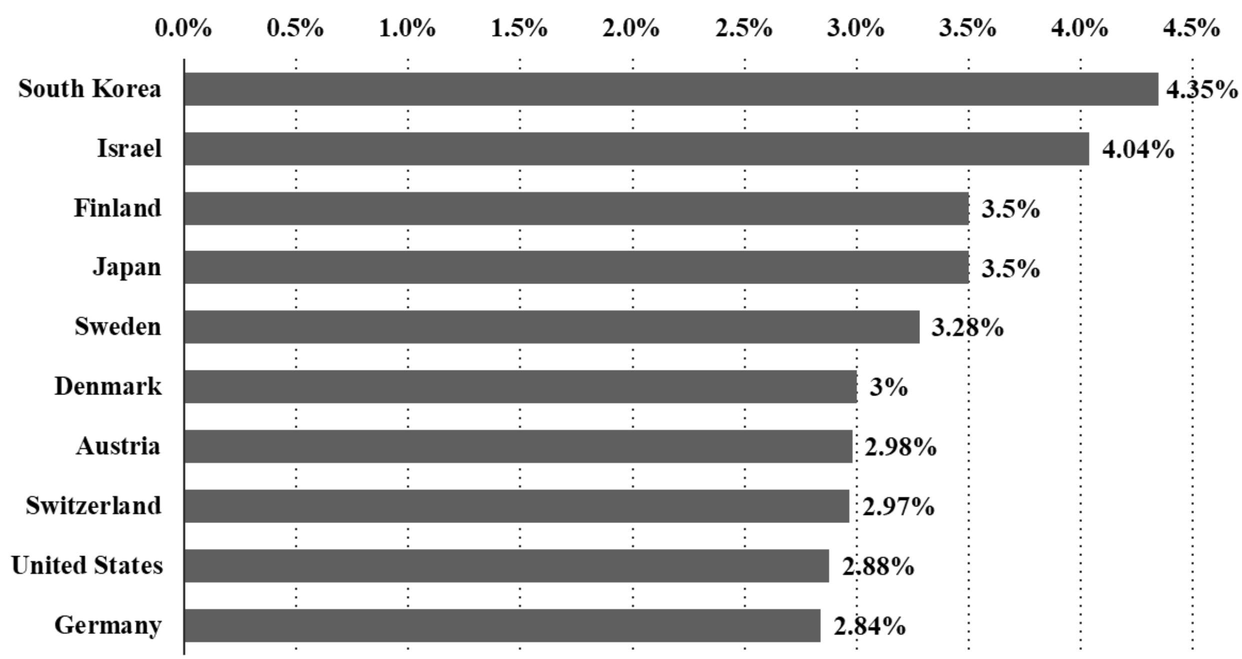
Table 2 Key technologies of the twenty-first century

Technology	Number of scientific publications from year 1996-2018	Number of patents filed from year 1996-2018	Key users
Artificial Intelligence (AI)	403596	116600	Retail, banking, discrete manufacturing
Internet of Things	66467	22180	Consumer, insurance, health-care providers
Big Data	73957	6850	Banking, discrete manufacturing, professional services
Blockchain	4821	2975	Finance, manufacturing, retail
5G	6828	4161	Energy utilities, manufacturing, public safety
3D printing	17039	13215	Discrete manufacturing, healthcare, education
Robotics	254409	59535	Discrete manufacturing, process manufacturing, resource industry
Drones	10979	10897	Utilities, construction, discrete manufacturing
Gene editing	12947	2899	Pharma-biotech, academics and research, agriculture
Nanotechnology	152359	4293	Medicine, manufacturing, energy
Solar photovoltaic	10768	20074	Residential, Commercial, Utilities

Source: Created by author

In the twenty-first century, innovation emerged as the key factor, determining the performance and growth of industries, companies, and countries (Foster Mc-Gregor, 2012). Parameters like investments in research and development (R&D), Foreign Direct Investment (FDI), patents, etc. gained popularity in measuring the trends in innovation at the industry and country level (Dubickis & Gaile-Sarkane, 2015). Figure 3 shows the leading countries with investment in R&D as a share of Gross Domestic Product (GDP). The literature shows that a systematic flow of knowledge and technology is necessary to enable innovation. Knowledge stickiness, or the phenomena where knowledge fails to diffuse across boundaries, from the point of application to the point of application, has been identified as a key factor that discourages innovation despite investment of resources (Jensen & Szulanski, 2004).

Figure 3 Leading countries by R&D spending as a share of GDP in 2021

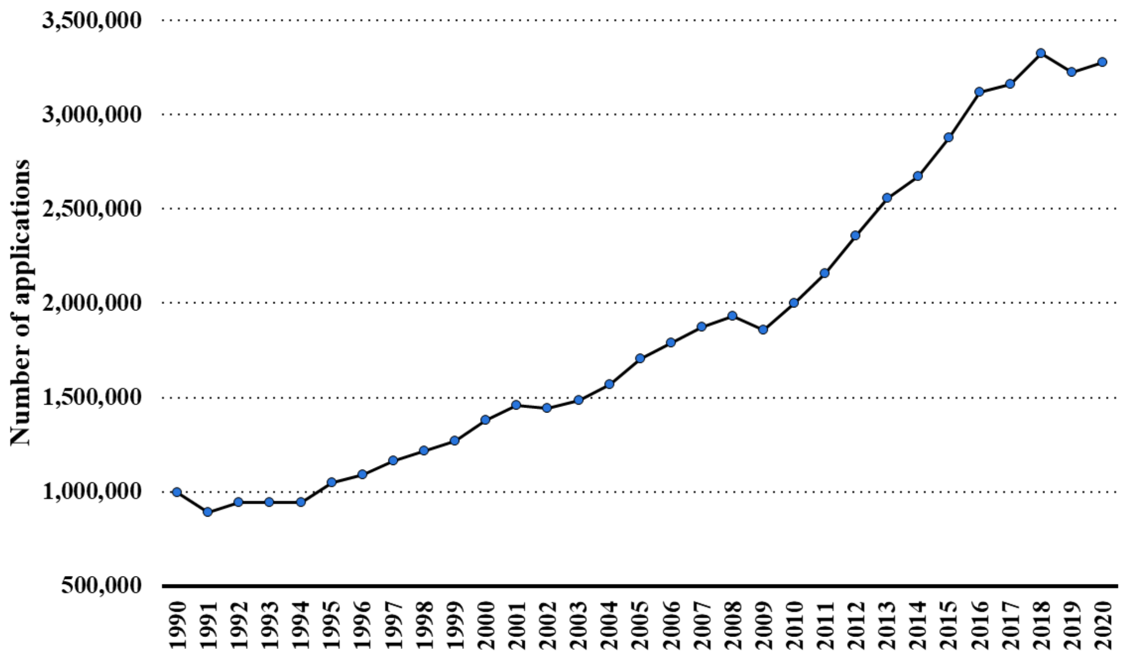


Source: Statista (2021a)

International technology transfer across several disciplines like health, industry, information technology, irrigation, to name a few, has been liked to economic growth and an improved degree of human wellbeing. This link between technology transfer and economic growth is discussed and highlighted in the scientific literature (Jamison & Jansen, 2001). An international dialogue initiated and motivated by international trade, including multinational organizations and FDI, facilitates diffusion of technology, that boosts further socio-economic development (Hoekman & Javorcik, 2006; Krattiger, 2004). The contemporary literature often focuses on technology transfer and FDI from West to East (Bright, 1979; Meissner, 1988) and highlights the significance of the knowledge and technology exchange for growth in developing countries, be it in terms of manufacturing (Ashrafuzzaman, 2020; Rimmer, 2020), robotics (Yun, Jeong, Lee, & Kim, 2018), biotechnology and medicines (Padmanabhan, Amin, Sampat, Cook-Deegan, & Chandrasekharan, 2010), sanitation (Chunga et al., 2016) or renewable energy (Fu & Zhang, 2011) etc. (UNCTAD, 2013), to name a few.

Linking technology transfer and innovation is the concept of Intellectual Property (IP). The World Intellectual Property Organization (WIPO) defines IP as the *creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce* (WIPO, 2021). The inventors can protect their IP with the help of tools like copyrights, patents, and licensing. IP protection is aimed at encouraging the innovators in their pursuit for new technologies, knowledge and in finding solutions to industrial, scientific, and human problems (WIPO, 2021). Well defined and enforced IP policies at national and international level have been associated to international technology transfer also at the policy level and have therefore often been studied hand-in-hand (Hall & Helmers, 2010; Gallochat, 2003; Owen-Smith & Powell, 2001). This link between intellectual property and international technology transfer also elaborates the reason why Table 2 uses the number of patents as one of the measurement criteria for the twenty-first century technologies. With the increasing speed of knowledge creation and technology transfer, the number of patent applications has seen a continuous increase over the last three decades, as shown in figure 4.

Figure 4 Number of patent applications worldwide from 1999 to 2020



Source: Statista (2021b)

As several organizations, research institutes, and companies around the world create new technologies and knowledge, technology transfer across borders gains importance, not only within an industry, but between diverse industries and fields of research. Moreover, with respect to technological developments, the world in the twenty-first century is highly interconnected (Kowalski, Rabaioli, & Vallejo, 2017). This necessitates a dynamic multilateral technological dialogue to bring the technologies from one field to the other. Here, the concept of technology brokerage is of increasing importance (Bergenholtz, 2011; Dodgson et al., 2013). Brokerage of technology or knowledge is used to indicate the process of using the existing technical knowledge from one field or industry to innovate in another field (Hsu & Lim, 2014). An early example of technology brokerage is found in the invention of the electric light bulb by Edison (Dodgson et al., 2013). By building upon the existing technologies in the fields of telegraph, electricity, and generators, a new invention of electric bulb could be made that had a lasting impact on the world (Dodgson et al., 2013; Hargadon & Sutton, 1997). Another example that has been studied in the literature is that of technology brokerage in the skiing and tennis sport by Howard Head (Laudone, Liguori, Muldoon, & Bendickson, 2015). These two examples highlight the versatility of technology brokerage with respect to the industries and technologies. Literature on technology brokerage underlines its significance in the current times. From groundbreaking innovations of the future, to addressing the ever-present challenges of food security, health, and sanitation, learning from diverse fields, and finding innovative products and practices to suit the local situations and challenge, technology brokerage acts as a driver for innovation across borders (Kilelu, Klerkx, Leeuwis, & Hall, 2011; Konsti-Laakso, 2018; Laudone, Liguori, Muldoon, & Bendickson, 2015).

On one side, there is an evolution of complex and interconnected technologies and on the other side, there are the challenges of human civilizations that have persisted over the centuries like food security, health, and sanitation. The imbalance and inequality of technology across borders is a cause of concern with international policymakers and academia (Grusky & Hill, 2018). The extent of technological inequality received international attention as the world was in the middle of COVID-19 pandemic. COVID-19 is a respiratory disease caused by the SARS-Cov-2 virus that was detected in late 2019. On January 30, 2021, the World Health Organization declared COVID-19 to be a public health emergency of international concern (WHO, 2020a). Following the fast spread of the disease and the severe health impacts on the global human population, it was declared to be pandemic on March 11, 2020. With no existing cure proving effective in curbing the spread of the disease, the global policy makers, academic and scientific institutions came together to develop technologies to curb the spread of the pandemic as well to offer a prevention and cure against the disease (Irwin & Nkengasong, 2021; Kelly, Craft, Machulu, & Dhakal, 2021). The international scientific community accelerated the technology transfer and knowledge exchange to avoid duplication of efforts. The first vaccine against COVID-19 was developed and approved for emergency use in the first half of 2021(Forman, Shah, Jeurissen, Jit, & Mossialos, 2021). However, the production and distribution of the vaccines to serve the global populations proved to be challenging tasks. In the first phase of production, the vaccine distribution was marked by a severe inequality, leading to increased human suffering around the world (Tatar, Shoorekchali, Faraji, & Wilson, 2021). It was then realized that technology transfer of the vaccine technology was one of the ways forward. International organizations like WHO urged the global community to come together and transfer the vaccine technology for capacity building and equitable production and distribution of vaccines across the globe. Technology transfer hubs were set up and licenses were released to the concerned patented technologies to bring the vaccine technologies to the remote part of the world (WHO, 2021a; UN, 2021). Based on the discussion in this section, table 3 shows the key characteristics of technology transfer relevant to the twenty-first century.

Table 3 Characteristics of technology transfer in the twenty-first century

Serial Number	Key takeaway
1	Technology & knowledge exchange drive innovation & growth
2	Technology brokerage - need for technology dialogue beyond borders and industries
3	Need of faster technological dialogue to avoid duplication of efforts
4	Technology transfer and innovation can be measured indirectly using parameters like FDI, investment in R&D, patent applications, scientific publications, etc.
5	Times of crisis like COVID-19 necessitate faster technological exchange at academic and policymaking level

Source: Created by author

1.1.3 Channels of technology transfer - university, MNCs, global organizations

Technology transfer is an interplay between the technology that is transferred, the owner or sender of technology, also addressed as the 'transferor' and the receiver of technology, also addressed as the 'transferee' (Diebold & Vetro, 2014; Khabiri, Rast, & Senin, 2012). The existence of a transferor and transfer by itself, however, does not ensure a transfer of technology (Khabiri et al., 2012). Technology transfer is a process that is supported by several agents of technology transfer at macro and micro levels (Cunningham & O'Reilly, 2018). At the macro level, international organizations, consortia, and strategic alliances may promote technology transfer (Gibson & Smilor, 1992). At the national level, technology transfer and innovation are often assisted by the national innovation system (NIS) (Sesay, Yulin, & Wang, 2018). At the international and national levels, technology transfer is also assisted by national and international policies and laws (Fodor, 2011). Another channel of technology transfer is through universities, which are often the point of creation and development of technology (Fitzgerald & Cunningham, 2016). Technology across borders is also transferred by multinational corporations, who often act as a technology pool for the subsidiaries in different locations (Peters, 1979). With different agents directing the flow of technology from diverse senders to receivers, it is of essence to look at how these agents are involved in technological dialogue across borders.

- *MNCs:* Multinational corporations or MNCs, as the name suggests, operate in multiple countries. MNCs often bring with them affiliate knowledge or technologies related to the products and services that help them compete with the local companies who have knowledge of the local market (Wang, J. & Blomström, 1992). MNCs often use the competitive advantage of different nations to boost their growth (Park & Mense-Petermann, 2014). In order to stay competitive, to innovate, or to expand in different geographical regions, MNCs are often involved in transferring knowledge and technologies across their units located across borders (Peters, 1979). MNCs, however, do not act alone. National policies in different countries aim at attracting the MNCs to their countries, to set up manufacturing or service providing subsidiaries and bring a mix of economic growth and technology to the host countries (Glass & Saggi, 2002). Scientific literature on technology transfer has studied the role that multinationals play in international technology transfer, with qualitative and quantitative methods used to understand and explain the phenomenon of technological dialogue (Glass & Saggi, 2002; Jensen & Szulanski, 2004; Noorderhaven & Harzing, 2009; Xu, 2000).

- *Universities and Scientific Institutions:* Another key contributor of international technological dialogue are the universities and scientific institutions. Academic institutes act as creators of knowledge (Vinig & Lips, 2015), and problem solvers by addressing the technological issues and addressing them together with the industry (Petruzzelli, 2011; Sanchez Preciado, Claes, & Rundquist, 2014; Secundo, De Beer, & Passiante, 2016). In their quest for knowledge and link to the society, the universities and academic institutions act as carriers of knowledge and technology and this they do in a variety of ways, for example, through scientific publications, movement of scholars across industry or other universities, university-industry partnerships, to name a few (Heinzl, Kor, Orange, & Kaufmann, 2013).

- *NIS:* National Innovation Systems or NIS is a national overarching system that works towards generation, transfer and assimilation of technology and knowledge with the goal of innovation and national productivity growth (Godin, 2009; Sesay et al., 2018). Freeman (1987) defined national innovation system as 'the *network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies'.* The national innovation systems link the policymakers with academic institutions and industry, to produce, transfer and absorb the technologies relevant to the economic and social development of a nation (OECD, 1997).

- *International Organizations and strategic alliances:* Development and transfer of technology at a cross-country level, necessitates international agents for promoting the technological dialogue. Such organizations or strategic alliances work on identifying the technologies of international importance and help bring such technologies to the international agenda, creating an international forum for the scientific, industrial, and political community (Gibson & Smilor, 1992). One example of such a strategic alliance is Gavi, the global vaccine alliance (Gavi, 2022a). Gavi is a public-partnership alliance working towards equitable and sustainable use of vaccines globally. International organizations like WHO also bring together cross-border scientific and industrial organizations to guide international technology transfer by defining a set of framework and guidelines in order to ensure high quality of technology transfer (WHO, 2021b). The importance of such international organizations and alliances is visible in times of crisis, when during the years 2019 to 2022, marked the COVID-19 pandemic, both, Gavi and WHO, worked on equitable distribution of vaccines by facilitating public-private partnerships, supporting the setting up of technology transfer hubs, and diffusing the vaccine technologies across the globe (WHO, 2021a; Gavi, 2022b).

National and international organizations interact in a variety of ways leading to the transfer of knowledge and technology. Hagedoorn (1990) classified different modes of co-operative agreements between firms, namely, joint-ventures, joint research and development, cross-licensing, direct investing, customer-supplier contracts including collaborative research and co-production. FDI, promoted by MNCs, public-private partnerships or national innovation systems is also considered to be a measure of technology transfer and national productivity growth (Goldberg, 2008; Kumar, Nagesh, 2003; Li & Qiu, 2014). Universities and scientific institutions promote technology transfer by creating scientific knowledge, creating best practices, exchange and promoting a technological dialogue between academia and industry (Heinzl et al., 2013). The role of skilled workers, both in academia and industry, has also been studied in a technology transfer literature (Glass & Saggi, 2002).

Be it MNCs, or scientific institutions, the movement of skilled workers across borders contributes to an international technological dialogue (Edler, Fier, & Grimpe, 2011; Šušteršič & Kejžar, 2020) between industry and academia, or even within different subsidies of an MNC. Supporting institutions like Technology Transfer Offices (TTOs), Technology Licensing Offices (TLOs), and providers of services related to management of intellectual property often support the industry and academia in the diffusion and commercialization of technology (Fitzgerald & Cunningham, 2016; Macho-Stadler, Pérez-Castrillo, & Veugelers, 2007; Senoo, Fukushima, Yoneyama, & Watanabe, 2009; York & Ahn, 2012). The interaction between industry and the scientific community, together with the movement of skilled workers and supported by management of intellectual property also promotes technology spin-offs, where technologies from one scientific field are transferred to other fields, leading to diffusion as well as commercialization of technologies (Stankiewicz, 1994). Wide reaching examples of such technology spin-offs are visible in the technology transfers from advanced research organizations like National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). Advanced technologies developed in such organizations were extended to agriculture, health, robotics, environment, textiles, and telecom to name a few (Hertzfeld, 2002; Szalai, Detsis, & Peeters, 2012).

International technology transfer is therefore a multifaceted process that involves several stakeholders to create, transfer and absorb technologies. Be it public or private institutions on one side or the university and academia on the other, the technology transfer endeavors continue to guide the technologies from the point of creation to the point of application, supported by several national and international agents.

1.1.4 Barriers to international technology transfer

The multifaceted nature of international technology transfer, as seen in the previous section, poses several challenges in the national as well as international environment. There are several factors that hinder the transfer of technologies across borders. Researchers have tried to cluster these in several categories, depending on whether the view is taken from an international, national or organization level perspective. At the national and international level, political barriers created by limitations of national and international laws, trade policies, tax regulations, level of financial and political stability, and level of corruption are some of the barriers that may hinder the cross-border technological dialogue (Shujing, 2012).

Multinational corporations, when transferring technologies, are also faced with challenges within their organizations, like skills and experience of the transferors and transferees, license, and intellectual property management (Beekhuyzen, Hellens, & Siedle, 2005), added by language and cultural dimensions (Beekhuyzen et al., 2005).

The barriers to international technology also depend on the technology being transferred. If the technology is relatively new for the host country, the barriers faced by international technology transfer are higher than if the technologies are already known in the host countries (Shujing, 2012).

When transferring technology between countries, the geographical and cultural distance may also pose challenges (Javidan, Stahl, Brodbeck, & Wilderom, 2005). Geographical and cultural distance are marked by several different aspects within themselves that have received attention in the scientific community in the last decades (Bijlsma-Frankema, 2001; Durach, Glasen, & Straube, 2017). As the geographical and cultural distance are relevant to this study on cross-border technology transfer, these are discussed in more detail in the following section.

1.1.5 Impact of distance on technology transfer

When technology is transferred across institutes, companies, industries or countries, several barriers need to be overcome. As highlighted in the previous section, geographical and cultural distance are two barriers that may restrict the technology transfer dynamics. With reference to the current study, these two types of barriers are relevant and therefore discussed in more detail in the next subsections.

- Geographical distance

The impact of geographical distance on the speed and effectiveness of technology transfer has received attention amongst the researchers in contemporary literature. As knowledge and technology in the twenty-first century become increasingly complex and interlinked across geographical borders, a careful understanding, management, and navigation of technology transfers across geographical borders becomes relevant (Jöns, Meusburger, & Heffernan, 2017). It was with the motivation of overcoming the large geographical and physical distances in the exchange of knowledge and goods that motivated the colonial powers of the nineteenth century to push for developments and expansion of telegraph and railroad technologies (Pacey, 1991). Increased geographical distance has been studied to be a decelerator in technology transfer (Hagerstrand, 1968) by making travel of experts difficult, communication slower (Coccia, 2010) or even by reducing the FDI in the countries' economies (Ly, Esperança, & Davcik, 2018).

In the last two decades, however, there is another trend visible in the scientific literature commenting on the low impact of the geographical distance on the knowledge and technology transfer. It has been studied that with the support of the available communication tools and with the understanding of the technology transfer in an international domain, geographical distance does not necessarily have a negative impact on the knowledge and technology exchange (Gupta & Govindarajan, 2000; Vlajcic, Marzi, Caputo, & Dabic, 2019). This will be analyzed in more detail in the later sections of this study.

- Cultural distance

The retarding effect of cultural distance on the exchange of knowledge and technology has been studied by several researchers in the last decades. Cultural differences could be linked to the countries (Durach, Glasen, & Straube, 2017) or organizations (Schein, 1990) between which the technology is transferred. From national political and legal setup to language, cultural distance is linked to differences in value and style of communication (Drucker, 1998; Welch & Welch, 2008). Studies concerning the impact of cultural distance within different units of MNCs show that international organizations are often affected by the various elements of cultural distances when exchanging knowledge, even within the same MNC (Beekhuyzen et al., 2005; Bijlsma-Frankema, 2001).

Hofstede (1984; 2011) studied the cultural distances between countries and identified five cultural dimensions that may be used to identify and measure cultural distances between countries. Table 4 shows these five cultural dimensions.

Another international study to understand the cultural, organizational and leadership practices across countries was initiated in the year 1999 by the Global Leadership and Organizational Behavior

Effectiveness (GLOBE) project (GLOBE, 2020). Increasing globalization leads to increased cultural interaction and therefore requires better understanding of cultural distances between organizations as well as nations (House, Robert J. et al., 1999). In project GLOBE, culture was highlighted as not only a characteristic of nations but also of organizations as well as of leaders (House, Robert, Javidan, Hanges, & Dorfman, 2002; Kabasakal, Dastmalchian, Karacay, & Bayraktar, 2012). Table 5 shows the cultural dimensions as per the GLOBE project.

Table 4 Hofstede's Cultural Dimensions

Hofstede's Cultural Dimensions	Brief description
Power Distance	The extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally.
Individualism versus Collectivism	Individualism on the one side versus its opposite, collectivism, that is the degree to which individuals are integrated into groups. On the individualist side are societies in which the ties between individuals are loose: everyone is expected to look after him/herself and his/her immediate family. On the collectivist side, are societies in which people from birth onwards are integrated into strong, cohesive in-groups, often extended families.
Masculinity	Masculinity versus its opposite, femininity, refers to the distribution of roles between the genders
Uncertainty Avoidance	Deals with a society's tolerance for uncertainty and ambiguity
Long Term Orientation	It can be said to deal with virtue regardless of truth. Values associated with Long Term Orientation are thrift and perseverance; values associated with Short Term Orientation are respect for tradition, fulfilling social obligations, and protecting one's 'face'.

Source: Hofstede (2009). Adapted by author.

Table 5 Cultural Dimensions based on the GLOBE project

GLOBE Cultural Dimension	Description
Uncertainty Avoidance	The extent to which members of an organization or society strive to avoid uncertainty by reliance on social norms, rituals, and bureaucratic practices to alleviate the unpredictability of future events
Power Distance	The degree to which members of an organization or society expect and agree that power should be unequally shared
Collectivism I	Societal Collectivism. It reflects the degree to which organizational and societal institutional practices encourage and reward collective distribution of resources and collective action
Collectivism II	In-Group Collectivism. It reflects the degree to which individuals express pride, loyalty, and cohesiveness in their organizations or families
Gender Egalitarianism	The extent to which an organization or a society minimizes gender role difference and gender discrimination
Assertiveness	The degree to which individuals in organizations or societies are assertive, confrontational, and aggressive in social relationships
Future Orientation	The degree to which individuals in organizations or societies engage in future-oriented behaviors such as planning, investing in the future, and delaying gratification
Performance Orientation	The extent to which an organization or a society encourages and rewards group members for performance improvement and excellence.
Humane Orientation	The degree to which individuals in organizations or societies encourage and reward individuals for being fair, altruistic, friendly, generous, caring, and kind to others

Source: House, Javidan, Hanges, & Dorfman (2002). Adapted by author.

Hoftsede's and GLOBE cultural dimensions have found resonance in further studies where organizations learn to adapt and prepare themselves for the cultural differences when interacting with their internal and external counterparts across the globe. Researchers, who experimented with different data-sets advise caution when using the different cultural scores as several external factors affect the technological and cultural dialogue between organizations and nations (Tung & Verbeke, 2010; Venaik & Brewer, 2010). Indeed, a lot of work has been done in order to gain a better understanding of cultural distance in the last decades. However, researchers still advise to carry on further study, collect more industry, organization and national level data as there seems to be no consensus still within the scientific community as to a one-size-fits-all universal cultural model (Tung & Verbeke, 2010; Venaik & Brewer, 2008; Venaik & Brewer, 2010).

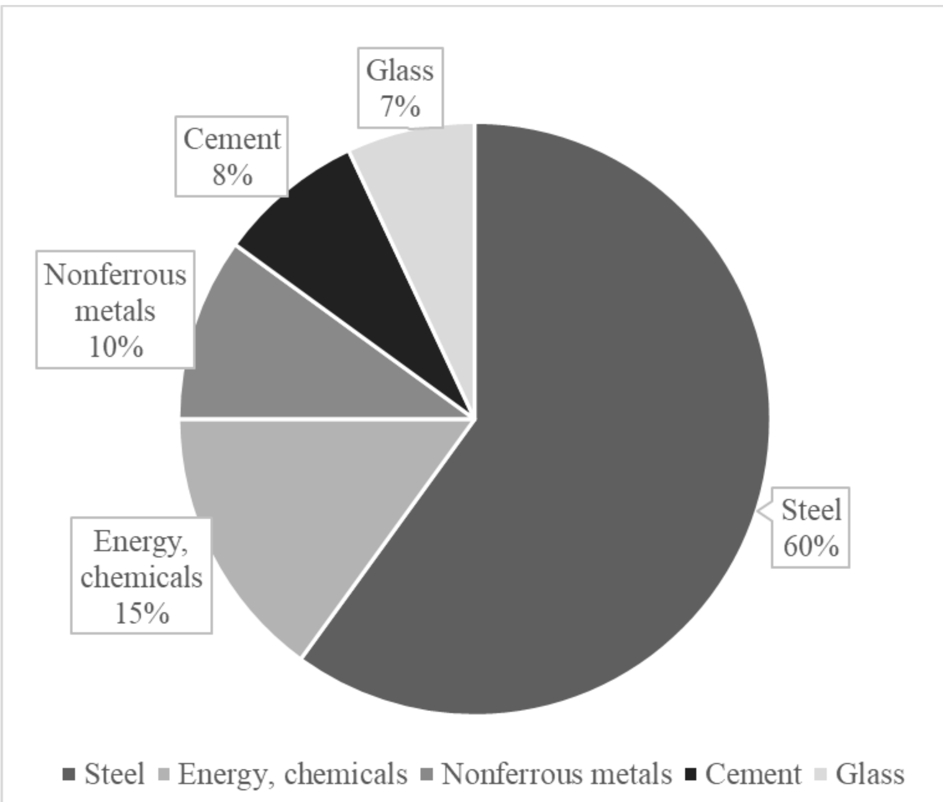
1.2 Refractories

Refractories are industrial products having high melting point and are able to maintain their structural properties at high temperature (Mason, 2016). Because of their ability to withstand high temperature, refractories form an integral part of high temperature industrial processes like manufacturing of steel, cement, glass, aluminium, etc.(Caniglia & Barna, 1992; Yurkov, 2015). The use of refractories can be traced back to ancient times in human civilization, indicating early use by the Phoenicians and the Chinese (Didier, 1997, p6). Refractories, that were once bricks of ceramic clays, have undergone significant research and product developments over the last decades, and now constitute an independent field of research (Rigaud & Zhou, 2002). Refractories are used to line industrial furnaces and vessels used in producing or transporting molten materials at temperatures from 400°C to even over 1500°C. What makes refractories relevant to the global economy is the irrefutable link to or rather dependency of the high temperature industries, like steel, aluminium and glass, on the refractory products (Semler, 2014), thereby making refractories a corner stone of economic as well as infrastructural growth. The next subsections highlight the relevance of the refractory industry with regard to the current study.

1.2.1 *International refractory industry - link between the steel & refractory industry*

The global market for refractory products is estimated to be around €20 billion worldwide, with more than half of the demand coming from the steel industry (RHIM, 2021a). Figure 5 shows the global refractory market with respect to the major industries and table 6 shows the average refractory consumption by end industry.

Figure 5 Main end markets for refractory products as share of total refractory production worldwide



Source: RHIM (2021a). Adapted by author to meet publishing requirements

The production and consumption of steel has been linked to progress, development, and economic growth of human civilization from ancient to modern times (Headrick, 1988; Pacey, 1991). Be it railroad, construction elements like bridges and skyscrapers, automobiles, or machinery, steel forms a fundamental building block for several developments (World Steel, 2021a). Researchers have studied the link between the evolution of steel industry and economic growth across different geographies like China (Yu, Li, Qiao, & Shi, 2015), India (Ghosh, 2006), Mexico (Cole, 2014), Korea (Huh, 2011), and also at a global level (Dobrotă & Căruntu, 2013).

Table 6 Estimated refractory consumption per ton of produced industrial material

Industry	Estimated average refractory consumption per ton of material
Steel	10-15 kg
Aluminium	6 kg
Glass	4 kg
Copper	3 kg
Cement	1 kg

Source: RHIM (2021a). Adapted by author.

With the steel demand set to grow in the next few years, the pull coming from the construction and automotive sector (World Steel, 2021b), the refractory industry continues to be relevant to the world industry and economy even in the next decades.

1.2.2 Technology transfer in the steel and refractory industry

The high interdependency between the steel and refractory industry necessitates a continuous technological dialogue between these two industries. Similar is the case with industries like cement and glass, that are also consumers of refractory products. The global refractory industry is marked by several global and regional players worldwide (RHIM, 2021a). Multinational corporations involved in the production of refractory products and with their organizational network spanning across multiple geographical boundaries, e.g., RHI Magnesita and Vesuvius, are often linked with an international technological dialogue across borders, both, within the organization as well as with the external partners like universities, consumers and suppliers (RHIM, 2021b; Vesuvius, 2021a). The history of the iron industry in human civilization is quite old (Pacey, 1991). As the industries like steel, cement and glass evolved, with higher production and improved quality, so did the refractory industry, in order to keep pace with the market demands (Freestone & Tite, 1986; Nadachowski, 1976; Poirier, 2015). Material development, quality improvement and higher mechanical strength have been few of the key technological focus of the last decades. However, as the world moves towards the technologies of the twenty-first century, so does the refractory industry. Digitalization, AI and robotics are expected to gain increased focus, both within the refractory industry (RHIM, 2021b; Vesuvius, 2021a) as well in the end customers like the steel industry (Palanco & Laserna, 2000). In line with the fourth industrial revolution or industry 4.0, an industrial term was coined to signify the digital age of the twenty-first century refractory industry, namely refractory 4.0 (Steiner, Lammer, Spiel, & Jandl, 2017). Looking at the global industrial landscape, the concept of digitalization of the refractory and steel industry has initiated a global technological dialogue, with the West and the East, sharing their knowledge and attempting to find collaborative ways towards industrial growth (Hallin, Lindell, Jonsson, & Uhlin, 2022; Hao, Bian, Bai, Li, & Sun, 2019; Mallik, Jha, & Shafi, ; Palanco & Laserna, 2000).

Another trend visible in the refractory and steel industry is a move towards increasing use of renewable energy, increased recycling, and reduced carbon footprint (Ariyama, Murai, Ishii, & SATO, 2005; Ariyama & Sato, 2006; Ryan, Miller, Skerlos, & Cooper, 2020; Wang, K., Wang, Lu, & Chen, 2007). In line with the need of the times, there is a clear understanding of the relevance of reduction of the carbon footprint in the steel and refractory industries. However, technological and policy challenges continue to exist that necessitate further international dialogue between experts from industry and policymaking (An, Li, & Middleton, 2018).

1.3 Interim Conclusions from the Literature Review

Identification of missing links in the scientific literature is one of the ways of defining the theoretical concern as well as the research questions that define a study (Auerbach & Silverstein, 2003; Creswell & Poth, 2016). While conducting a literature review, grounded theory methodology involves looking for issues that are open or unclear, be it perspectives to an issue that have not been addressed or assumptions that need to be challenged (Auerbach & Silverstein, 2003, p.15). Taking the lead from the review of scientific literature presented in the preceding sections, in this section the author presents two missing links in the scientific literature that this study addresses and builds upon.

1.3.1 Missing link: Cross-country analysis in the field of technology transfer

There is indeed a lot of scientific literature on the general topic of technology transfer. How technology is transferred, what are the modes and agents of technology transfer, factors that promote or hinder technology transfer, have been highlighted in the literature. There is, however, a lack of scientific literature focusing on cross-country comparison of technology transfer between multiple geographical regions (Cunningham & O'Reilly, 2018). One of the possible reasons that is attributed to the low volume of literature on cross-country technology transfer is not the lack of interest in the scientific community, but rather the challenge in data collection (Cunningham & O'Reilly, 2018). At a macroscopic level, the significance of international technology transfer has been discussed and accepted over the last decades (Hoekman & Javorcik, 2006). However, what this means at the firm level, when individuals and organizations interact across multiple geographical borders and transfer technology, which challenges they face and how these challenges could possibly be addressed, this has been studied only in limited regions and industries (Dechezleprêtre, Glachant, & Ménière, 2009; Decter, Bennett, & Leseure, 2007; Kumar, Vinod, Cray, Kumar, & Madanmohan, 2002).

This study was an attempt to bridge this gap and focused on a cross-country analysis of technology transfer. This research compared the technology transfer within Europe, as well as between Europe, Brazil, China, India, and the United States of America.

1.3.2 Missing link: International technology transfer in the refractory industry

Another missing link that was identified in the scientific literature is the dearth of literature focusing on technology transfer specifically in the refractory industry. The link between refractory and steel industries was established in the previous sections. Technology transfer in the steel industry, focusing on the technological developments across the last decades as well as technological dialogue between countries has been studied and the scientific literature exists (Congress of the United States,1980; Ito & Inuzuka, 2008; Okazaki & Yamaguchi, 2011). This may be related to the fact that steel has often been identified as an important component of national and global economic growth. It is, however, as shown in the previous sections, also established that there is a strong link between the steel and refractory industry. Scientific literature is abundant with examples showing the lack of universal processes and technology transfer methods in the field of technology transfer (Pacey, 1991). Be it research in the field of cross-country analysis or across industries, every now and again, researchers have cautioned against over-generalization of scientific results and highlighted the importance of pursuing an industry specific research in order to be closer to the elements under observations. This study was, therefore, an attempt to bridge this gap and focused on technology transfer specifically in the refractory industry.

2 AIM OF THE RESEARCH

This study focuses on international cross-country technology transfer. The literature study shows that international technology transfer in itself is a topic that has been in existence for centuries. Technology transfer has also been a focus of study from different aspects, namely, international, national and firm-level. Even though the scientific literature abounds in the field of technology transfer, one clear message that emerges from the literature research is the absence of a universal technology transfer that could be applicable to all industries and organizations. Seeing the role that technology transfer plays in national and international economies and organizational growth, and the ever-changing landscape of new technologies that mark the twenty-first century, the study of international technology transfer remains relevant even now. With this view, this study has a primary aim and a partial aim, that this study sets out to fulfill.

2.1 Primary and partial aims of the research

The primary aim of this study is to study the human aspect of international cross-country technology transfer at a firm level. With the research findings, this study is an attempt to add to the firm-level knowledge-base on cross-country technology transfer. Based on the experience of individuals involved directly in the field of international technology transfer, this study identifies the challenges faced and lessons learnt when transferring technologies across different geographical regions. This study aims at enabling multinational organizations to better understand and anticipate the challenges in international technology transfer and define organizational best practices for international cross-country technology transfer assignments.

The partial or secondary aim of this study aims to bridge the missing links that were identified in the scientific literature. One of these missing links was the lack of research on cross-country technology transfer. The second missing link identified in the scientific literature was the focus of technology transfer studies in the refractory industry. Refractory industry is a cornerstone of the steel industry. Even though the steel industry is often linked to infrastructural growth and economic development of nations, the refractory industry has received only limited attention from the scientific community, especially with regard to international interactions and technology transfer. With a cross-country international technology transfer view specific to the refractory industry, this study aims to bridge the identified missing links in the literature.

2.2 Selection of the Case Study

Multinational corporations often act as agents of cross-border technology transfer (Peters, 1979). For this study, a multinational organization named RHI Magnesita with twenty-eight main production sites, five research and development locations, and supplying to customers in over hundred countries globally was selected (RHIM, 2021c). RHI Magnesita is a provider of refractory products and services for industries like steel, cement, chemicals, nonferrous metals, glass, etc. (RHIM, 2021d), and holds a world market share of 15 percent (RHIM, 2021a) in the global refractory industry worldwide. The five research and development locations of RHI Magnesita are situated in five different geographical regions, namely, China, Europe, India, North-America and South-America (2021c). These research locations are in close geographical proximity to at least one of the production sites and industrial customers (2021c). There were therefore two motivations for selecting RHI Magnesita as a target for this study. First, the high market share at the global level in the refractory industry (RHIM, 2021a). Secondly, and importantly, the global production, research, and customer footprint. RHI Magnesita is international not only in terms of its customer reach but also in terms of mining, production, and research activities (RHIM, 2021c). This in turn implies that international technological dialogue and transfer of knowledge and technology at cross-country level is an ongoing practice within this company and employees, across diverse fields, come in contact with knowledge and technology exchange. This was especially relevant in the context of the current study.

2.3 Research Questions

Research begins with curiosity (Auerbach & Silverstein, 2003, p.3). A key aspect of a scientific research is to identify a research issue that resonates throughout the study and guides the different aspects of the research, from selection of a research methodology to data collection and analysis (Agee, 2009; Auerbach & Silverstein, 2003). Following the literature study and the identification of missing links in the scientific literature, three research issues were identified and these were then framed as research questions. With respect to international cross-country technology transfer in the refractory industry, this study aims to address the following research questions:

- What are the basic characteristics of international cross-country technology transfer in the refractory industry? Which technologies are transferred, who transfers them and how?
- What are the challenges faced in the international cross-country technology transfer in the refractory industry?
- What are the lessons learnt for improving the technology transfer in the refractory industry?

3 RESEARCH METHODOLOGY

Methodology may be defined *as a way of thinking about and studying social reality* (Corbin, & Strauss, 2015, p. 3). At the onset of a research project, a researcher is faced with the selection of a research methodology that is suited to the research and the questions or theories that the study aims to address. Qualitative, quantitative, or mixed methods research, this is in fact one of the first questions that needs to be answered (Babbie, 2013). Both qualitative and quantitative data are suitable for social research, but these do require a different set of procedures to be followed during the research (Babbie, 2013). Quantitative research usually involves quantification of data, in finding patterns in numbers (Bernard, 2017). Qualitative research on the other hand, focuses more on the interpretation of collected data without complete quantification (Corbin et al., 2015). Then there is mixed-methods research, that involves an interplay between qualitative and quantitative research (Creswell & Creswell, 2005). All three research methodologies find continuing interest within the scientific community (Creswell, 2014). Some research questions are easy to categorize in the qualitative or quantitative methodology, others however, may need some deeper thinking and even experimentation with different research methodologies to understand the suitability of different research methodologies to the aim of the research (Babbie, 2013; Israel, 2007).

At the onset of this study, an exploratory project was conducted in order to understand the suitability of qualitative and quantitative data collection to the aims of the research (Jain, 2021). Exploratory projects are used by researchers to prepare the ground for the research study and carry out the preparative work (FFG, 2014). Exploratory projects work as a tool for checking the feasibility of research ideas, research methodology, and approach to data analysis. Changes to the research methodology, if required, can therefore be made after the exploratory project and the researcher is saved from the extra effort of making the changes during the course of the main study. Exploratory projects can follow qualitative (Twinn, 1997), quantitative (Phillips, 2002) or mixed methods (Tortorella, Fettermann, Anzanello, & Sawhney, 2017) research methodology and have found acceptance in the scientific community across diverse fields of study, be it social sciences, health and nursing or even organizational studies, psychology, to name a few (Fonseca & Domingues, 2018; Kilelu et al., 2011; Stebbins, 2001).

In the exploratory project preceding this study, data was collected using an online survey on one side and face-to-face or online interviews on the other side. The results were then compared, and the final outcome was that face-to-face interviews were more suited to meet the goal of this study as they allowed for open-ended questions and had the ability to reveal unexpected information (Jain, 20021). Moreover, interviews added a personal dimension to the data collection, allowed time for a cordial warm-up and introduction between the interviewer and the interviewee, and to explain the motive of the interview and the aim of the research to the interviewee. More details are discussed in the next subsections.

3.1 Qualitative Research

This study follows a qualitative research methodology, following a qualitative grounded theory approach. Qualitative research has been increasingly used in studying human feelings, experience, cultural dimensions, etc. (Corbin et al., 2015). Over the last decades, qualitative research has found increasing acceptance in anthropological studies (Bernard, 2017). The use and reach of qualitative research has extended to organizational studies (Emerald Group Publishing, 2006), health and nursing (Duffy, 1985), to name a few. Qualitative research involves a contact and interaction between the researcher and the subject (Creswell & Poth, 2016) and data collection tools like field studies, interviews, participant observation enable the researcher to get an insight into the individual, group or phenomenon being studied (Auerbach & Silverstein, 2003). Qualitative research is useful when instead of working with a predetermined set of information and data, a group or events may need to be explored and studied in their natural settings (Creswell & Poth, 2016). Qualitative research, as used in this study, follows an interpretive framework, in an attempt to gather a detailed understanding of the research subject through observation and interviews.

Figure 6 shows the possible scenarios when qualitative research may be used. Creswell and Poth (2016) list eight characteristics of qualitative research that are shown in table 7.

Figure 6 When to use qualitative research

Source: Creswell & Poth (2016, p. 46). Adapted by author.

Table 7 Characteristics of qualitative research

Characteristic of qualitative research	**Description**
Natural setting	Qualitative research involves collecting data in the natural setting of the research subject, either during fieldwork or by observing or talking to research participants. This is for example different from doing laboratory trials in a contrived situation, which are used in other research fields.
Researcher as key instrument	In qualitative research, the researcher acts as a key instrument as the data and the results are filtered through the researcher. From leading the interview questions to interpreting the results of the analysis, the researcher plays a pivotal role
Multiple methods	Qualitative research allows multiple forms of data e.g., interviews, memos & notes, observations, etc.
Complex reasoning through inductive and deductive logic	Qualitative researchers build a bottom-up analysis, from a large volume of raw data towards more abstract themes or ideas. This inductive process involves a constant interaction between the data and the result until a clear interpretation emerges. The deductive part involves constantly checking the identified abstract themes and ideas against the data.
Participants' multiple perspectives and meanings	Qualitative research aims at bringing to light the perspectives of the research subject, not what the researcher's predetermined ideas are.
Context-dependent	The research is set in the context of participants or on sites. The analysis and the results of the research are therefore linked to this context. This differentiates qualitative research from other fields of research.

Emergent design	Qualitative research sets out to explore the subject in their context and has an emergent nature - as there are often natural individuals or phenomena involved, not all parts of the process can be prescribed beforehand. Qualitative nature emerges during the process continuously, based on the ongoing status of research, for example, interview questions may be added or deleted, or new participants may be added to the study.
Reflexivity	This is linked to the fact that the researcher is the key instrument in a qualitative study. The interpretation of data during the analysis is reflected through the researcher and involves a constant back and forth between the researcher and the data
Holistic account	Qualitative researchers are not bound to the cause-and-effect relationship like for example in quantitative research and therefore try to develop a complex holistic picture of the phenomenon under study.

Source: Creswell & Poth (2016, pp.43-44). Adapted by author.

Several approaches may be linked to qualitative research, however, Creswell and Poth (2016) cluster these varied approaches into five groups:

- *Narrative research*: its main focus is to collect stories from individuals, aiming to get deeper insight into their experiences (Creswell & Poth, 2016, pp. 67-74). Narrative research may use multiple data collection tools like interviews, photographs, documents, etc. One of the characteristics of narrative research is its temporality - the researcher often shapes the experiences and observations of the research participants in a chronological order. Narrative research often highlights a turning point in the life or experiences of the research participant. This is, in turn, useful in structuring the narrative from a starting point to the turning point and further leading to the consequences of the turning point.
- *Phenomenology:* A phenomenological study aims to understand and explain a concept or phenomena (Creswell & Poth, 2016, pp. 75-82). Phenomenology focuses on defining a collective and common meaning for the experiences of several individuals who faced the same phenomena . Phenomenology, therefore, differentiates itself from narrative research that

focuses on individual experiences of one or more individuals. Phenomenology is marked by its philosophical component, linking the subjective experiences of individuals and the objective overlaps with the experiences of other individuals. Data is often collected using interviews, however, other data sources like documents, observations etc. are also used.

- *Grounded theory:* The grounded theory approach moves beyond the description of experiences of a single or group of individuals as in narrative research or phenomenology (Creswell & Poth, 2016, pp. 82-90). The grounded theory approach aims at generating a unified theoretical interpretation and explanation for an event or process. In grounded theory, as the name suggests, the theory or explanation is not predetermined by the researcher or by the literature. It is, on the contrary, grounded in the data that is collected and analyzed during the study . A defining characteristic of the grounded theory approach is the constant interaction between the data collection and analysis (Glaser, 1965). These two steps overlap considerably, and the researcher goes back and forth between the data and the emerging theory. The collected data is then analyzed in the form of codes, concepts and categories, with each step of analysis clustering the information in a more abstract form, directing the raw data towards a theoretical explanation of the subject under study (Creswell & Poth, 2016, pp. 82-90). More details on the grounded theory approach with regard to the current study, including the reason for selecting this research methodology to the process of sampling, data collection and analysis are discussed in more detail in the following subsections.

- *Ethnography*: The focus of ethnographic studies is on studying the shared patterns among a group of individuals who share patterns of cultural aspects like behavior, beliefs or language (Creswell & Poth, 2016, pp. 90-96). In grounded theory for example, the target groups may typically consist of about twenty individuals, who may or may not share the same cultural aspects (Creswell & Poth, 2016, p. 90). Ethnographic studies, on the other hand, usually consist of much larger groups, exceptions are however also possible where smaller cultural groups are observed and studied (Creswell & Poth, 2016, p. 90).

- *Case study:* Case studies focus on studying one or more cases within a real-life setting (Yin, 2009). Case studies have often been defined in two different ways. Some researchers highlight that case studies are research methodologies of their own, studying one or more bounded systems in their real-life settings (Yin, 2009). The others highlight that case studies are rather a choice of what is studied and not a research methodology of its own (Stake, 1995). Either way, case studies start with the definition of a case that is bounded with a set of parameters and boundaries, e.g., location or time frame of study and are marked by an in-depth analysis of the selected case (Creswell & Poth, 2016, p. 98).

3.2 Grounded Theory Methodology

The development of grounded theory as a research methodology can be first traced back to Barney Glaser and Anselm Strauss (Glaser, Strauss, & Strutzel, 1968), as they set out to develop a systematic procedure for collecting and analyzing qualitative data and to encourage creative research (Goulding, 2002, p. 40). Grounded theory as developed by Glaser and Strauss (Glaser & Strauss, 2017) aimed at creating a 'theory' or a theoretical description that is grounded in systematically collected data followed by a systematic analysis (Goulding, 2002, p. 41). The later years found the grounded theory splitting into two camps, the 'Glaserian' approach (Glaser, 1965) and the 'Strauss & Corbin' approach (Corbin et al., 2015) . The two approaches to the grounded theory methodology bear several similarities, primarily those that are the essence of qualitative research, that is, enabling understanding and explanation of behavior, events, and processes, promoting theoretical advance in sociology, and following a systematic analysis of collected data (Goulding, 2002, p. 43). However, the two approaches to the grounded theory methodology are marked by few fundamental differences. The 'Glaserian' approach recommends an inductive approach to create a theoretical description of the issue at hand. As per this approach, the purpose of the developed theoretical description is only to explain the phenomenon at hand. Additionally, Glaser (Glaser & Strauss, 2017) stresses on the inductive, interpretive, and emergent nature of the theoretical description at hand, enabling the collected data to tell their own story (Goulding, 2002, p. 47). The 'Strauss & Corbin' approach, on the other hand, puts a higher emphasis on the mechanics of the research, leading to multiple levels of coding and interconnecting data and explanations at various levels (Goulding, 2002, p.47). The 'Strauss & Corbin' approach received criticism for over-analyzing and manipulating the data and leading away from theoretical sensitivity and insightful interpretation of data (Glaser, 1992). Over the decades, since their development, both approaches to the grounded theory methodology have found acceptance in the scientific community for studying diverse fields of interest, like, sociology, nursing, organizational practices, human behavior, cultural dimensions, to name a few (Goulding, 2002; Sbaraini, Carter, Evans, & Blinkhorn, 2011; Stray, Sjøberg, & Dybå, 2016; Wan, Liang, & Wan, 2013).

Grounded theory has often been used by researchers to investigate a subject when the area of interest has received less or only superficial attention in the literature and scientific community (Goulding, 2002, p. 55). This was also the motivation for selecting the grounded theory methodology for the current study. As the previous sections on literature review showed, the author is of the opinion that there is a dearth of literature on technology transfer in the refractory industry, especially when focusing on cross-country technology transfer. Furthermore, grounded theory, in addition to being explorative and inductive in nature, allows for a wider choice of data collection tools like interviews, observations, memos, survey, and integrating these in the analysis leading towards a theoretical explanation of the subject under study (Glaser et al., 1968).

Auerbach and Silverstein (2003, pp. 20-21), highlight the following five steps in the grounded theory research:

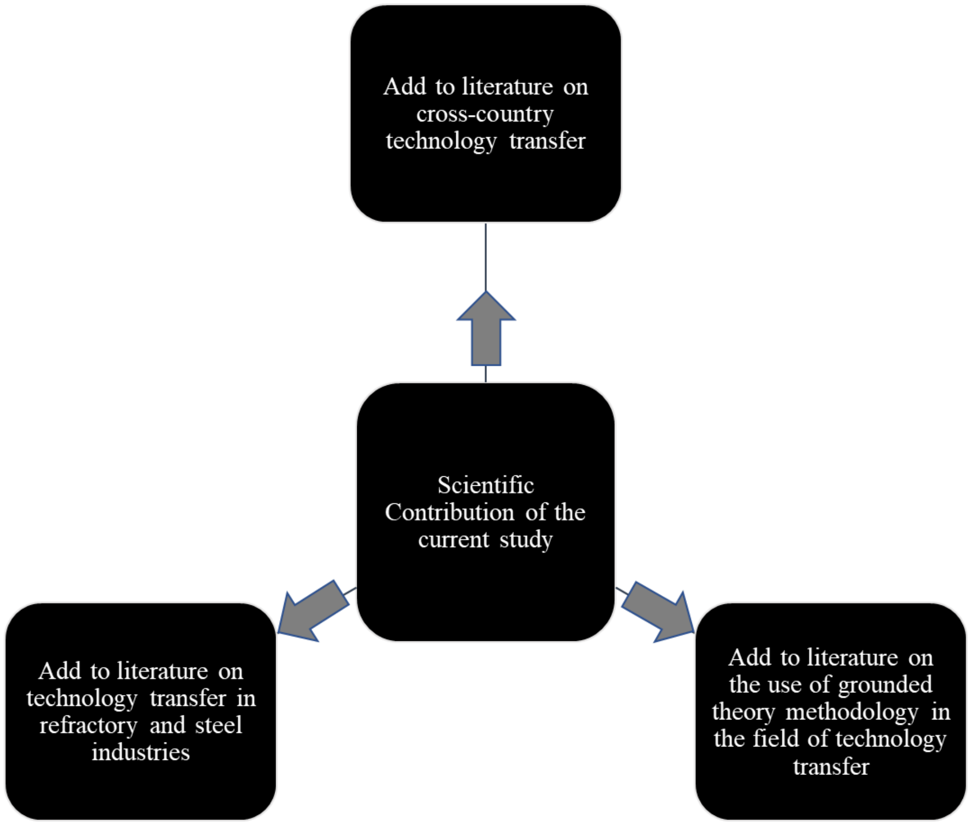
- Conducting a literature review and identification of the research concern. Here the focus is on the open areas in research that have not been explored in detail in the scientific literature.
- Defining the research concern that then becomes the subject of the study. The research concern in the grounded theory is often focused on investigating the experiences of a group of individuals.
- Creating narrative interviews with the aim of collecting the experiences of the individuals under study.
- Choosing an initial research sample based on the selected research concern. A small set of individuals may initially be selected to gain initial insights and this group can be expanded later as need for more data is identified.
- Deciding on the sample size. This is necessary in order to gather enough data until a theoretical explanation for the events, experiences or phenomenon under study can be created.

The use of grounded theory methodology in studying diverse aspects of technology transfer process across multinational organizations and universities is evident in the literature. Wan et. al (2013) studied the risk factory in the commercialization of Information and Communication Technologies (ICT) using the ‘Strauss & Corbin’ approach to the grounded theory. Markman et. al (2005), following the ‘Strauss & Corbin’ approach studied the link between the University Technology Transfer Offices (UTTO) and entrepreneurship, focusing on business incubators and technology parks. Bürger and Fiates (2021) (Bürger & Fiates, 2021) used the ‘Strauss and Corbin’ approach to study the interaction between Brazilian universities and industries. Maital et. al (2008) also worked on developing a theory on business incubation, focusing on India and Israel. McArthur (1998) worked on developing a grounded theory for technology transfer within multinational corporations. By investigating thirteen technology transfers within MNCs, McArthur (1998) highlighted the adaptations the transferring unit needs to undergo in order to make the international technology transfers successful. Crossman and Noma (2013) used the ‘Glaserian’ approach to grounded theory methodology to study the impact of authenticity and trust in intercultural communication within Japanese subsidiaries in Japan and Australia. Götz (2013) used the ‘Glaserian’ approach to study foreign direct investment, one of the indicators of international technological dialogue, in Poland. Iyer and Banaerjee (2018) used the grounded theory methodology for investigating the facilitators and inhibitors in the process of technology transfer with an industrial landscape, focusing on the thermal power generation industry in India.

The acceptance of grounded theory methodology, both, ‘Glaserian’ and ‘Strauss and Corbin’ approach in studying technology transfer within the scientific community also supported the decision to follow a grounded theory methodology in the current study. This study follows a ‘Glaserian’ grounded theory methodology. It builds on the interpretive nature of the ‘Glaserian’ grounded research methodology, allowing the data to tell the story and developing a theoretical description without undue mechanized analysis. The literature on the use of grounded theory methodology in the refractory and steel industry is scarce, and the current study extends the use of grounded theory to these industries.

Based on the missing links that were identified in the literature review in the previous sections focusing on cross-country technology transfer and literature on refractory and steel industries, together with the discussion on the literature on grounded theory, the scientific contribution of this study can be summarized as shown in figure 7.

Figure 7 Scientific contribution of the current study

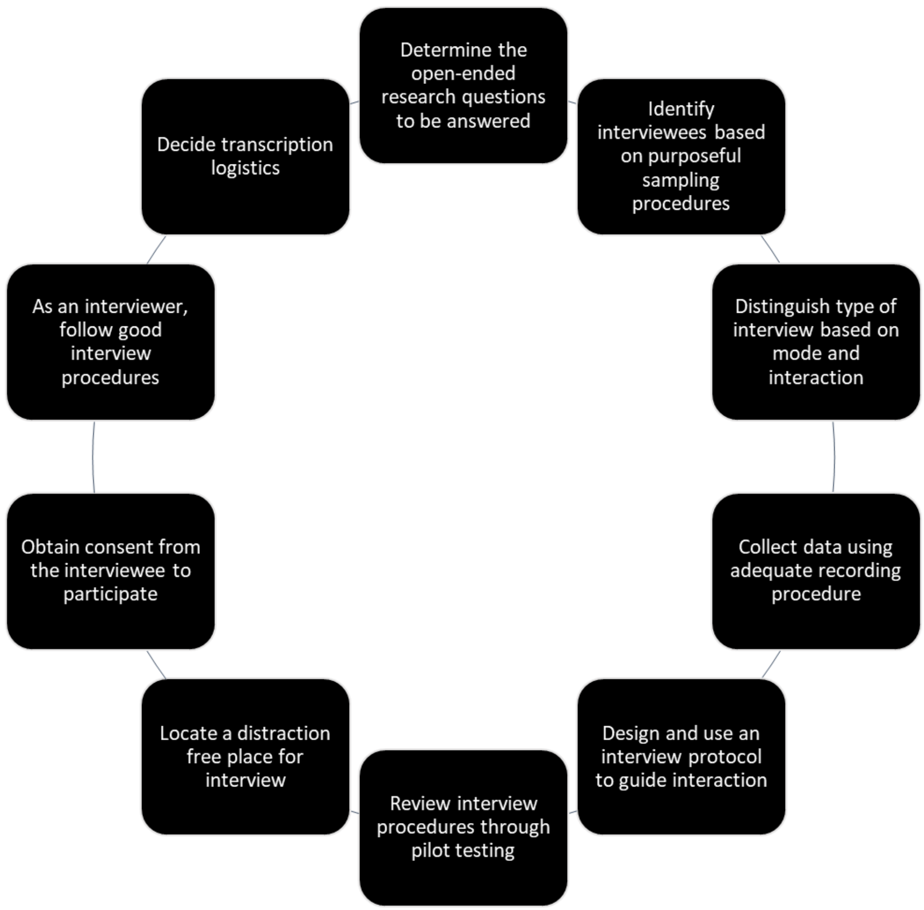


Source: Created by author

3.3 Data Collection using Interviews

An interview may be defined as a thematic conversation or social interaction between the interviewer and the interviewee (Edwards & Holland, 2013; Rubin & Rubin, 2011). Through an interview, an interviewer aims to get the insights from the interviewee's point of view (Kvale & Brinkmann, 2009). Interviews have gained increasing acceptance as a data-collection tool in qualitative research (Auerbach & Silverstein, 2003; May, 1991; Taylor, Bogdan, & DeVault, 2016). Qualitative interviews can be structured or semi-structured, where the structured interviews tend to move more in the direction of a survey or quantitative research (Creswell & Poth, 2016). Grounded theory research methodology usually involves semi-structured, open-ended conversational interviews that aim to understand the interviewee's experiences in depth (Goulding, 2002, p. 59). Figure 8 shows a set of procedures for conducting qualitative interviews.

Figure 8 Procedures for preparing and conducting interviews



Source: Creswell & Poth (2016, p. 166)

Before deciding on interviews as a data collection tool for this study, an explorative project was conducted, comparing the use of surveys with structured questions versus semi-structured interviews Jain (2021). Conducting an online survey had its benefits like the possibility to reach out a larger target group, ease of reaching out targets in different geographical time-zones without the time or costs of travel, and sometimes even faster analysis time (Jain, 2021). However, when exploring a topic where a new idea needs to be explored, interviews offer the possibility of collecting in-depth information by following a semi-structured process, building on leading questions for requesting more information and also helps build a rapport between the interviewer and the interviewees, that may be useful if follow-up interviews, or clarification of some details is needed at a later stage (Jain, 2021). Collection and analysis of data using interviews is, however, often a time-consuming process and this needs to be planned in the research schedule (Goulding, 2002). The interviews can be conducted face-to-face or remotely via telephone (Babbie, 2013) or online using digital conferencing tools like Skype (2021), Microsoft Teams (2021) or Zoom (2021), to name a few (Johnson, Scheitle, & Ecklund, 2019).

This study followed a semi-structured interview approach. Individuals with first-hand professional experience in the field of knowledge and technology transfer in the refractory industry across different geographical locations were interviewed.

In this study, a mix of face-to-face and online semi-structured interviews was used to collect data. Online interviews were used when interviewers and interviewees were in different locations or time zones. Table 8 shows the questionnaire used during the interviews.

Table 8 Questionnaire used in semi-structured interviews in this study

Serial Number	Question	Open or close-ended question
1	Were you directly involved in technology transfer?	Close-ended
2	Between which geographical regions did you work on transferring the technology?	Open-ended
3	Which technologies were transferred?	Open-ended
4	How was the technology transferred?	Open-ended
5	What were the challenges in transferring technology across different geographical regions?	Open-ended
6	What could you suggest for improving the technology transfer across different geographical regions?	Open-ended

Source: Created by author

3.4 Sampling

Unlike quantitative research that uses random sampling, qualitative grounded theory methodology follows a theoretical sampling procedure (Auerbach & Silverstein, 2003, pp. 91-98). Theoretical sampling involves selecting research participants who have information related to the research concern under study (Auerbach & Silverstein, p. 18). Selection of such research participants may be done in a variety of ways, depending especially on the goal of the research (Auerbach & Silverstein, p. 96) as shown in table 9.

Table 9 Six strategies for theoretical sampling to further develop theoretical constructs

Theoretical sampling strategy	Purpose
Convenience sampling	To obtain information about the theoretical construct in a convenient fashion
Extreme or unusual case sampling	To obtain information about extreme or unusual examples of the theoretical construct
Central or critical case sampling	To obtain information about situations where the theoretical construct is assumed to be present
Typical or paradigm case sampling	To obtain information about the theoretical construct in everyday life
Similar case sampling	To obtain information about how the theoretical construct appears in a range of situations similar to the original study
Sentitive or political case sampling	To obtain information about how the theoretical construct operations in situations in the public eye

Source: Auerbach & Silverstein (2003, p. 96)

In this study, convenience sampling followed by snowball sampling was used. In the first part, namely, convenience sampling, a small initial target group was identified for the research. The second part was the snowball sampling, where based on the inputs and experiences of the convenience target group, further research participants were identified, contacted, and interviewed. The convenience sampling led to 10 interviews. Convenience sampling was used to identify further research participants using snowball sampling. Following the snowball sampling, a total of forty-six interviews could be collected, focusing on technology transfer in the refractory industry across diverse geographical regions. Table 10 shows the distribution of the conducted interviews for studying cross-country technology transfer across different geographical regions. The data could be collected for technology transfer to six different countries. The research participants who were interviewed for data collection were all directly involved in technology transfer in the refractory industry. The experience of research participants who were interviewed in this study ranged from two to twenty years in the field of refractory technology transfer to the selected geographical region.

Table 10 Details of interviews conducted for data collection

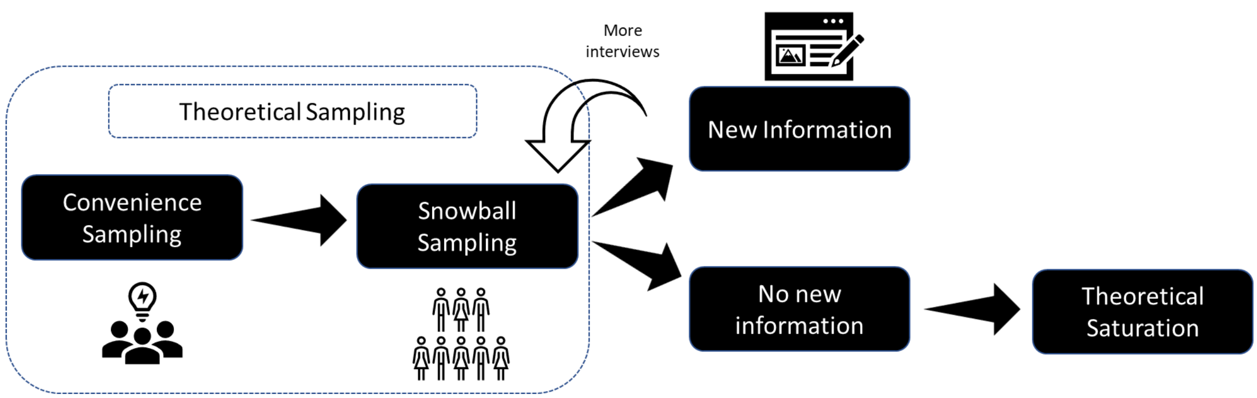
Country to which technology was transferred	Number of interviews	Experience of research participants in technology transfer to the selected country
India	12	5-20 years
Germany	5	5-20 years
China	8	2-12 years
Ireland	5	2-4 years
Norway	5	1-4 years
USA	5	2-7 years
Brazil	6	4-6 years

Source: Created by author

3.5 Theoretical Saturation

The grounded theory methodology aims at elaborating the selected research issue, by collecting and analyzing data that helps create a theoretical explanation for the research issue under study (Glaser & Strauss, 2017). Theoretical sampling in the grounded theory research, therefore, involves studying new samples until a point of saturation is reached, meaning, no new information is revealed by studying new samples (Auerbach & Silverstein, 2003). This is called theoretical saturation, which is, therefore, guided by the developing theoretical explanation of the phenomenon under study. Figure 9 shows the process of theoretical sampling, consisting of convenience and snowball sampling, leading the way to theoretical saturation. In the course of this study, theoretical saturation regarding the lessons learnt and challenges faced in the technology transfer was achieved by about 6 detailed open-ended interviews per geographical region. In the case of technology transfer to India, 12 interviews were conducted as this was the first region that was studied. Here the twelve interviews were already scheduled, and the author went ahead with the planned interviews. Even though these extra interviews in the initial phase of study did not generate significant new information with regards to the research questions, they served two purposes. Firstly, the extra interviews in the preliminary phase of the research offered deeper insights into the process of technology transfer beyond the challenges and limitations. This supported the overall research by creating a better understanding of the refractory industry from the technology transfer perspective. Secondly, the extra interviews enabled the author to test and confirm the concept of theoretical saturation as shown in figure 9. This was useful in the latter phase of the research when identifying interviewees and collecting data for the other geographical regions.

Figure 9 Theoretical saturation using convenience and snowball sampling



Source: Created by author

4 RESULTS OF THE RESEARCH

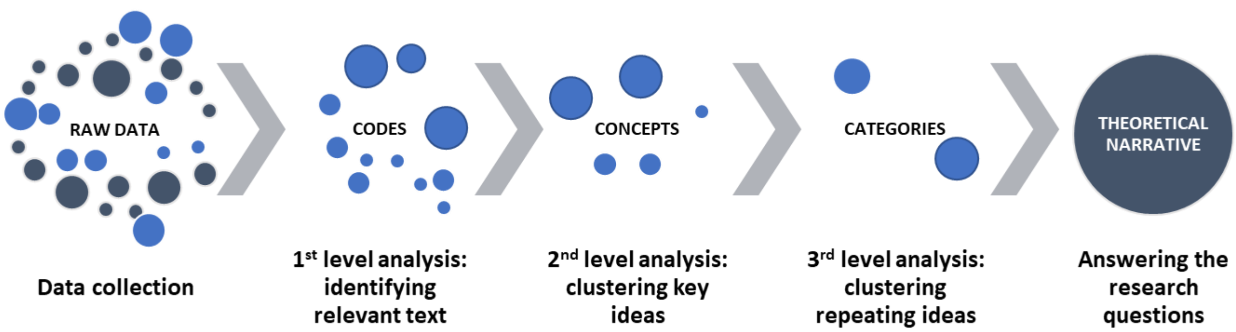
In grounded theory methodology, the steps of data-collection and analysis are not completely separated, but rather overlapping (Goulding, 2002). The grounded theory methodology involves a constant interaction between the researcher and the data, a process called constant comparison. Grounded theory methodology uses a coding process for data analysis, moving from a large volume of collected data, clustering them based on relevancy and similarity to more abstract description of the phenomenon under study (Auerbach & Silverstein, 2003).

The research is guided by the data. During data collection and analysis, if needed, sample size can be increased to collect further data (Goulding, 2002). In the first level of analysis, from the raw text collected by the interviews, the relevant text is identified and selected. These are called first level codes. In the second step of the analysis, these relevant texts are clustered into repeating ideas or second level concepts. In the next step of analysis, the repeating ideas are clustered into third level categories. Once the text has undergone a three-level coding process, the collected codes, concepts and categories are then used to create a theoretical narrative that offers an explanation to the phenomenon under study (Auerbach & Silverstein, 2003). The analysis process is shown in figure 10.

Glaser (1992) recommends getting acquainted with the collected data by going over it multiple times. Transcription of interviews is a time-consuming process and Glaser (1992) recommends that word-by-word translation of all the interview transcripts is not always mandatory, as long as the central ideas in the interviews are included in the data analysis. By repeatedly going over the interview, be it audio or video, the researcher can capture the key ideas and use these for the analysis. Data collection is not only limited to interviews, as the Glaserian grounded theory methodology allows for collection of a broad field of data, like photographs, observational memos, documents, etc. For the purpose of this study, the interviews were recorded as audio files. The interviews were recorded as audio files. These were played multiple times in order to understand, as Glaser (2004) puts it, '*What is happening in the data?*' and to better absorb '*What is the main concern being faced by the participant?*' .

An additional data set, namely the data from an exploratory survey that was conducted at the onset of the study (Jain, 2021) was also used.

Figure 10 Analysis of the collected data using Glaserian grounded theory methodology



Source: Created by author

4.1 Theoretical description of technology transfer in the refractory industry

The results of the constant comparative analysis were used to develop the theoretical description of technology transfer for the refractory industry. The theoretical description has been clustered in three sections, each section addressing one of the research questions. The first section addresses the general characteristics of the technology transfer, highlighting the technologies that are transferred and the role that individuals, teams and tools play in ensuring the technology transfer. The second section addresses the second research question, namely, the challenges faced in the technology transfer in the refractory industry. The third section addresses the third and last research question, offering the lessons learnt in improving the cross-country technology transfer in the refractory industry.

4.2 Addressing the first research question - What are the basic characteristics of international cross-country technology transfer in the refractory industry? Which technologies are transferred, who transfers them and how?

This section elaborates the theory generated for addressing the first research question. The name of the theory is *"The theory of multifaceted technology transfer on the border of traditional elements and modern challenges of human society"*. The three subsections below address the three interlinked elements that were identified when addressing the first research question.

4.2.1 Contemporary and state-of-the art technologies - the "What" of technology transfer

The first characteristic of the refractory technology transfer that emerged from the current study focused on what is transferred, namely which technologies are transferred across borders in the refractory industry. Refractory industry is a traditional industry, finding its existence alongside several high temperature industries like steel and cement over the last centuries. On one side, the long history of this industry links it to the traditional aspects of technology. On the other side, faced with the technological developments and scientific, economic, and environmental challenges of the twenty-first century, the state-of-the-art technologies in the refractory industry also claim technology transfer. On the traditional side, knowledge and technologies linked to production equipment, production processes and product composition receive considerable attention. On the modern side, technology transfer in the refractory industry finds resonance in the contemporary challenges of human society, e.g., environmental technologies, reduction of carbon footprint, improving energy efficiency, and increasing digitalization in diverse fields of refractory production and application attract technology transfer. It is this mix of traditional and modern technologies that makes technology transfer in the refractory industry challenging. The study revealed that technology transfer in the refractory industry necessitates technical knowledge of the historical evolution and development in the refractory and associated industries like steel, cement, glass, over the last decades as well as requires keeping uptodate with the latest technologies and legislations.

4.2.2 Right people and right tools is recipe for success - The "How" and "Who" of technology transfer

Technology transfer as studied here focused on the human aspect of the cross-country technology transfer. The interviews conducted with the research participants linked the researcher to the human side of the cross-country technology transfer. The research participants were identified through convenience sampling followed by snowball sampling. The research participants who were interviewed in this study had experience of five to twenty years in the field of technology transfer in the refractory industry, as shown in table 10 earlier. The research participants covered a wide range of technologies that were transferred across different countries. At the time when this study was conducted, the research participants were based in different countries, across Europe, India, and China. All research participants had physically traveled to the countries to which they worked on transferring the technologies multiple times.

The study highlighted the key role that individuals and teams play in technology transfer. As one of the research participants said, "*it is not a simple flow in one direction, it is a collaborative effort. For one side to be able to share technology and knowledge, the person and the team on the other side should be willing to accept this knowledge and act on it.".* Another research participant added to it, saying *" You need people who understand that it takes conscious effort on the part of each individual and the whole organization to make a technology transfer successful. It is a team effort. You need the best people in the technology transfer team".*

Different tools were used for technology transfer, like visits to production, research and customer sites, participation in scientific conferences, knowledge exchange meetings, creating and sharing know-how books, on-site support, and remote support via online and digital tools. Research participants highlighted that a combination of right people and tools is the key to a technology transfer. One without the other is a recipe of failure, if the right persons are not equipped with the right tools or if the best of tools are not supported and used by the right persons, a technology transfer risks failure.

4.2.3 Holistic view on transferred technologies - the complete picture of technology transfer

The study showed that technology and knowledge exchange in the refractory industry is deemed necessary throughout the whole value chain of the products - from raw material acquisition to production of refractories, to application of refractory products in the high-temperature industries like cement and steel. Limiting the technology transfer study to only a specific aspect of the value chain risked missing out on the holistic view of the industry. Therefore, this study aimed to collect experiences of individuals involved in transfer of diverse technologies across the international geographical boundaries. The interviews with the research participants revealed the multifaceted aspect of technology transfer in the refractory industry. Mining and treatment of raw materials, product composition, mixing and forming of products, heat treatment, packaging, application of refractories in different industrial conditions, use of knowledge management tools and enterprise resource planning systems were revealed as the focused streams of cross-border technology and knowledge transfer in the refractory industry within the scope of the current study. This diversity of technologies that are transferred in the refractory industry could be revealed due to the snowball sampling used in this study. The research participant with several years of industrial experience in technology transfer had worked with multiple individuals and teams in their time working on cross-border technology transfer and often had contacts to potential research targets in different fields within the refractory industry. This helped not only in increasing the sample size but also in increasing the coverage of this study to different fields of refractory industry.

4.3 Addressing the second research question - What are the challenges faced in the international cross-country technology transfer in the refractory industry?

This section elaborates the theoretical description generated for addressing the second research question. The name of this theory is *"Challenges – mismatch between organizational culture, geographical regional cultures and expectations from international technology transfer".* This theory is made up of nine components, each of which is highlighted in the subsections below.

4.3.1 Throwing people in at the deep end of the pool

This phrase generally means throwing someone at the deep end of the pool who then has to learn to swim rather suddenly, without being completely prepared for it. This in-vivo code was used to reflect how several persons involved in cross-border technology transfer were pulled in without being prepared for the technology transfer.

Cross-border technology transfers involve people from across different geographical locations coming together and sharing their knowledge and technology base with each other. This involves cultural, organizational as well as personal adjustments. In several cases the research participants stated that the teams involved in cross-border technology transfer were not fully prepared for the challenges ahead. Also, when preparing the technology transfer, it is often thought that only the transferor needs to be prepared. This approach fails to consider technology transfer as a bilateral process, it is not just a give and take process, rather a give, adapt, take, process. It essentially requires that both, the transferor, and the transferee are prepared for working together, sharing technology, adapting it to the local conditions and making the technology transfer successful.

An example that was given in this context was from the European research participants who worked as skilled expatriates in China. They sometimes received less or no intercultural training on how to deal with people and organizations in China. If such training did take place, these were rather theoretical with less practical relevance. The real challenge, however, was that the teams in the transferee countries like China and India, received no training on how to work on technology transfer with a European team. This resulted in the fact that the team from Europe landed half-prepared in these countries, where the local team had low or no experience and training to work with them. This not only slowed the technology transfer, but also led to several cultural clashes which could nevertheless be overcome with mutual teamwork and cooperation. This approach, however, highlights the misleading presumption of certain organizations and teams that technology transfer is a unidirectional process. A research participant highlighted it well by saying "*It is not technology transfer from Europe to India, rather technology transfer between India and Europe. I don't understand why we [the refractory industry] think we can just push a certain technology on someone. The economies are growing, steel production in India and China is growing. It is a two-way street, you know. They have probably the highest number of persons working in the refractory industry globally. We can all [in the global refractory industry] learn from them, you know*". Another research participant highlighted, "*I have been in this field for over ten years now. I still don't understand why we don't prepare people well for a transfer. It is a very resource intensive process and full of strategic implications for the organization. Language, tools, technologies, we need to prepare the teams on both sides in the first phase of the [technology] transfer. If we don't do it earlier, we pay for it dearly later*".

4.3.2 Knowledge protectionism

This challenge was reported by multiple experts involved in the technology transfer. In the course of technology transfer, some stakeholders, especially the owners of the knowledge that needed to be transferred tend to get protective of the knowledge. Knowledge protectionism hinders technology transfer especially when the boundaries between knowledge as organizational property versus personal asset tends to blur. The knowledge owners then either tend to slow down the transfer process in order to win time and gain trust of the transferees, or in some cases they may completely hinder the technology transfer by refraining from sharing complete information on tools, products, or processes. Such fragmented technology transfer is a burden on organizational resources, leading to wastage of financial resources or even loss of motivation in the technology transfer team. As one of the research participants highlighted, *"the technology and knowledge that is transferred within an organization is not personal property, rather a corporate asset. In technology transfer, the knowledge* *does not belong to you or to me, it belongs to the company [organization]. We cannot let our personal biases and prejudices define a corporate project. But it happens, sadly, again and again".* It could also be assessed that in several cases of knowledge protectionism, the transferees believed that they were actually acting in the interest of the organization, unaware of the impact that such a behavior could cause on the cross-country technology transfer. When this issue was taken up with the transferees, it was highlighted that personal behavior together with fear of misuse of intellectual property once it is shared were the prime causes of knowledge protectionism. A research participant addressed this issue saying, *"if we are afraid of our [organizational] intellectual property being misused, we should make the people within the organization more aware of how intellectual property works. We can't spend resources in intellectual property protection and then hoard the knowledge. Knowledge without being shared and applied practically fails to justify the investments we make in generating it".*

4.3.3 Cultural hierarchy as an organizational barrier

Hierarchy was reported as a challenge when the European teams were working together with Asian and South-American teams on international cross-country technology transfer. Be it China, India or Brazil, the transferors as well as the transferees faced a mismatch with regard to the openness of communication that could be linked to different perceptions of organizational and social hierarchies in different countries.

In countries with a strongly defined social and organizational hierarchy, the people involved in technology transfer were afraid to ask direct questions owing to the fear of being reprimanded or speaking out of line. Even if the topic under discussion was unclear, often no clear questions were asked. As one research participant put it, *"we had regular meetings to discuss the status updates of the technology transfer. However, when meetings were held with different hierarchies present in the room, the technical experts didn't express their views openly and mildly agreed with their organizational superiors. This does not help us at all. I then organized separate meetings with the technical team, without their superiors, so that they can talk openly".* Some transferees, with years of experience in intercultural hierarchy, enforced a rule on the technology transfer teams, to ask questions, just in order to encourage everyone in the team, regardless of social or organizational order, to clarify their doubt as and when they arise. As one interviewee put it, *"every [working] day, the first thirty minutes were for asking questions. No question was too simple, too complicated, or too silly."*. Those who implemented such a practice could find a way around the problem. This, however, could not be enforced everywhere at the onset of the technology transfer processes and therefore this challenge resonated often when discussing international cross-country technology transfer in the refractory industry.

4.3.4 Not valuing the time plan

This challenge was highlighted in technology transfer with South-America but was also hinted at in general for all the countries involved in technology transfer. Different approaches to time management owing to regional cultures and habits were deemed to affect the flow of international technology transfer. The research participants emphasized the importance of adhering to a time plan when working on international technology transfers. As one of the research participants put it, "*respecting time is respecting people. If you don't respect time and the project timeline, you risk the project, waste organizational resources, and throw away the efforts of everyone in your team. Time is money - old but still true".* Looking at the collected data, the author identified a mismatch in the expectations with regards to time management, with some regions facing more critique than others. Interesting enough, it was not a universal West versus East or North versus South phenomenon. The research participants involved in technology transfer across India and China had lesser problems with time management, where the time management reportedly worked well. A mismatch of time-management, with technology transfer timelines being extended to more than twice that of planned, created hurdles more than that of lost time and money. It reportedly caused frustration and discontent in the technology transfer team. Additionally, when the members of the technology transfer team moved to other projects or switched to other roles, the extended timelines caused disinterest, leading the technology transfer to fall in a slumber in some cases.

4.3.5 Unwillingness to share and learn

Technology transfer by its definition necessitates the flow of ideas, knowledge, and technologies from the place of origin to the place of application. This flow is disrupted when the people and teams involved in technology transfer are unwilling to share knowledge or unwilling to learn something new. This was evident on the transferor as well as transferee side. Individuals acting as transferors, owing to some negative previous experiences coupled with the fear of misuse of shared knowledge and technology were sometimes unwilling to share in full the technology under transfer. When other team members noticed this unwillingness to share the technology and knowledge, they tried to address this issue by discussing it within their teams. Sometimes it worked and sometimes not. As one of the research participants put it, *"it [knowledge and technology] is not a personal property. It is the organization's property. It is doing us no good sitting here on the shelves. Technology needs to go out, where people can use it to increase business. We need to grow beyond our fear of our own team. We are all one company".*

4.3.6 Technology dumping

The next challenge faced during international cross-country technology transfer in the refractory industry was one that resonates with the literature review. It is when the technology transfer teams focus more on geographical relocation of technology instead of cultural relocation and adaptation of technology. As one research participant put it, *"one would expect that students of history would know better than to repeat the problems well known from the past. But unfortunately, even now we [humans] fail to learn from the past. We [technology transferor] need to assess the situation at the target location. What are their resources? What are their strengths? What are their limitations?".* Adding to this, another research participant mentioned, *"what works in a research lab in the United States or in Europe cannot automatically fit into India, China, Brazil. Or even between European or American countries, the production facilities are often very different from each other. You cannot just go and dump the technology there. Such a transfer is a sign of inexperience, naivety and haste."*

4.3.7 *Doing half work and expecting full return*

The next challenge that was identified in this study was that of the organizational importance put on technology transfers in terms of resource allocation. Research participants reported that technology transfer is a job that requires full concentration of the involved team members. One research participant highlighted this saying, *" cross-country technology transfer is very resource intensive, especially if the goal is to make the transfer a success in planned time. You need good people working with full focus on the [transfer] project. And you need good tools. It is not something that people can dabble at in their additional time".* Stingy manpower planning was reported by research participants as a phenomenon that they encountered often in the initial phase of technology transfers. Once the technology transfer hit a roadblock owing to scarce manpower, more resources were added. This did help in the following phase of the technology transfer but was rarely able to make up for the lost time. This challenge was often reported in terms of manpower but was extended by some research participants to general resource allocation, including equipment, hardware, software and training.

Another aspect that was reported and fits well in this category is the challenge that is faced by the technology transfer teams when the organization or parts thereof avoid seeing the real picture and the harsh reality. As one of the research participants put it, " *sometimes we [the organization] see only what we want to see. We willingly and eagerly see only half of the picture, avoiding the bad or uncomfortable aspects. But these hit harder in the later phase of the technology transfer. Sometimes we are out of budget or outside our planned timeline. Sometimes the contractor is delayed. But we need to learn to accept the reality so that we can act on it fast"*. This delayed the response time, causing the technology transfers to be more cost intensive or in the worst case being scrapped off completely.

4.3.8 *Non-standardized tools and process*

One challenge that the research participants highlighted in all the interviews was the effort needed to transfer technologies across borders using non-standardized tools and equipment. Be it hardware production equipment like presses, mixers or kilns, software and digital tools like enterprise resource planning and knowledge management tools, or general processes like quality control, production planning, data reporting, to name a few. Non-standardized tools require, in addition to the transferor and transferee, individuals and teams on both sides who take time in understanding such tools and exchanging the information. When such resources that could bridge the non-standardized tools and processes were not planned in the beginning, the negative impact was visible later in terms of delayed or unsuccessful technology transfers. As one research participant put it, " *In some cases it is possible to implement standardized tools, in other cases it is out of scope of the technology transfer. But it is important to calculate the risk such non-standardized tools can have on the transfer at the beginning. There is nothing wrong in accepting a problem and asking for help at the right time".* Adding to this, another research participant shared views on the challenges of non-standardized tools saying, *"if we had known that these different systems could have such a big impact on our [technology transfer] project, we would have asked for more resources. No one thought of it. It delayed our [technology transfer] project considerably and in the end, we still had to adopt a completely different solution than planned in the beginning. Best would be if we had standardized tools everywhere [within the organization]. But we can't have it. And we need to accept this. But we also can't ignore it".*

4.3.9 The cultural paradigm

When comparing the ease and challenges of technology transfer across diverse geographical boundaries and comparing the observations with the previously presented Hofstede and GLOBE cultural dimensions, a cultural paradigm was noted in this study. In this study, technology transfer experiences were collected from Austria, Brazil, China, Germany, Ireland, Norway, and the United States of America. While sharing experiences of their individual and collective technology transfer experience across different geographical regions, the research participants from central Europe were unanimous in their opinion that for them technology transfer with China was marked by a significant ease of transfer as compared to other geographical locations. On the other extreme was Norway, which was reported unanimously as the most challenging region for technology transfer among the regions that were studied.

Analyzing this paradox further, the geographical distance between central Europe and China is much larger than that between central Europe and Norway. Also, the cultural components like language, food, and religion, differ between central Europe and China more than that between Norway and central Europe. The study showed that despite the larger geographical distance and different cultural aspects, the willingness to learn, exchange ideas and collaborate towards technology transfer worked exceptionally well in China . As one of the research participants highlighted the experience of technology transfer between Europe and China, *"it was perfect! Everything that we aimed to implement; we could implement together. Very co-operative, collaborative, and supportive. Most importantly there were no biases or prejudices".* Another research participant stated that as compared to India, and South America, working in China was safer, and mentioned, "*Safety is important. If I always have to look over my shoulder and my mind is always full of fear, I think I can't deliver my best. In my years of working in China, I never felt unsafe".* That the technology transfer between Europe and China worked well does not mean there were no challenges. As one research participant put it, "*In China, you have to learn and respect the hierarchy. And one needs to encourage a team culture where everyone asks questions openly without the fear of losing face. And this you need to practice each and every day. And you need to be structured in your approach. If you can do this, you can work harmoniously and exchange ideas and knowledge smoothly".*

On the other hand, the observations regarding technology transfer with Norway revealed the higher degree of challenge that were faced in the technology transfer. The challenges that were reported were specifically linked to the human aspect of working with teams in Norway. The research participants reported lack of sufficient feedback, open exchange of ideas, and willingness to collaborate openly as the major challenges. As one of the research participants put it, "*I was doing training in Norway, and after the training, I couldn't gather whether the team there understood what I said, whether some parts of the training needed to be repeated, explained better or if everything was clear. There were no expressions. It was as if I couldn't read their faces".* Another research participant, who had worked on technology transfer across several geographical regions, added to it saying, *"It was the biggest challenge for me in the beginning. But slowly I learnt that I need to see beyond the limitations. When working there you need to talk, ask for feedback, ask to collaborate. If you don't ask, it will not happen".*

One might say that the differences between China and Norway could be attributed to the East-West paradigm. But the cultural paradigm that was observed in this study goes well beyond these two countries. Interviews with research participants who had been involved in technology transfer across multiple geographical locations revealed that technology transfer even between Austria and

Germany, Austria and South America was more challenging than with China. One country that reportedly offered a favorable ground for technology transfer was Ireland. Looking at these experiences, the interview participants were invited again for a dialogue to understand this cultural paradox. In this dialogue, one research participant summarized the phenomenon saying, *"Technology transfer is never an easy process. There are two important components in a technology transfer - people and technology. And the people need to be willing to transfer the technology, and absorb the technology, for the transfer to work. They need to look beyond personal and regional cultures, biases, and limitations. They need to think as a global organization with a common organizational culture. Some regions do it better than others. Some individuals do it better than others. And the regional paradox reveals just that".*

4.4 Addressing the third research question - What are the lessons learnt for improving the technology transfer in the refractory industry?

This section elaborates the theory generated for addressing the third research question. The name of the theory is *"Lessons learnt - assess, collaborate, evaluate. Create an organizational culture of technology transfer"*. This theory is made up of a total of four components, each of which is highlighted in the four subsections below.

4.4.1 Prepare the people

Prepare not only the transferor but also the transferee - considering cross-border technology transfer to be a bilateral technological dialogue, it is important to prepare not only the transferor but also the transferee to open up and collaborate with each other. The usual practice in multinational corporations when sending skilled workers or expatriates to another location for technology transfer is to offer training in language and intercultural aspects to these expatriates. What is often overlooked is that the transferor, in this example the expatriate, is only one side of the technology transfer process. It is useful to also prepare the transferee for the upcoming cultural and technological change. This concept is based on the idea that technology transfer is a bilateral process and not a unilateral one. As one research participant put it, *"language training is no doubt important in some regions. But above all else, the technology transfer teams on both sides should talk more, ask more questions, and request clarification when there are doubts. They should learn to confer and differ".* Preparing the people also includes preparing the organization, by instilling in the employees a sense of organizational culture that unites the cross-country teams despite the regional cultural differences. One of the research participants highlighted it saying, "*There are two important components in a technology transfer - people and technology. And the people need to be willing to transfer the technology, and absorb the technology, for the transfer to work. They need to look beyond personal and regional cultures, biases, and limitations. They need to think as a global organization with a common organizational culture".*

Another aspect that resonated often in the interviews was the need to adhere to a time plan in a technology transfer. Despite the regional and cultural differences that mark time management and punctuality across the different geographical regions, the research participants highlighted the importance of time management in technology transfer multiple times. As one research participant put it, "*respecting time is respecting people. If you don't respect time and the project timeline, you risk the project, waste organizational resources, and throw away the efforts of everyone in your team".*

4.4.2 Adapt the technology

The second lesson that could be drawn from the study was that when planning and executing technology transfer, technologies need to be adapted to the region receiving the technologies. Technology dumping or simple geographical relocation of technologies fails to utilize the full potential of technologies in different regions. This result also resonates with the examples highlighted in the literature review showing the benefits of cultural adaptation of technologies as compared to geographical relocation of technologies in international cross-country technology transfer. As one of the research participants put it, *"one would expect that students of history would know better than to repeat the problems well known from the past. But unfortunately, even now we [humans] fail to learn from the past. We [technology transferor] need to assess the situation at the target location. What are their resources? What are their strengths? What are their limitations?"* Another research participant elaborated on this further by saying, *"We [technology transferor] need to assess the strengths of each region and use them fully during the technology transfer. Each region has different strengths. Some are good at automation, some are faster with manual manipulation, some have different raw materials available close to their location, some equipment may be mandatory or even forbidden by law in some regions".*

4.4.3 Standardize the tools

The research participants highlighted that standardized tools and processes across the organization could support international cross-country technology transfer. It was also noted that standardization of tools and processes is not always within the scope of technology transfer, but it needs to be considered in the beginning as non-standardized tools and processes may necessitate additional resources in order for the technology transfer to work. As one of the research participants put it " *In some cases it is possible to implement standardized tools, in other cases it is out of scope of the technology transfer. But it is important to calculate the risk such non-standardized tools can have on the transfer at the beginning. There is nothing wrong in accepting a problem and asking for help at the right time".*

Standardization of tools and processes, however, needs to be done keeping the regional and global norms, laws, and policies in mind. As one of the research participants highlighted, *"No doubt different countries have different laws and policies, and then there are global laws and organizational policies. It makes it all the more important to evaluate the regional and organizational policies, create transparency, and define clear processes that can navigate the technology transfer. If there is no clarity in this regard, there is so much confusion during the technology transfer"*.

4.4.4 Complete the process

Another lesson learnt as reported by the research participants, was to take a holistic approach and to look at the complete process and not only parts of the process. One example in this regard was highlighted by a research participant, *"One of the things I learnt from my experience is to look at cost to customer and not just cost of production and do that in the initial phase of technology transfer. In some regions for example, the import duties or regional taxes are so high that even with lower cost of production from the technology transfer, the cost to customer could be higher. This could put a* *big question mark on the whole technology transfer"*. Another research participant put this further into perspective by adding, *"If a technology transfer aims at a product, then the goal should be to create a product that is not only producible in the other region but is also sellable out of this region"*. Adding further to this aspect, and highlighting how this could be achieved, the research participants underscored the importance of creating a cross-functional technology transfer teams, including different stakeholders like technical experts, production facilities, tax and finance teams, research and development, from the beginning. This could support in building a holistic approach to technology transfer.

4.4.5 Plan, execute and track

As reported by the research participants, taking a holistic approach, involving a cross-functional team, and evaluating the regional law, policies and limitations are the key to planning an international cross-country technology transfer. However, planning alone without proper execution is not enough. A technology transfer, like any other project, needs to be broken down into clear tasks, assigned responsibles and a timeline, and the progress of each task needs to be controlled at regular intervals. Highlighting this as a key lesson learnt in international technology transfer, a research participant mentioned, *"We have to break the whole technology transfer into small, clearly defined tasks with clearly defined roles, responsibilities, and timeframe. And we need to track the progress regularly. It is very important. Without tracking, it is like taking a small sailing boat in the ocean, you can't control where you are headed"*. Another research participant added, *"Action tracking brings discipline. It ensures executions. Without action tracking, it is just a plan with chaotic execution"*.

4.5 Interim Conclusions of the Study

This study aimed to analyze international cross-country technology transfer in the refractory industry. The literature study showed the history and evolution of technological dialogue in human civilization. The history of international technology transfer is rich in examples of successful and failed attempts, across diverse technology disciplines like agriculture, irrigation, railway, electricity, telegraph, telecommunication, to name a few. Even though technology transfer has been known for centuries, it still remains relevant today, owing to two reasons - firstly, the technologies that are to be transferred are changing fast and secondly, the speed of technology transfer is increasing. Therefore, the approach needed for international technology transfer needs to be adapted to the current times. This study analyzed technology transfer in the refractory industry from the perspective of individuals who were directly involved in international cross-country technology transfer in the refractory industry. Refractories are products that are used in high temperature industrial processes like production of steel, cement, glass, aluminum, copper, etc. As the global demand for these industrial products grows, so does the demand for high performance refractories, necessitating technology transfer across borders in the refractory industry.

This study followed a qualitative Glaserian grounded theory approach. Owing to the scarcity of literature on technology transfer in the refractory industry, the author aimed to explore the different aspects of this phenomenon. Glaserian grounded theory was selected as it supports an explorative study and aids in creating a theoretical description of the phenomenon being studied. Additionally, the Glaserian grounded theory focuses more on understanding and interpreting the data from the perspective of the research participants without over-quantification or forced quantification of data.

This study was guided by three research questions, and a Glaserian grounded theory was developed to address each of the research questions. The results of this study are summarized in table 11.

Table 11 Summarized results of the analysis

Research question 1	What are the basic characteristics of international cross-country technology transfer in the refractory industry? Which technologies are transferred, who transfers them and how?
Name of the Theory that was developed	*The theory of multifaceted technology transfer on the border of traditional elements and modern challenges of human society*
Elements of Theory	Contemporary and state-of-the art technologies - the "What" of technology transfer
	Right people and right tools is recipe of success - The "How" and "Who" of technology transfer
	Holistic view on transferred technologies - the complete picture of technology transfer
Research question 2	What are the challenges faced in the international cross-country technology transfer in the refractory industry?
Name of the Theory that was developed	*Challenges – mismatch between organizational culture, geographical regional cultures and expectations from international technology transfer*
Elements of Theory	Throwing people in at the deep end of the pool
	Knowledge protectionism
	Cultural hierarchy as an organizational barrier
	Not valuing the time-plan
	Unwillingness to share and learn
	Technology dumping
	Doing half work and expecting full return
	Non-standardized tools and process
	The cultural paradigm
Research question 3	What are the lessons learnt for improving the technology transfer in the refractory industry?
Name of the Theory that was developed	*Lessons learnt* - *assess, collaborate, evaluate. Create an organizational culture of technology transfer*
Elements of Theory	Prepare the people
	Adapt the technology
	Standardize the tools
	Plan, implement and track

Source: Created by author

5 DISCUSSION

5.1 Link to Previous Research

The topic of technology transfer has received much attention in the last decades. The literature review highlighted a scarcity of scientific literature on international cross country technology transfer, especially concerning studies that compare technology transfer more than two countries. This study fills this gap by comparing technology transfer across Austria, Brazil, China, Germany, Ireland, Norway, and the United States of America. Contemporary literature often focuses on highlighting the transfer of technologies from the North to the South, or from the West to the East. This study, however, takes a holistic approach and studies the technology transfer process as a bilateral dialogue and not just as a unilateral phenomenon. While studying the human aspect of technology transfer, this study revealed that a holistic view helps avoid biases, reveals the challenges faced by international organizations during cross-border technology transfer and offers a comprehensive understanding of lessons learnt that could then be used to build best practices for international technology transfer assignments. Additionally, the study avoids taking a preconceived North-South or West-East view on technology transfer, looking at the technology transfer process as a global technology dialogue.

Contemporary literature also studies the effect of distance on technology transfer, be it geographical or cultural distance. Normally, it could be understood from the literature that the larger the geographical or cultural distance, more difficult is it to transfer technologies across border. Such studies, however, often compare only two countries in practice or derive their data from theoretical studies of cultural and geographical distance. The cultural paradigm that was identified in this study, however, showed a different picture. Among the countries like China, Ireland, Norway, the transfer of technology from Austria and Germany was found to be the easiest for China and the most challenging for Norway.

Resonance could be found in the scientific literature that underline the significance of organizational culture to bridge the regional differences. The literature highlights the role of an organizational culture for better knowledge management and organizational success, among others. This was revealed in the current study, that a strong organizational culture of technology transfer could indeed support the technology transfer goals of an organization and help mitigate the challenges posed by the regional cultures and mind-sets.

5.2 Scientific Contribution

The literature review revealed a scarcity in systematic study of international cross-country technology transfer and in the study of human aspect in international technology transfer. This study highlights the human aspect of international cross-border technology transfer and therewith attempts to fill this gap in the scientific literature. By analyzing international technology transfer between several countries, this study collected practical data from the experts directly involved in international technology transfer assignments – which challenges they faced and which lessons could be learnt from their experience. This could form the basis for defining organizational best practices for international technology transfer assignments.

Additionally, using refractory industry as a case study, this study contributes to the scientific literature in the field of organizational practices and technology transfer in the refractory industry. The literature review revealed an abundance of technical literature in the field of refractories but a scarcity of literature on organizational practices, including technology transfer. Considering the relevance of refractory industry for the industries like steel, cement, glass, etc., this study built on the experience of experts from the refractory industry.

This study uses Glaserian grounded theory methodology. This research methodology offers the benefit of conducting an explorative study, flexibility of data collection tools, letting the theory emerge from the collected data, and all of this while avoiding forced quantification of data. This study, with focus on international cross-country technology transfer, and using refractory industry as a case study, necessitated an explorative approach for which the Glaserian grounded theory methodology was considered appropriate. This study adds to the literature on Glaserian grounded theory, especially with focus on international cross-country technology transfer in the refractory industry.

5.3 Organizational Implication

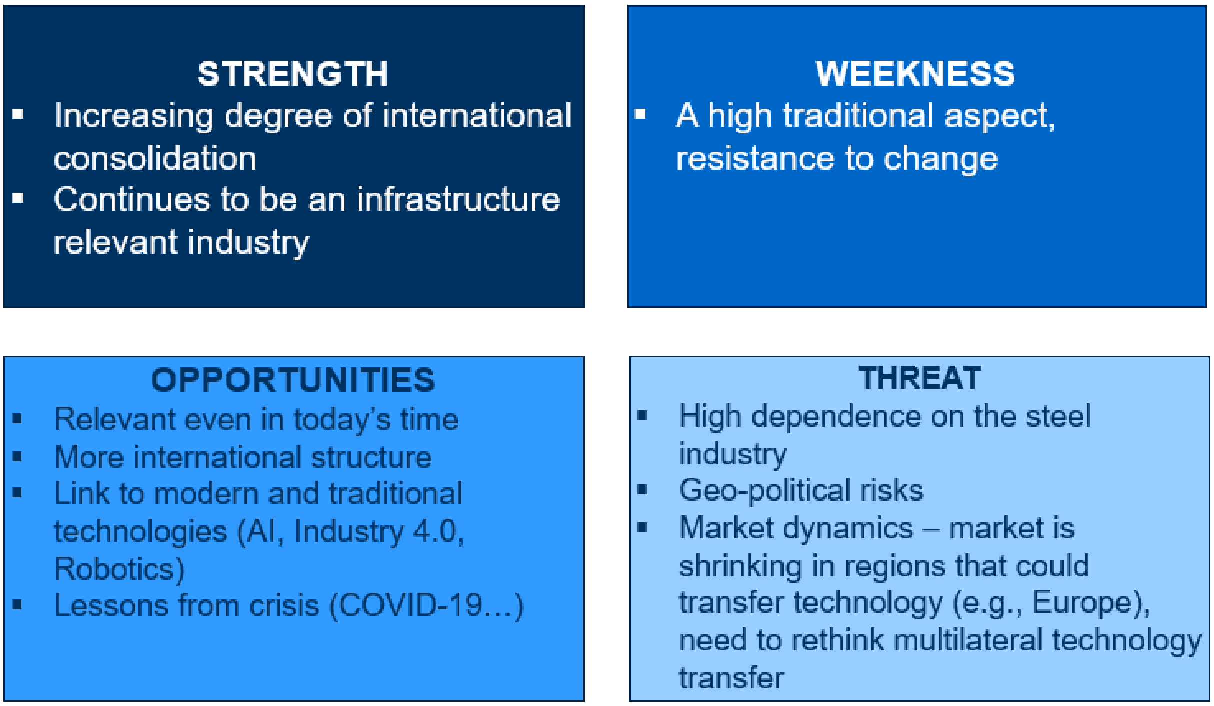
This study has a direct implication for the organizations involved in international cross-country technology transfer. A total of 46 interviews were conducted in this study with experts directly involved in international technology transfer assignments across different countries in the refractory industry. The results of this study could form the basis for defining the organizational best practices for international technology transfer assignments.

Figure 11 shows a SWOT analysis, showing the strengths, weakness, opportunities, and threats of the refractory industry from the viewpoint of international technology transfer. The different elements of this SWOT analysis are listed below:

- Strengths: From the viewpoint of international technology transfer, the strength of the refractor industry lies in the fact that there is an increasing degree of organizational consolidation visible in this industry globally. Activities like mergers and acquisitions, joint-ventures and international collaborations continue to necessitate international technology dialogue in this industry. With its link to the infrastructure industries like steel, cement, glass, etc., the refractory industry continues to be an infrastructure relevant industry.
- Weakness: As also revealed in this study, from the viewpoint of international technology transfer, the refractory industry is a mix of traditional technologies and state-of-the-art technologies. Marked by a high degree of traditional technologies and mindset, this poses to be a barrier or a weakness when considering international technology transfer assignments.
- Opportunity: The refractory industry continues to be of interest and full of opportunities from the viewpoint of international technology transfer. It is supported by the fact that it is a infrastructure relevant industry, undergoing a lot of internationalization, and includes an intricate mix of traditional and state-of-the-art technologies. This necessitates, however, a focused approach to address the international technology transfer assignments.
- Threats: An industrial threat is the high degree of dependance of the refractory industry on the steel industry. Any changes on the steel market have an impact on the refractory industry. Another threat is the changing market dynamics and the geo-political conditions. The traditional carriers of technology, like Europe, show a slow growth in the industry as compared to traditional receivers of technology like China and India. This also highlights the

relevance of re-thinking the technology transfer process as a bilateral dialogue as opposed to a traditional West-East or North-South process.

Figure 11 SWOT analysis of the refractory industry from the viewpoint of international technology transfer



Source: Created by author

5.4 Limitations of the Current Study

Each research is marked by certain limitations, as is also this current study. The limitations arise from diverse factors, like available resources, time, network, availability of research participants, to name a few. This study is an attempt to highlight the human aspect of international technology transfer, using the refractory industry as a case study. One of the limitations is the selection sample size. The author used theoretical sampling followed by snowball sampling until a theoretical saturation was achieved. It would, however, be correct to say that the list of interview participants reveals only a limited sample size and is not an exhaustive list.

5.5 Recommendations for Further Research

This study took a holistic approach on international cross-country technology transfer in the refractory industry by interviewing research participants within one single organization. Further research in this field could take into account that a holistic view on international technology transfer might be suitable to the current times of internationalization and ever-changing geo-political landscape. This study could be used as a basis and be extended to define organizational best practices for international cross-country technology transfer assignments across different organizations and industries. The literature review revealed that there is no one universal solution that may fit all industries and organizations and industry-specific studies continues to be relevant, even in today's time of continuously evolving technological landscape and ever changing geo-political setup.

The cultural paradigm revealed in this study when analyzing technology transfer across countries with different geographical and cultural distance indicates an anomaly to the traditional West-East or North-South technology transfer theories and could also form the basis of further research.

6 CONCLUSION

This section summarizes this study and offers recommendation for using the results of this study further across organizations and industries. This aim of this study was to highlight human aspects linked to international cross-country technology transfer in the refractory industry. Starting with the literature review, the history of technological dialogue in the human civilization was highlighted. The human history has been marked with continued technological developments, that then found their way across the globe. From railways and telegraphs to artificial intelligence and vaccines, technologies that were once developed in one corner of the world have over time found their way in the cultures, regions, organizations, and industries across the world. The literature review revealed the multifaceted aspect of technology transfer in the human history, how diverse technologies developed in one part of the world, could be transferred across borders by the support of several agents like policy makers, scientific institutions, industries and traders, financial institutions, to name a few. Over time, as technologies grew more complex, so did the international technological dialogue. Looking at the long history of international technological dialogue in the human civilization, one is bound to ask whether the study of international technology transfer is relevant in today's time. This has also been discussed in the literature review. The literature study shows that with ever increasing globalization, ever changing geopolitical situations, and increasing costs of research and development, the focus on accelerated technology transfer continues to be relevant even in contemporary times.

Technology transfer by definition, aims at bringing new and existing technologies from the point of creation to the point of application, thereby enabling commercialization of technologies and justifying the investments made in the research and development. Additionally, technology transfer facilitates capacity building and with faster dissemination of technologies, duplication of efforts can be avoided thereby facilitating better use of scientific and financial resources. The lessons from history revealed that technology transfer existed centuries ago. The contemporary literature abounds in studies that consider technological dialogue to be in a specific geographical direction. But a closer look at the historic literature revealed that the technological dialogue in history never followed a specific geographical direction, it was never clearly West to East or North to South. In order to address this paradox, the author took a holistic approach, and followed the flow of technology in whichever direction the research participants reported, instead of preconceived geographical limitations.

Refractories are industrial products that are used in high temperature industrial applications like production and treatment of molten metals, glass, cement, to name a few. Refractories are therefore an integral pillar of all industrial products that need high temperature treatment at some part of their value chain. This links the refractory industry to the industrial materials like steel, cement, glass, and aluminium. As the global demand for such materials grows, so does the demand for refractories. Building on over a decade of professional industrial experience in the refractory industry, the author selected this industry as a case to study international cross-country technology transfer. The literature review revealed two missing links in the scientific literature. First, the scarcity of scientific literature on cross-country technology transfer , and second, the scarcity of literature on technology transfer specific to the refractory industry. This study aims to address this gap in the scientific literature.

With the aim of exploring the human aspect of international technology transfer in the refractory industry, several research methodologies were compared to find the suitable fit for this research. Qualitative research, with the proximity to the research subject, and offering the possibility to study the research subject in their natural surrounding emerged as the preferred choice. Qualitative research, however, includes several forms of research methodologies, namely, case study, ethnology, grounded theory, narrative study, and phenomenology. Each of these is suited for a different target group. Out of these research methodologies, grounded theory, more specifically Glaserian grounded theory methodology, was selected for this research as it offered the possibility to conduct explorative research, allowing the theory to emerge from the collected data. Additionally, Glaserian grounded theory enables the research to be closely associated with the research subject without forced quantification of research data.

This study was guided by three research questions. The first research question addressed the basic characteristics of technology transfer in the refractory industry – which technologies are transferred and how they are transferred. The theoretical description addressing this research question was titled, *"The theory of multifaceted technology transfer on the border of traditional elements and modern challenges of human society"*. The study revealed that refractory industry is an intricate mix of conventional and modern technologies. From metal processing to digitalization, recycling and environmental technologies, this industry is marked by international technology transfer covering a wide spectrum of knowledge and technology. The study also showed that technology in the refractory industry is transferred with the help of diverse tools facilitated by people. Visits to production, research and customer sites, participation in scientific conferences, on-site support and remote support via online and digital tools were some of the ways how technology was reportedly transferred. The human aspect of technology transfer analyzed in detail in the next research questions.

The second research question addressed the challenges faced by individuals involved in international technology transfer in the refractory industry. Following the Glaserian grounded theory approach, the theoretical description generated for addressing this research question was titled, *"Challenges – mismatch between organizational culture, geographical regional cultures and expectations from international technology transfer"*. This consisted of nine elements that highlighted different challenges faced by industry experts when transferring technology across diverse geographical boundaries. These nine elements are:

- *Throwing people in at the deep end of the pool:* insufficient preparation for the transferor and transferee, highlighting the significance of training both sides involved in technology transfer
- *Knowledge protectionism:* unwillingness to share information due to personal biases, fear of loss of intellectual property or due to missing clear organizational guidelines
- *Cultural hierarchy as an organizational barrier:* mismatch of cultural hierarchies that hinder a free flow of knowledge in the desired direction
- *Not valuing the time-plan:* mismatch between cultural interpretation of time and the time-plan set by the organization for the technology transfer
- *Unwillingness to share and learn:* highlights the important role that individuals and teams play in technology transfer. If the individuals or teams are unwilling to share or learn from each other, technology transfer becomes a challenge.
- *Technology dumping:* this finding resonates with lessons learn from history as revealed by the literature review. Simple geographical relocation of technologies without cultural adaptation could render the technology transfer a failure.
- *Doing half work and expecting full return:* this element indicates the mismatch between the expectations from technology transfer and the resources invested in it. A half-hearted

approach to international technology transfer could only extend the timelines, increase the cost, or even render the technology transfer to be a failure.

- *Non-standardized tools and process:* even though it is often difficult to have standardized tools and processes across the complete span of a multinational organization, non-standardized tools and processes could hinder the technology transfers. The study showed that even if standardization of tools and processes is out of scope of the technology transfer, it needs to be considered as a risk and mitigation measures should be planned in advance.
- *The cultural paradigm:* this element of the analysis revealed that challenges faced in international technology transfer could not be defined by a West-East or North-South phenomenon. Research participants unanimously attributed China as the easiest location for technology transfer despite large geographical and cultural distance with respect to Europe. Norway, on the other side, was reported as the most challenging region for international technology transfer among the geographical regions that were studied. Willingness to learn and share, implement, and adapt technologies were attributed as the major factors affecting this paradox.

The third research question addressed the lessons learnt by individuals involved in international technology transfer in the refractory industry. Following the Glaserian grounded theory approach, the theoretical description generated for addressing this research question was titled, *"Lessons learnt - assess, collaborate, evaluate. Create an organizational culture of technology transfer"*. This theoretical description comprised of four elements that were as follows:

- *Prepare the people:* the study showed that often while training employees and teams for international technology transfer, only one side, namely, the transferor is trained. This study, however, revealed that preparing both sides, namely the transferor and the transferee could facilitate technology transfer across borders. This resonates also with the literature review, where it was seen that technology transfer is a bilateral process and not a unilateral one. For one side to be able to transfer a technology, the other side should be prepared and willing to receive the technology.
- *Adapt the technology:* the research participants emphasized that during international technology transfer, technologies need to be adapted to the receiving location. A simple

geographical relocation of technology with disregard to the local conditions, laws, technical capabilities could endanger the success of international technology transfer.

- *Standardize the tools:* non-standardized tools and processes often challenge the success of international technology transfer. The research participants underlined the importance of standardized tools and processes. It could therefore be recommended to standardize the tools and processes where possible and to evaluate and analyze the risk of non-standardized tools and processes where standardization is not included within the scope of the technology transfer.
- *Plan, implement and track:* the best plans are fruitless without a meticulous execution. Along these lines, the study recommends dividing the technology transfer assignment into clearly defined tasks, assigning clear roles and responsibilities, together with a time plan and deadlines. International technology transfer is a resource intensive process and with regular action-tracking an efficient use of resources could be realized.

This study aimed to bring the refractory industry to the forefront of technology transfer research. Additionally, it aimed to highlight the significance of human aspect in international cross-country technology transfer by comparing technology transfer experiences in not one or two but a total of six geographical regions. With the ever changing technological and geopolitical landscape, new technologies continue to emerge, and international technology transfer continues to be relevant even in the contemporary times. The fact that the research participants revealed several challenges faced in international technology transfer highlights that a universal set of best practices that could be implemented universally across all regions and industries fails to exist. Another fact that resonated throughout the study was a need for an overarching organizational culture that enables bridging the cultural distances across geographies. What this study also revealed is that technology transfer is a bilateral dialogue that requires active participation, preparation, and involvement from both, the transferor, and the transferee. To consider international technology transfer only as a unilateral process and focusing only on the transferor and ignoring the needs of the transferee could hinder the success of internal technology transfer. Although this study focused on refractory industry for analyzing the human aspect of technology transfer, its essence echoes across other industries as well. Regardless of the industry, the author recommends analyzing the results of this study with the individuals and teams involved in international technology transfer and using these results as basis to develop best organizational practices for enabling international technology transfer.

7 RESUME

Táto štúdia sa zameriava na medzinárodný transfer technológií medzi krajinami v žiaruvzdornom priemysle. Podľa kvalitatívneho prístupu Glaserovej zakotvenej teórie sa údaje zbierali pomocou pološtruktúrovaných rozhovorov. Zozbierané údaje boli následne analyzované pomocou trojstupňového procesu analýzy s cieľom získať teoretický opis výskumných otázok.

Žiaromateriály sú priemyselné výrobky s vysokou teplotou tavenia, ktoré si dokážu zachovať svoje štrukturálne vlastnosti pri vysokej teplote (Mason, 2016). Vďaka svojej schopnosti odolávať vysokým teplotám tvoria žiaruvzdorné materiály neoddeliteľnú súčasť vysokoteplotných priemyselných procesov, ako je výroba ocele, cementu, skla, hliníka atď (Caniglia a Barna, 1992; Yurkov, 2015). Používanie žiaruvzdorných materiálov možno vysledovať až do dávnych čias ľudskej civilizácie, čo naznačuje skoré používanie Feničanmi a Číňanmi (Didier, 1997, s. 6). To, čo robí žiaruvzdorné materiály relevantnými pre globálne hospodárstvo, je nevyvrátiteľná súvislosť alebo skôr závislosť vysokoteplotných odvetví, ako sú oceliarsky, hlinikársky a sklársky priemysel, od žiaruvzdorných výrobkov (Semler, 2014), čím sa žiaruvzdorné materiály stávajú základným kameňom hospodárskeho, ako aj infraštruktúrneho rastu. Celosvetový trh so žiaruvzdornými výrobkami sa odhaduje na približne 20 miliárd EUR, pričom viac ako polovica dopytu pochádza z oceliarskeho priemyslu (RHIM, 2021a).

Štúdia literatúry ukazuje, že medzinárodný transfer technológií je sám o sebe témou, ktorá existuje už stáročia. Transfer technológií bol tiež predmetom štúdia z rôznych hľadísk, a to na medzinárodnej, národnej a podnikovej úrovni. Aj napriek tomu, že vedecká literatúra v oblasti transferu technológií je bohatá, z literárneho výskumu vyplýva jedno jasné posolstvo, a to absencia univerzálneho transferu technológií, ktorý by sa dal aplikovať na všetky odvetvia a organizácie. Ak vidíme úlohu, ktorú transfer technológií zohráva v národných a medzinárodných ekonomikách a v raste organizácií, a neustále sa meniace prostredie nových technológií, ktoré poznačuje dvadsiate prvé storočie, štúdium medzinárodného transferu technológií zostáva aktuálne aj v súčasnosti. S týmto pohľadom mala táto štúdia dva ciele.

Po prvé, cieľom tejto štúdie je preklenúť chýbajúce súvislosti, ktoré boli identifikované vo vedeckej literatúre. Jedným z týchto chýbajúcich článkov bol nedostatočný výskum prenosu technológií medzi krajinami. Druhým chýbajúcim článkom identifikovaným vo vedeckej literatúre bolo zameranie štúdií o transfere technológií v žiaruvzdornom priemysle. Žiaruvzdorný priemysel je základným kameňom oceliarskeho priemyslu. Hoci je oceliarsky priemysel často spojený s rastom infraštruktúry a hospodárskym rozvojom štátov, vedecká komunita venovala žiaruvzdornému priemyslu len obmedzenú pozornosť, najmä pokiaľ ide o medzinárodné interakcie a transfer technológií. Cieľom tejto štúdie je prostredníctvom pohľadu na medzinárodný transfer technológií medzi jednotlivými krajinami, ktorý je špecifický pre žiaruvzdorný priemysel, preklenúť zistené chýbajúce súvislosti v literatúre.

Po druhé, cieľom tejto štúdie je priniesť pohľad na medzinárodný transfer technológií v žiaruvzdornom priemysle na úrovni podniku. Cieľom tejto štúdie je na základe výsledkov výskumu doplniť poznatkovú základňu o transfere technológií medzi krajinami na úrovni podnikov. Na základe skúseností osôb, ktoré sa priamo podieľajú na medzinárodnom transfere technológií, je cieľom tejto štúdie identifikovať problémy pri transfere technológií v rôznych geografických regiónoch, ktoré sú špecifické pre žiaruvzdorný priemysel.

Výskumné otázky

V súvislosti s medzinárodným transferom technológií medzi krajinami v žiaruvzdornom priemysle sa táto štúdia zameriava na tieto výskumné otázky:

1. Aké sú základné charakteristiky medzinárodného prenosu technológií medzi krajinami v žiaruvzdornom priemysle? Ktoré technológie sa prenášajú, kto ich prenáša a ako?
2. Akým výzvam čelí medzinárodný transfer technológií medzi krajinami v žiaruvzdornom priemysle?
3. Aké sú poznatky pre zlepšenie transferu technológií v žiaruvzdornom priemysle?

Metodológia výskumu

Táto štúdia sa riadila kvalitatívnou metodológiou Glaserovej zakotvenej teórie. Vychádzala z interpretačnej povahy glaserovskej metodológie zakotveného výskumu, pričom umožnila údajom vyrozprávať príbeh a rozvinúť teoretický opis bez zbytočnej mechanizovanej analýzy. Literatúra o používaní metodológie zakotvenej teórie v žiaruvzdornom a oceliarskom priemysle je nedostatočná a súčasná štúdia rozširuje používanie zakotvenej teórie na tieto odvetvia. Výskum zakotvenej teórie sa začína výskumným konštruktom alebo výskumnou otázkou namiesto hypotézy. Po zbere a analýze údajov vzniká ako výsledok štúdie teoretický opis, ktorý je zameraný na riešenie výskumných otázok.

Zber údajov

Táto štúdia sa uskutočnila metódou pološtruktúrovaného rozhovoru. Rozhovory sa uskutočnili s osobami, ktoré majú priame profesionálne skúsenosti v oblasti prenosu poznatkov a technológií v žiaruvzdornom priemysle v rôznych geografických lokalitách. V tabuľke 1 je uvedené rozdelenie účastníkov výskumu a v tabuľke 2 sú uvedené otázky položené v pološtruktúrovaných rozhovoroch

Tabuľka 1 Podrobnosti o rozhovoroch uskutočnených na účely zberu údajov

Krajina, do ktorej bola technológia prenesená	Počet rozhovorov	Skúsenosti účastníkov výskumu s transferom technológií do vybranej krajiny
India	12	5-20 rokov
Nemecko	5	5-20 rokov
Čína	8	2-12 rokov
Írsko	5	2-4 roky
Nórsko	5	1-4 roky
USA	5	2-7 rokov
Brazília	6	4-6 rokov

Zdroj: Vytvorené autorom

Tabuľka 2 Dotazník použitý v pološtruktúrovaných rozhovoroch v tejto štúdii

Sériové číslo	Otázka	Otvorená alebo uzavretá otázka
1	Podieľali ste sa priamo na transfere technológií?	Uzavreté
2	Medzi ktorými geografickými regiónmi ste pracovali na prenose technológie?	Otvorené
3	Ktoré technológie boli prenesené?	Otvorené
4	Ako bola technológia prenesená?	Otvorené
5	Aké boli výzvy pri prenose technológií medzi rôznymi geografickými regiónmi?	Otvorené
6	Čo by ste mohli navrhnúť na zlepšenie prenosu technológií medzi rôznymi geografickými regiónmi?	Otvorené

Zdroj: Vytvorené autorom

V metodológii zakotvenej teórie nie sú kroky zberu a analýzy údajov úplne oddelené, ale skôr sa prekrývajú (Goulding, 2002). Metodológia zakotvenej teórie zahŕňa neustálu interakciu medzi výskumníkom a údajmi, proces nazývaný neustále porovnávanie. Metodológia zakotvenej teórie využíva pri analýze údajov proces kódovania, pričom sa postupuje od veľkého objemu zozbieraných údajov, ich zoskupovania na základe relevantnosti a podobnosti až po abstraktnejší opis skúmaného javu (Auerbach, Silverstein, 2003).

Výskum sa riadi údajmi. Počas zberu a analýzy údajov sa v prípade potreby môže veľkosť vzorky zväčšiť, aby sa získali ďalšie údaje (Goulding, 2002). V prvej úrovni analýzy sa zo surového textu získaného rozhovormi identifikuje a vyberie relevantný text. Tieto sa nazývajú kódy prvej úrovne. V druhom kroku analýzy sa tieto relevantné texty zoskupujú do opakujúcich sa myšlienok alebo pojmov druhej úrovne. V ďalšom kroku analýzy sa opakujúce sa myšlienky zoskupujú do kategórií tretej úrovne. Keď text prejde trojúrovňovým procesom kódovania, zhromaždené kódy, koncepty a kategórie sa potom použijú na vytvorenie teoretického rozprávania, ktoré ponúka vysvetlenie skúmaného javu (Auerbach a Silverstein, 2003).

Analýza - Teoretický opis transferu technológií v žiaruvzdornom priemysle

Výsledky konštantnej komparatívnej analýzy boli použité na vypracovanie teoretického opisu transferu technológií pre žiaruvzdorný priemysel. Teoretický opis bol zoskupený do troch častí, pričom každá časť sa zaoberá jednou z výskumných otázok. Prvá časť sa zaoberá všeobecnými charakteristikami transferu technológií, pričom zdôrazňuje technológie, ktoré sa prenášajú, a úlohu, ktorú pri zabezpečovaní transferu technológií zohrávajú jednotlivci, tímy a nástroje. Druhá časť sa zaoberá druhou výskumnou otázkou, a to výzvami, ktorým čelí transfer technológií v žiaruvzdornom priemysle. Tretia časť sa zaoberá treťou a poslednou výskumnou otázkou a ponúka poznatky získané pri zlepšovaní prenosu technológií medzi krajinami v žiaruvzdornom priemysle.

Riešenie prvej výskumnej otázky - Aké sú základné charakteristiky medzinárodného transferu technológií medzi krajinami v žiaruvzdornom priemysle? Ktoré technológie sa prenášajú, kto ich prenáša a ako?

V tejto časti je rozpracovaná teória vytvorená na riešenie prvej výskumnej otázky. Názov teórie je *"Teória mnohostranného transferu technológií na rozhraní tradičných prvkov a moderných výziev ľudskej spoločnosti"*. Nasledujúce tri podkapitoly sa zaoberajú tromi vzájomne prepojenými prvkami, ktoré boli identifikované pri riešení prvej výskumnej otázky.

- ***Súčasné a najmodernejšie technológie - "čo" transferu technológií***

Prvá charakteristika transferu žiaruvzdorných technológií, ktorá vyplynula z tejto štúdie, sa zamerala na to, čo sa prenáša, konkrétne ktoré technológie sa v žiaruvzdornom priemysle prenášajú cez hranice. Žiaruvzdorný priemysel je tradičným odvetvím, ktoré v posledných storočiach existovalo popri viacerých odvetviach s vysokou teplotou, ako je oceliarsky a cementársky priemysel. Dlhá história tohto odvetvia ho na jednej strane spája s tradičnými aspektmi technológie. Na druhej strane, tvárou v tvár technologickému vývoju a vedeckým, hospodárskym a environmentálnym výzvam dvadsiateho prvého storočia si najmodernejšie technológie v žiaruvzdornom priemysle tiež nárokujú na transfer technológií. Na tradičnej strane sa značná pozornosť venuje poznatkom a technológiám spojeným s výrobnými zariadeniami, výrobnými procesmi a zložením výrobkov. Na modernej strane nachádza transfer technológií v žiaruvzdornom priemysle odozvu v súčasných výzvach ľudskej spoločnosti, napr. environmentálne technológie, znižovanie uhlíkovej stopy, zvyšovanie energetickej účinnosti a rastúca digitalizácia v rozmanitých oblastiach výroby a aplikácie žiaruvzdorných materiálov priťahujú transfer technológií. Práve táto kombinácia tradičných a moderných technológií robí transfer technológií v žiaruvzdornom priemysle náročným. Štúdia odhalila, že transfer technológií v žiaruvzdornom priemysle si vyžaduje technické znalosti o historickom vývoji a vývoji v žiaruvzdornom a súvisiacich odvetviach, ako je oceliarsky, cementársky, sklársky priemysel, za posledné desaťročia, ako aj udržiavanie aktuálneho stavu najnovších technológií a legislatívy.

- ***Správni ľudia a správne nástroje sú receptom na úspech - "Ako" a "Kto" v transfere technológií***

Transfer technológií, ktorý sa tu skúmal, sa zameral na ľudský aspekt transferu technológií medzi krajinami. Rozhovory uskutočnené s účastníkmi výskumu prepojili výskumníka s ľudskou stránkou transferu technológií medzi krajinami. Účastníci výskumu boli identifikovaní prostredníctvom pohodlného výberu, po ktorom nasledoval výber metódou snehovej gule. Účastníci výskumu, s ktorými boli v tejto štúdii uskutočnené rozhovory, mali päť až dvadsaťročné skúsenosti v oblasti transferu technológií v žiaruvzdornom priemysle, ako je uvedené v predchádzajúcej tabuľke 10. Účastníci výskumu pokrývali širokú škálu technológií, ktoré boli transferované v rôznych krajinách. V čase, keď sa táto štúdia uskutočnila, účastníci výskumu sídlili v rôznych krajinách, v Európe a Ázii. Všetci účastníci výskumu fyzicky cestovali do krajín, v ktorých pracovali na prenose technológií, viackrát.

Štúdia zdôraznila kľúčovú úlohu, ktorú pri prenose technológií zohrávajú jednotlivci a tímy. Ako povedal jeden z účastníkov výskumu, "*nie je to jednoduchý tok jedným smerom, je to spoločné úsilie. Aby jedna strana mohla zdieľať technológie a znalosti, osoba a tím na druhej strane by mali byť* *ochotní tieto znalosti prijať a konať podľa nich."*. Ďalší účastník výskumu ho doplnil slovami: *" Potrebujete ľudí, ktorí chápu, že na to, aby bol transfer technológií úspešný, je potrebné vedomé úsilie každého jednotlivca a celej organizácie. Je to tímové úsilie. V tíme pre transfer technológií potrebujete tých najlepších ľudí".*

Na prenos technológií sa využívali rôzne nástroje, ako napríklad návštevy výrobných, výskumných a zákazníckych pracovísk, účasť na vedeckých konferenciách, stretnutia zamerané na výmenu poznatkov, vytváranie a zdieľanie kníh know-how, podpora na mieste a podpora na diaľku prostredníctvom online a digitálnych nástrojov. Účastníci výskumu zdôraznili, že kľúčom k transferu technológií je kombinácia správnych ľudí a nástrojov. Jedno bez druhého je receptom na neúspech, ak správne osoby nie sú vybavené správnymi nástrojmi alebo ak tie najlepšie nástroje nie sú podporované a používané správnymi osobami, transfer technológií riskuje neúspech.

- ***Komplexný pohľad na transfer technológií - úplný obraz transferu technológií***

Štúdia ukázala, že výmena technológií a poznatkov v žiaruvzdornom priemysle sa považuje za nevyhnutnú v celom hodnotovom reťazci výrobkov - od získavania surovín, cez výrobu žiaruvzdorných materiálov až po použitie žiaruvzdorných výrobkov vo vysokoteplotných odvetviach, ako sú cementárenský a oceliarsky priemysel. Obmedzenie štúdie o transfere technológií len na určitý aspekt hodnotového reťazca by znamenalo riziko, že sa vynechá komplexný pohľad na toto odvetvie. Cieľom tejto štúdie bolo preto zhromaždiť skúsenosti jednotlivcov zapojených do prenosu rôznych technológií naprieč medzinárodnými geografickými hranicami. Rozhovory s účastníkmi výskumu odhalili mnohostranný aspekt prenosu technológií v žiaruvzdornom priemysle. Ťažba a úprava surovín, zloženie výrobkov, miešanie a tvarovanie výrobkov, tepelné spracovanie, balenie, použitie žiaruvzdorných materiálov v rôznych priemyselných podmienkach, využívanie nástrojov riadenia znalostí a systémov plánovania podnikových zdrojov sa odhalili ako cielené prúdy cezhraničného prenosu technológií a znalostí v žiaruvzdornom priemysle v rámci tejto štúdie. Túto rozmanitosť technológií, ktoré sa prenášajú v žiaruvzdornom priemysle, bolo možné odhaliť vďaka výberu vzorky snehovej gule použitej v tejto štúdii. Účastník výskumu s niekoľkoročnými priemyselnými skúsenosťami v oblasti transferu technológií spolupracoval počas svojej práce na cezhraničnom transfere technológií s viacerými jednotlivcami a tímami a často mal kontakty na potenciálne ciele výskumu v rôznych oblastiach v rámci žiaruvzdorného priemyslu. To pomohlo nielen pri zväčšení veľkosti vzorky, ale aj pri rozšírení záberu tejto štúdie na rôzne oblasti žiaruvzdorného priemyslu.

Riešenie druhej výskumnej otázky - Aké sú výzvy, ktorým čelí medzinárodný transfer technológií medzi krajinami v žiaruvzdornom priemysle?

V tejto časti je spracovaný teoretický opis vytvorený na riešenie druhej výskumnej otázky. Názov tejto teórie je *"Výzvy - nesúlad medzi organizačnou kultúrou, geografickými regionálnymi kultúrami a očakávaniami od medzinárodného transferu technológií".* Táto teória sa skladá z deviatich zložiek, z ktorých každá je zvýraznená v podkapitolách nižšie.

- ***Hádzanie ľudí do hlbokého bazéna***

Toto slovné spojenie vo všeobecnosti znamená hodiť niekoho do hlbokého bazéna, ktorý sa potom musí naučiť plávať pomerne náhle, bez toho, aby bol na to úplne pripravený. Tento kód in vivo bol použitý na vyjadrenie toho, ako bolo niekoľko osôb zapojených do cezhraničného prenosu technológií vtiahnutých do vody bez toho, aby boli na prenos technológií pripravené.

Cezhraničné transfery technológií zahŕňajú stretnutia ľudí z rôznych geografických lokalít, ktorí sa navzájom delia o svoje znalosti a technologickú základňu. To si vyžaduje kultúrne, organizačné, ako aj osobné prispôsobenie. Vo viacerých prípadoch účastníci výskumu uviedli, že tímy zapojené do cezhraničného prenosu technológií neboli úplne pripravené na výzvy, ktoré ich čakajú. Pri príprave transferu technológií sa tiež často predpokladá, že pripravený musí byť len transferujúci subjekt. Tento prístup neberie do úvahy transfer technológií ako dvojstranný proces, nie je to len proces dávania a prijímania, skôr proces dávania, prispôsobovania, prijímania. V podstate si vyžaduje, aby boli obaja, odovzdávajúci aj prijímajúci, pripravení na spoluprácu, zdieľanie technológie, jej prispôsobenie miestnym podmienkam a úspešný transfer technológie.

V tejto súvislosti bol uvedený príklad európskych účastníkov výskumu, ktorí pracovali ako kvalifikovaní cudzinci v Číne. Niekedy absolvovali menej alebo vôbec žiadne medzikultúrne školenie o tom, ako jednať s ľuďmi a organizáciami v Číne. Ak sa takéto školenia uskutočnili, boli skôr teoretické s menším praktickým významom. Skutočnou výzvou však bolo, že tímy v krajinách, do ktorých sa transfer uskutočnil, ako napríklad Čína a India, nedostali žiadne školenie o tom, ako pracovať na transfere technológií s európskym tímom. To malo za následok, že tím z Európy pristál v týchto krajinách napoly pripravený, pričom miestny tím mal málo alebo žiadne skúsenosti a školenia na spoluprácu s nimi. To nielenže spomalilo transfer technológií, ale viedlo aj k viacerým kultúrnym stretom, ktoré sa však dali prekonať vzájomnou tímovou prácou a spoluprácou. Tento prístup však poukazuje na mylnú domnienku niektorých organizácií a tímov, že transfer technológií je jednosmerný proces. Dobre to vystihol jeden z účastníkov výskumu, keď povedal: "*Nejde o transfer technológií z Európy do Indie, ale skôr o transfer technológií medzi Indiou a Európou. Nechápem, prečo si my [žiaruvzdorný priemysel] myslíme, že môžeme len tak niekomu vnucovať určitú technológiu. Ekonomiky rastú, výroba ocele v Indii a Číne rastie. Je to obojsmerná ulica, viete. Majú pravdepodobne najvyšší počet osôb pracujúcich v žiaruvzdornom priemysle na svete. Všetci [v globálnom žiaruvzdornom priemysle] sa od nich môžeme učiť, viete*". Ďalší účastník výskumu zdôraznil: "*V tejto oblasti pracujem už viac ako desať rokov. Stále nechápem, prečo ľudí dobre nepripravujeme na prestup. Je to proces veľmi náročný na zdroje a plný strategických dôsledkov pre organizáciu. Jazyk, nástroje, technológie, musíme pripraviť tímy na oboch stranách v prvej fáze prenosu [technológie]. Ak to neurobíme skôr, neskôr za to draho zaplatíme*".

- ***Znalostný protekcionizmus***

Túto výzvu uviedli viacerí odborníci zapojení do prenosu technológií. V priebehu transferu technológií majú niektoré zainteresované strany, najmä vlastníci znalostí, ktoré je potrebné preniesť, tendenciu chrániť si tieto znalosti. Znalostný protekcionizmus bráni transferu technológií najmä vtedy, keď sa hranice medzi znalosťami ako majetkom organizácie a osobným majetkom majú tendenciu stierať. Vlastníci znalostí majú potom tendenciu buď spomaliť proces prenosu, aby získali čas a dôveru nadobúdateľov, alebo v niektorých prípadoch môžu úplne brániť prenosu technológií tým, že sa zdržia zdieľania úplných informácií o nástrojoch, produktoch alebo procesoch. Takýto roztrieštený transfer technológií predstavuje záťaž pre organizačné zdroje, čo vedie k plytvaniu finančnými prostriedkami alebo dokonca k strate motivácie v tíme pre transfer technológií. Ako zdôraznil jeden z účastníkov výskumu, *"technológie a znalosti, ktoré sa prenášajú v rámci organizácie, nie sú osobným vlastníctvom, ale skôr podnikovým majetkom. Pri transfere technológií znalosti nepatria vám ani mne, ale spoločnosti [organizácii]. Nemôžeme dovoliť, aby naše osobné predsudky a zaujatosť definovali podnikový projekt. Ale to sa, bohužiaľ, opakovane stáva".* Dalo sa tiež zhodnotiť, že v niekoľkých prípadoch protekcionizmu znalostí boli prijímatelia transferu presvedčení, že v skutočnosti konajú v záujme organizácie, pričom si neuvedomovali, aký vplyv môže takéto správanie spôsobiť na transfer technológií medzi krajinami. Keď sa táto otázka rozoberala s prijímateľmi, zdôraznilo sa, že osobné správanie spolu so strachom zo zneužitia duševného vlastníctva po jeho zdieľaní boli hlavnými príčinami protekcionizmu znalostí. Účastník výskumu sa k tejto otázke vyjadril takto: *"Ak sa bojíme, že naše [organizačné] duševné vlastníctvo bude zneužité, mali by sme ľudí v organizácii viac informovať o tom, ako duševné vlastníctvo funguje. Nemôžeme vynakladať prostriedky na ochranu duševného vlastníctva a potom znalosti hromadiť. Znalosti bez toho, aby boli zdieľané a aplikované, prakticky neoprávňujú investície, ktoré sme vynaložili na ich vytvorenie".*

- ***Kultúrna hierarchia ako organizačná bariéra***

Hierarchia bola uvádzaná ako problém, keď európske tímy spolupracovali s ázijskými a juhoamerickými tímami na medzinárodnom transfere technológií medzi krajinami. Či už išlo o Čínu, Indiu alebo Brazíliu, odovzdávajúci aj preberajúci čelili nesúladu, pokiaľ ide o otvorenosť komunikácie, čo mohlo súvisieť s rozdielnym vnímaním organizačnej a sociálnej hierarchie v rôznych krajinách.

V krajinách so silne definovanou sociálnou a organizačnou hierarchiou sa ľudia zapojení do transferu technológií báli klásť priame otázky zo strachu, že budú pokarhaní alebo že budú hovoriť nad rámec. Aj keď diskutovaná téma bola nejasná, často sa nekládli jasné otázky. Ako uviedol jeden z účastníkov výskumu, *"mali sme pravidelné stretnutia, na ktorých sme diskutovali o aktuálnom stave transferu technológií. Keď sa však stretnutia konali za prítomnosti rôznych hierarchií v miestnosti, technickí experti nevyjadrovali svoje názory otvorene a mierne súhlasili so svojimi organizačnými* *nadriadenými. To nám vôbec nepomohlo. Potom som zorganizoval samostatné stretnutia s technickým tímom bez ich nadriadených, aby mohli otvorene hovoriť".* Niektorí transférni pracovníci s dlhoročnými skúsenosťami v medzikultúrnej hierarchii presadili v tímoch pre transfer technológií pravidlo, že sa majú klásť otázky, práve preto, aby povzbudili všetkých v tíme bez ohľadu na spoločenské alebo organizačné usporiadanie, aby si vyjasnili svoje pochybnosti, keď sa objavia. Ako povedal jeden z respondentov, *"každý [pracovný] deň bolo prvých tridsať minút určených na kladenie otázok. Žiadna otázka nebola príliš jednoduchá, príliš zložitá alebo príliš hlúpa.".* Tí, ktorí zaviedli takúto prax, mohli nájsť spôsob, ako problém obísť. To sa však nedalo presadiť všade na začiatku procesov transferu technológií, a preto tento problém často rezonoval pri diskusii o medzinárodnom transfere technológií medzi krajinami v žiaruvzdornom priemysle.

- ***Nehodnotenie času – plán***

Táto výzva bola zdôraznená pri transfere technológií s Južnou Amerikou, ale bola naznačená aj všeobecne pre všetky krajiny zapojené do transferu technológií. Rozdielne prístupy k riadeniu času spôsobené regionálnymi kultúrami a zvyklosťami sa považovali za faktory, ktoré ovplyvňujú priebeh medzinárodného transferu technológií. Účastníci výskumu zdôraznili význam dodržiavania časového plánu pri práci na medzinárodnom transfere technológií. Ako povedal jeden z účastníkov výskumu, "*rešpektovanie času znamená rešpektovanie ľudí. Ak nerešpektujete čas a časový plán projektu, riskujete projekt, plytváte organizačnými zdrojmi a zahadzujete úsilie všetkých členov tímu. Čas sú peniaze - staré, ale stále pravdivé".* Pri pohľade na zozbierané údaje autor identifikoval nesúlad v očakávaniach v súvislosti s riadením času, pričom niektoré regióny čelili väčšej kritike ako iné. Zaujímavé je, že nešlo o univerzálny fenomén Západ verzus Východ alebo Sever verzus Juh. Účastníci výskumu zapojení do transferu technológií naprieč Indiou a Čínou mali menšie problémy s riadením času, kde údajne riadenie času fungovalo dobre. Nesúlad v riadení času, keď sa časový harmonogram transferu technológií predĺžil na viac ako dvojnásobok plánovaného, vytváral prekážky viac ako strata času a peňazí. To údajne spôsobilo frustráciu a nespokojnosť v tíme pre transfer technológií. Okrem toho, keď sa členovia tímu pre transfer technológií presunuli na iné projekty alebo prešli na iné úlohy, predĺžené časové harmonogramy spôsobili nezáujem, čo v niektorých prípadoch viedlo k tomu, že transfer technológií upadol do útlmu.

- ***Neochota zdieľať a učiť sa***

Transfer technológií si podľa svojej definície vyžaduje tok myšlienok, poznatkov a technológií z miesta pôvodu na miesto použitia. Tento tok sa narúša, keď ľudia a tímy zapojené do prenosu technológií nie sú ochotní zdieľať poznatky alebo nie sú ochotní naučiť sa niečo nové. To bolo zjavné na strane odovzdávajúceho aj preberajúceho. Jednotlivci, ktorí vystupovali ako odovzdávajúci, sa kvôli niektorým negatívnym predchádzajúcim skúsenostiam spojeným so strachom zo zneužitia zdieľaných znalostí a technológií niekedy nechceli podeliť o celú odovzdávanú technológiu. Keď si ostatní členovia tímu všimli túto neochotu podeliť sa o technológiu a znalosti, snažili sa tento problém riešiť diskusiou v rámci svojich tímov. Niekedy sa to podarilo a niekedy nie. Ako sa vyjadril jeden z účastníkov výskumu, *"nie je to [vedomosti a technológia] osobný majetok. Je to majetok organizácie. Neprináša nám to nič dobré, keď to tu leží na policiach. Technológia musí ísť von, tam, kde ju ľudia môžu použiť na zvýšenie obchodnej činnosti. Musíme prerásť náš strach z vlastného tímu. Všetci sme jedna spoločnosť."*

- ***Technologický dumping***

Ďalšou výzvou, s ktorou sa stretávame pri medzinárodnom transfere technológií v žiaruvzdornom priemysle, bola výzva, ktorá rezonuje s prehľadom literatúry. Je to situácia, keď sa tímy pre transfer technológií zameriavajú viac na geografické premiestnenie technológie namiesto kultúrneho premiestnenia a prispôsobenia technológie. Ako povedal jeden z účastníkov výskumu, *"človek by očakával, že študenti histórie budú vedieť lepšie, ako opakovať problémy dobre známe z minulosti. Ale, žiaľ, ani teraz sa nám [ľuďom] nedarí poučiť sa z minulosti. My [transferátori technológií] musíme posúdiť situáciu na cieľovom mieste. Aké sú ich zdroje? Aké sú ich silné stránky? Aké sú ich obmedzenia?". K tomu* ďalší účastník výskumu uviedol: *"To, čo funguje vo výskumnom laboratóriu v Spojených štátoch alebo v Európe, nemôže automaticky pasovať do Indie, Číny, Brazílie. Alebo aj medzi európskymi či americkými krajinami, výrobné zariadenia sa často navzájom veľmi líšia. Nemôžete tam jednoducho ísť a vyhodiť technológiu. Takýto transfer je znakom neskúsenosti, naivity a unáhlenosti."*

- ***Vykonávanie polovičnej práce a očakávanie plného zisku***

Ďalšou výzvou, ktorá bola identifikovaná v tejto štúdii, bola dôležitosť, ktorú organizácia prikladá transferu technológií z hľadiska prideľovania zdrojov. Účastníci výskumu uviedli, že transfer technológií je práca, ktorá si vyžaduje plné sústredenie zúčastnených členov tímu. Jeden z účastníkov výskumu to zdôraznil slovami: *" Transfer technológií medzi krajinami je veľmi náročný na zdroje, najmä ak je cieľom, aby bol transfer úspešný v plánovanom čase. Potrebujete dobrých ľudí, ktorí pracujú s plným sústredením na projekt [transferu]. A potrebujete dobré nástroje. Nie je to niečo, v čom sa môžu ľudia babrať vo svojom voľnom čase".* Šetrné plánovanie pracovnej sily uvádzali účastníci výskumu ako jav, s ktorým sa často stretávali v počiatočnej fáze transferu technológií. Keď sa transfer technológií dostal do slepej uličky kvôli nedostatku pracovnej sily, pridali sa ďalšie zdroje. To síce pomohlo v nasledujúcej fáze transferu technológií, ale málokedy dokázalo nahradiť stratený čas. Tento problém sa často uvádzal v súvislosti s pracovnou silou, ale niektorí účastníci výskumu ho rozšírili na všeobecné prideľovanie zdrojov vrátane vybavenia, hardvéru, softvéru a odbornej prípravy.

Ďalším aspektom, ktorý bol uvedený a dobre zapadá do tejto kategórie, je problém, ktorému čelia tímy pre transfer technológií, keď sa organizácia alebo jej časti vyhýbajú videniu skutočného obrazu a tvrdej reality. Ako sa vyjadril jeden z účastníkov výskumu, " *niekedy vidíme [organizácia] len to, čo chceme vidieť. Chtiac-nechtiac vidíme len polovicu obrazu a vyhýbame sa zlým alebo nepríjemným aspektom. Tie však v neskoršej fáze transferu technológií zasiahnu silnejšie. Niekedy sme mimo rozpočtu alebo mimo plánovaného časového harmonogramu. Niekedy sa dodávateľ oneskorí. Musíme sa však naučiť prijať realitu, aby sme mohli rýchlo konať"*. Tým sa oneskorila reakcia, čo spôsobilo, že transfery technológií boli nákladnejšie alebo v najhoršom prípade boli úplne vyradené.

- ***Neštandardizované nástroje a postupy***

Jednou z výziev, ktorú účastníci výskumu zdôraznili vo všetkých rozhovoroch, bolo úsilie potrebné na cezhraničný prenos technológií s použitím neštandardizovaných nástrojov a zariadení. Či už ide o hardvérové výrobné zariadenia, ako sú lisy, miešačky alebo pece, softvérové a digitálne nástroje, ako je plánovanie podnikových zdrojov a nástroje na riadenie znalostí, alebo všeobecné procesy, ako je kontrola kvality, plánovanie výroby, vykazovanie údajov a pod. Neštandardizované nástroje si okrem odovzdávajúceho a preberajúceho vyžadujú aj jednotlivcov a tímy na oboch stranách, ktoré venujú čas pochopeniu takýchto nástrojov a výmene informácií. Keď sa takéto zdroje, ktoré by mohli preklenúť neštandardizované nástroje a procesy, neplánovali na začiatku, negatívny vplyv sa prejavil neskôr v podobe oneskoreného alebo neúspešného prenosu technológií. Ako uviedol jeden z účastníkov výskumu: " *V niektorých prípadoch je možné implementovať štandardizované nástroje, v iných prípadoch to nie je v rámci transferu technológií. Dôležité je však na začiatku vypočítať riziko, ktoré môžu mať takéto neštandardizované nástroje na transfer. Nie je nič zlé na tom, keď sa človek zmieri s problémom a v správnom čase požiada o pomoc". K tomu sa* pridal ďalší účastník výskumu, ktorý sa podelil o názory na problémy spojené s neštandardizovanými nástrojmi slovami: *"Keby sme vedeli, že tieto rôzne systémy môžu mať taký veľký vplyv na náš projekt [transferu technológií], požiadali by sme o viac zdrojov. Nikto na to nemyslel. Výrazne to zdržalo náš projekt [transferu technológií] a nakoniec sme aj tak museli prijať úplne iné riešenie, ako sme plánovali na začiatku. Najlepšie by bolo, keby sme mali všade [v rámci organizácie] štandardizované nástroje. To však nemôžeme mať. A musíme to akceptovať. Ale nemôžeme to ani ignorovať".*

- ***Kultúrna paradigma***

Pri porovnávaní jednoduchosti a náročnosti transferu technológií cez rôzne geografické hranice a pri porovnávaní pozorovaní s predtým prezentovanými Hofstedeho a GLOBE kultúrnymi dimenziami bola v tejto štúdii zaznamenaná kultúrna paradigma. V tejto štúdii boli zozbierané skúsenosti s transferom technológií z Rakúska, Brazílie, Číny, Nemecka, Írska, Nórska a Spojených štátov amerických. Účastníci výskumu zo strednej Európy sa pri výmene skúseností s individuálnymi a kolektívnymi skúsenosťami s transferom technológií v rôznych geografických regiónoch zhodli na tom, že pre nich sa transfer technológií s Čínou vyznačoval výraznou jednoduchosťou transferu v porovnaní s inými geografickými lokalitami. Na opačnom póle bolo Nórsko, ktoré bolo jednohlasne označené za najnáročnejší región pre transfer technológií spomedzi skúmaných regiónov.

Pri ďalšej analýze tohto paradoxu je geografická vzdialenosť medzi strednou Európou a Čínou oveľa väčšia ako medzi strednou Európou a Nórskom. Aj kultúrne zložky, ako sú jazyk, jedlo a náboženstvo, sa medzi strednou Európou a Čínou líšia viac ako medzi Nórskom a strednou Európou. Štúdia ukázala, že napriek väčšej geografickej vzdialenosti a odlišným kultúrnym aspektom ochota učiť sa, vymieňať si myšlienky a spolupracovať na transfere technológií funguje v Číne výnimočne dobre . Ako vyzdvihol jeden z účastníkov výskumu skúsenosti s transferom technológií medzi Európou a Čínou, *"bolo to perfektné! Všetko, čo sme chceli realizovať, sme mohli realizovať spoločne. Veľmi kooperatívne, spolupracujúce a podporujúce. A čo je najdôležitejšie, neexistovali žiadne predsudky ani zaujatosť"*. Ďalší účastník výskumu uviedol, že v porovnaní s Indiou a Južnou Amerikou bola práca v Číne bezpečnejšia, a spomenul: "*Bezpečnosť je dôležitá. Ak sa musím stále obzerať cez plece a moja myseľ je stále plná strachu, myslím si, že nemôžem podať najlepší výkon. Počas rokov práce v Číne som sa nikdy necítil nebezpečne"*. To, že prenos technológií medzi Európou a Čínou fungoval dobre, neznamená, že neexistovali žiadne problémy. Ako povedal jeden z účastníkov výskumu: "*V Číne sa musíte naučiť a rešpektovať hierarchiu. A treba podporovať tímovú kultúru, v ktorej sa každý otvorene pýta bez strachu, že stratí tvár. A to musíte praktizovať každý deň. A musíte mať štruktúrovaný prístup. Ak sa vám to podarí, môžete pracovať harmonicky a hladko si vymieňať myšlienky a poznatky."*

Na druhej strane, pozorovania týkajúce sa transferu technológií s Nórskom odhalili vyššiu mieru problémov, ktorým sa pri transfere technológií čelilo. Problémy, ktoré boli uvedené, boli konkrétne spojené s ľudským aspektom práce s tímami v Nórsku. Účastníci výskumu uviedli ako hlavné výzvy nedostatočnú spätnú väzbu, otvorenú výmenu nápadov a ochotu otvorene spolupracovať. Ako uviedol jeden z účastníkov výskumu: "*Robil som školenie v Nórsku a po školení som nedokázal zhromaždiť, či tamojší tím pochopil, čo som povedal, či niektoré časti školenia treba zopakovať, lepšie vysvetliť alebo či bolo všetko jasné. Neboli tam žiadne vyjadrenia. Bolo to, akoby som nevedel čítať z ich tvárí"*. Ďalší účastník výskumu, ktorý pracoval na transfere technológií v niekoľkých geografických regiónoch, k tomu dodal: *"Na začiatku to bola pre mňa najväčšia výzva. Ale pomaly som sa naučil, že musím vidieť ďalej ako len na obmedzenia. Pri práci tam musíte hovoriť, žiadať o spätnú väzbu, žiadať o spoluprácu. Ak sa nepýtate, tak sa to nestane"*.

Dalo by sa povedať, že rozdiely medzi Čínou a Nórskom možno pripísať paradigme Východ-Západ. Ale kultúrna paradigma, ktorá bola pozorovaná v tejto štúdii, ďaleko presahuje tieto dve krajiny. Rozhovory s účastníkmi výskumu, ktorí sa podieľali na transfere technológií na viacerých geografických miestach, ukázali, že transfer technológií dokonca medzi Rakúskom a Nemeckom, Rakúskom a Južnou Amerikou bol náročnejší ako s Čínou. Jednou z krajín, ktorá údajne poskytovala priaznivú pôdu pre transfer technológií, bolo Írsko. Pri pohľade na tieto skúsenosti boli účastníci rozhovorov opäť pozvaní na dialóg s cieľom pochopiť tento kultúrny paradox. V tomto dialógu jeden z účastníkov výskumu zhrnul tento jav slovami: *"Transfer technológií nikdy nie je jednoduchý proces. V transfere technológií sú dve dôležité zložky - ľudia a technológie. A aby transfer fungoval, musia byť ľudia ochotní technológiu preniesť a technológiu si osvojiť. Musia sa pozerať nad rámec osobných a regionálnych kultúr, predsudkov a obmedzení. Musia myslieť ako globálna organizácia so spoločnou organizačnou kultúrou. Niektoré regióny to dokážu lepšie ako iné. Niektorí jednotlivci to robia lepšie ako iní. A práve to odhaľuje regionálny paradox".*

Riešenie tretej výskumnej otázky - Aké sú získané poznatky pre zlepšenie transferu technológií v žiaruvzdornom priemysle?

V tejto časti je rozpracovaná teória vytvorená na riešenie tretej výskumnej otázky. Názov teórie je *"Získané skúsenosti - posúdiť, spolupracovať, vyhodnotiť. Vytvorenie organizačnej kultúry transferu technológií"*. Táto teória sa skladá z celkovo štyroch zložiek, z ktorých každá je zvýraznená v štyroch podkapitolách nižšie.

- ***Pripravte ľudí***

Pripraviť nielen odovzdávajúceho, ale aj prijímateľa - vzhľadom na to, že cezhraničný prenos technológií je dvojstranným technologickým dialógom, je dôležité pripraviť nielen odovzdávajúceho, ale aj prijímateľa na otvorenie sa a vzájomnú spoluprácu. Bežnou praxou v nadnárodných spoločnostiach pri vysielaní kvalifikovaných pracovníkov alebo expatriantov do inej lokality na účely transferu technológií je ponúknuť týmto expatriantom školenie v oblasti jazykových a medzikultúrnych aspektov. Často sa však prehliada, že transferujúci, v tomto prípade expatriant, je len jednou stranou procesu transferu technológií. Je užitočné pripraviť na nadchádzajúcu kultúrnu a technologickú zmenu aj vyslanca. Táto koncepcia vychádza z myšlienky, že transfer technológií je bilaterálny, a nie jednostranný proces. Ako uviedol jeden z účastníkov výskumu, *"jazyková príprava je v niektorých regiónoch nepochybne dôležitá. Ale predovšetkým by mali tímy pre transfer* *technológií na oboch stranách viac hovoriť, klásť viac otázok a žiadať vysvetlenie v prípade pochybností. Mali by sa naučiť radiť sa a odlišovať"*. Príprava ľudí zahŕňa aj prípravu organizácie, a to tak, že sa zamestnancom vštepí zmysel pre organizačnú kultúru, ktorá zjednocuje tímy z rôznych krajín napriek regionálnym kultúrnym rozdielom. Jeden z účastníkov výskumu to zdôraznil slovami: "*Pri transfere technológií sú dve dôležité zložky - ľudia a technológie. A aby transfer fungoval, musia byť ľudia ochotní technológiu preniesť a technológiu si osvojiť. Musia sa pozerať nad rámec osobných a regionálnych kultúr, predsudkov a obmedzení. Musia myslieť ako globálna organizácia so spoločnou organizačnou kultúrou"*.

Ďalším aspektom, ktorý často rezonoval v rozhovoroch, bola potreba dodržiavať časový plán pri transfere technológií. Napriek regionálnym a kultúrnym rozdielom, ktoré poznačili riadenie času a dochvíľnosť v rôznych geografických regiónoch, účastníci výskumu viackrát zdôraznili dôležitosť riadenia času pri transfere technológií. Ako povedal jeden z účastníkov výskumu, "*rešpektovanie času znamená rešpektovanie ľudí. Ak nerešpektujete čas a časový harmonogram projektu, riskujete projekt, plytváte organizačnými zdrojmi a zahadzujete úsilie všetkých členov tímu"*.

- ***Prispôsobenie technológie***

Druhým poučením, ktoré možno zo štúdie vyvodiť, je, že pri plánovaní a realizácii transferu technológií je potrebné technológie prispôsobiť regiónu, ktorý ich prijíma. Technologický dumping alebo jednoduché geografické premiestnenie technológií nedokáže využiť plný potenciál technológií v rôznych regiónoch. Tento výsledok sa zhoduje aj s príkladmi uvedenými v prehľade literatúry, ktoré poukazujú na výhody kultúrneho prispôsobenia technológií v porovnaní s geografickým premiestnením technológií pri medzinárodnom transfere technológií medzi krajinami. Ako uviedol jeden z účastníkov výskumu, *"dalo by sa očakávať, že študenti histórie budú lepšie vedieť, ako opakovať problémy dobre známe z minulosti. Ale žiaľ, ani teraz sa nám [ľuďom] nedarí poučiť sa z minulosti. My [transferátori technológií] musíme posúdiť situáciu na cieľovom mieste. Aké sú ich zdroje? Aké sú ich silné stránky? Aké sú ich obmedzenia?"* Ďalší účastník výskumu to ďalej rozvinul slovami: *"Musíme [transferátor technológií] posúdiť silné stránky každého regiónu a plne ich využiť počas transferu technológií. Každý región má iné silné stránky. Niektoré sú dobré v automatizácii, niektoré sú rýchlejšie pri ručnej manipulácii, niektoré majú v blízkosti svojej lokality k dispozícii* *rôzne suroviny, niektoré zariadenia môžu byť v niektorých regiónoch povinné alebo dokonca zakázané zákonom".*

- ***Štandardizácia nástrojov***

Účastníci výskumu zdôraznili, že štandardizované nástroje a procesy v rámci organizácie by mohli podporiť medzinárodný prenos technológií medzi krajinami. Taktiež bolo uvedené, že štandardizácia nástrojov a procesov nie je vždy v rámci transferu technológií, ale je potrebné ju zvážiť na začiatku, pretože neštandardizované nástroje a procesy si môžu vyžadovať dodatočné zdroje, aby transfer technológií fungoval. Ako uviedol jeden z účastníkov výskumu " *V niektorých prípadoch je možné zaviesť štandardizované nástroje, v iných prípadoch to nie je v rámci transferu technológií. Na začiatku je však dôležité vypočítať riziko, ktoré môžu mať takéto neštandardizované nástroje na transfer. Nie je nič zlé na tom, keď sa človek zmieri s problémom a v správnom čase požiada o pomoc".*

Štandardizácia nástrojov a procesov sa však musí uskutočniť s ohľadom na regionálne a globálne normy, zákony a politiky. Ako zdôraznil jeden z účastníkov výskumu: *"Bezpochyby majú rôzne krajiny rôzne zákony a politiky a potom sú tu globálne zákony a organizačné politiky. O to dôležitejšie je vyhodnotiť regionálne a organizačné politiky, vytvoriť transparentnosť a definovať jasné procesy, ktoré môžu navigovať transfer technológií. Ak v tomto* ohľade *neexistuje jasnosť, vzniká počas transferu technológií toľko nejasností".*

- ***Dokončenie procesu***

Ďalším ponaučením, ktoré účastníci výskumu uviedli, bolo zaujať holistický prístup a pozrieť sa na celý proces, a nie len na jeho časti. Jeden z príkladov v tejto súvislosti uviedol účastník výskumu: *"Jedna z vecí, ktorú som sa naučil zo svojej skúsenosti, je pozrieť sa na náklady pre zákazníka, a nielen na výrobné náklady, a to v počiatočnej fáze prenosu technológie. V niektorých regiónoch sú napríklad dovozné clá alebo regionálne dane také vysoké, že aj pri nižších výrobných nákladoch z* *transferu technológií môžu byť náklady pre zákazníka vyššie. To by mohlo celý transfer technológií výrazne spochybniť"*. Ďalší účastník výskumu to ešte viac priblížil, keď dodal: *"Ak je cieľom transferu technológií výrobok, potom by malo byť cieľom vytvoriť výrobok, ktorý sa dá nielen vyrábať v inom regióne, ale je aj predajný mimo tohto regiónu"*. K tomuto aspektu účastníci výskumu ďalej dodali a zdôraznili, ako by sa to dalo dosiahnuť, že je dôležité od začiatku vytvoriť multifunkčné tímy pre transfer technológií, ktoré by zahŕňali rôzne zainteresované strany, ako sú technickí experti, výrobné zariadenia, daňové a finančné tímy, výskum a vývoj. To by mohlo podporiť budovanie holistického prístupu k transferu technológií.

- ***Plánovanie, vykonávanie a sledovanie***

Ako uviedli účastníci výskumu, kľúčom k plánovaniu medzinárodného transferu technológií medzi krajinami je holistický prístup, zapojenie multifunkčného tímu a posúdenie regionálnych právnych predpisov, politík a obmedzení. Samotné plánovanie bez riadneho vykonania však nestačí. Transfer technológií, podobne ako akýkoľvek iný projekt, je potrebné rozdeliť na jasné úlohy, priradiť zodpovedné osoby a časový harmonogram a v pravidelných intervaloch kontrolovať priebeh jednotlivých úloh. Zdôrazňujúc to ako kľúčové ponaučenie z medzinárodného transferu technológií, účastník výskumu uviedol: *"Celý transfer technológií musíme rozdeliť na malé, jasne definované úlohy s jasne určenými úlohami, zodpovednosťami a časovým rámcom. A musíme pravidelne sledovať pokrok. Je to veľmi dôležité. Bez sledovania je to ako s malou plachetnicou v oceáne, nemôžete kontrolovať, kam smerujete"*. Ďalší účastník výskumu dodal: *"Sledovanie činnosti prináša disciplínu. Zabezpečuje vykonávanie. Bez sledovania činnosti je to len plán s chaotickým vykonávaním"*.

Výsledky

Cieľom tejto štúdie bolo analyzovať medzinárodný transfer technológií medzi krajinami v žiaruvzdornom priemysle. Štúdia literatúry ukázala históriu a vývoj technologického dialógu v ľudskej civilizácii. História medzinárodného transferu technológií je bohatá na príklady úspešných aj neúspešných pokusov, a to v rôznych technologických disciplínach, ako je poľnohospodárstvo, zavlažovanie, železnice, elektrina, telegraf, telekomunikácie a pod. Hoci je transfer technológií známy už niekoľko storočí, je aktuálny aj dnes, a to z dvoch dôvodov - po prvé, technológie, ktoré sa majú prenášať, sa rýchlo menia a po druhé, rýchlosť transferu technológií sa zvyšuje. Preto je potrebné prispôsobiť prístup potrebný na medzinárodný transfer technológií súčasnej dobe. V tejto štúdii sa analyzoval transfer technológií v žiaruvzdornom priemysle z pohľadu jednotlivcov, ktorí boli priamo zapojení do medzinárodného transferu technológií medzi krajinami v žiaruvzdornom priemysle. Žiaromateriály sú výrobky, ktoré sa používajú v priemyselných procesoch pri vysokých teplotách, ako je výroba ocele, cementu, skla, hliníka, medi atď. Keďže celosvetový dopyt po týchto priemyselných výrobkoch rastie, rastie aj dopyt po vysoko výkonných žiaruvzdorných materiáloch, čo si vyžaduje cezhraničný prenos technológií v žiaruvzdornom priemysle.

Táto štúdia sa riadila klasickým alebo "glaserovským" prístupom Grounded Theory. Vzhľadom na nedostatok literatúry o transfere technológií v žiaruvzdornom priemysle sa autor zameral na preskúmanie rôznych aspektov tohto javu. Glaserova Grounded Theory bola zvolená, pretože podporuje exploratívnu štúdiu a pomáha pri vytváraní teoretického opisu skúmaného javu. Okrem toho sa Glaserova zakotvená teória viac zameriava na pochopenie a interpretáciu údajov z pohľadu účastníkov výskumu bez nadmernej kvantifikácie alebo nútenej kvantifikácie údajov.

Táto štúdia sa riadila tromi výskumnými otázkami a na riešenie každej z nich bola vytvorená Glaserova zakotvená teória. Výsledky tejto štúdie sú zhrnuté v tabuľke 3.

Tabuľka 3 Súhrnné výsledky analýzy

Výskumná otázka 1	Aké sú základné charakteristiky medzinárodného prenosu technológií medzi krajinami v žiaruvzdornom priemysle? Ktoré technológie sa prenášajú, kto ich prenáša a ako?
Názov vytvorenej teórie	*Teória mnohostranného transferu technológií na rozhraní tradičných prvkov a moderných výziev ľudskej spoločnosti*
Prvky teórie	Súčasné a najmodernejšie technológie - "čo" transferu technológií
	Správni ľudia a správne nástroje sú receptom na úspech - "Ako" a "Kto" v transfere technológií
	Komplexný pohľad na transfer technológií - úplný obraz transferu technológií
Výskumná otázka 2	Akým výzvam čelí medzinárodný transfer technológií medzi krajinami v žiaruvzdornom priemysle?
Názov vytvorenej teórie	*"Výzvy - nesúlad medzi organizačnou kultúrou, geografickými regionálnymi kultúrami a očakávaniami od medzinárodného transferu technológií".*
Prvky teórie	Hádzanie ľudí do hlbokého bazéna
	Znalostný protekcionizmus
	Kultúrna hierarchia ako organizačná bariéra
	Nedocenenie časového plánu
	neochota zdieľať a učiť sa
	Technologický dumping
	Vykonávanie polovičnej práce a očakávanie plného zisku
	Neštandardizované nástroje a postupy
	Kultúrna paradigma
Výskumná otázka 3	Aké sú poznatky pre zlepšenie transferu technológií v žiaruvzdornom priemysle?
Názov vytvorenej teórie	*Získané skúsenosti - posudzovať, spolupracovať, hodnotiť. Vytvorenie organizačnej kultúry prenosu technológií*
Prvky teórie	Pripravte ľudí
	Prispôsobenie technológie
	Štandardizácia nástrojov
	Plánovanie, implementácia a sledovanie

Zdroj: Vytvorené autorom

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