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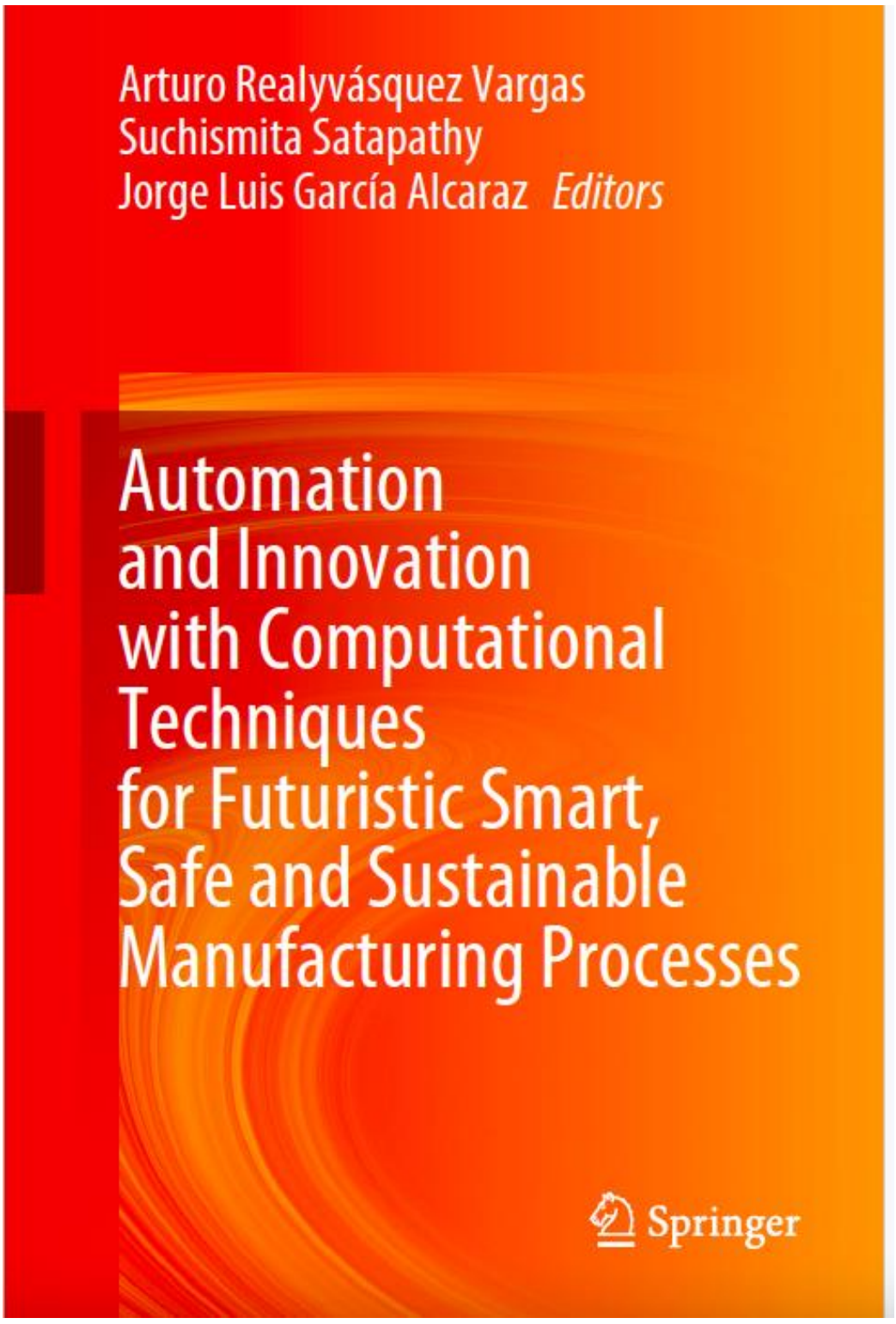

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Contents

Chapter 14
University-Industry Technology Transfer in Developing Countries for Smart Cities

Roberto Frías-Castillo, Julieta Flores-Amador, Roberto Romero-López, and Pilar Pérez-Hernández

Abstract This chapter presents a Technology Transfer Model proposed for the Autonomous University of Ciudad Juarez, Mexico's most important industrial city. The model includes the key managerial, linkage, technological, and research elements required for university–industry (U-I) technology transfer. The convenience of this model is that it takes advantage of the accumulated capabilities in Ciudad Juarez universities to improve the products and processes in manufacturing firms located in the city using technology and knowledge transfer, which could lead to the economic and technological development of the region.

Keywords Technology transfer · Innovation · University-industry linkage · R&D

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14.1 Introduction

Since the last decade, smart manufacturing has been an important issue in this rapidly changing and competitive world, in which innovation and technological-scientific knowledge have played a crucial role in generating innovations. Developing countries usually advance at a limited pace when creating new technologies despite their efforts to design and implement new policies to achieve competitive and innovative capabilities. In countries such as Mexico, Research and Development (R&D) activities are mainly conducted at universities and research centers; thus, it is widely accepted that academia is an important source of innovation that can influence both enterprises and the country's development.

The linkage between universities and industries (U-I) is a fundamental component of the innovation system. It is a network in which many agents interact in a certain industry or economic sector within a specific institutional structure to generate, use, and diffuse technology (Lundvall et al. 2002). Therefore, firms and universities in Mexico collaborate through different channels, such as human resource mobility, joint R&D, consulting, and patents, to obtain several benefits (e.g., product and process innovation, scientific publications, and funding) (De Fuentes and Dutrénit 2016).

Technology transfer (TT) is another U–I interaction channel in which a new knowledge or technology developed at universities is adopted by a firm to enhance a product or process, making the adopting firm more effective and competitive by achieving its production, quality, manufacturing, timing, cost reduction, or customer satisfaction goals. TT involves many elements and attributes from two entities with different cultures, knowledge, objectives, regulatory frameworks, dynamics, and contexts (Bozeman 2000).

This document focuses on Ciudad Juarez, a Mexican city located at the border with the United States. The city's main economic activity is the manufacturing industry, accounting for 2018 2651 units related to this industry (INEGI 2020). Ciudad Juarez has been accumulating economic and human capital for five decades, developing technological and organizational capabilities that potentially can be used to innovate. Additionally, most universities in the city have supported the manufacturing industry through graduate and undergraduate programs and provided solutions and new technological applications for local firms.

Some models of the TT process have been developed in less-developed countries. Some have focused on universities' technology management (IPN 2018; UNAM 2022), the process followed by researchers to generate research (Colciencias 2018; Vásquez Rizo 2010), and the technology transfer process (Jagoda et al. 2010; Junior et al. 2014). This study proposes a new model for technology transfer that includes the perspectives mentioned above, based on the university's technology management process, the researcher's knowledge production process, the process of transferring new knowledge or technology, and the capabilities required to perform TT successfully.

The remainder of this chapter is structured as follows. Section 14.2 describes the theoretical framework of the TT and Ciudad Juárez innovation systems. The proposed model for measuring the TT activity is presented in Sect. 14.3. In Sect. 14.4, the methodology is presented, the case study of the Autonomous University of Ciudad Juárez (UACJ). A brief discussion of the subject is given in Sect. 14.5, based on the partial results of this research. Finally, the conclusions and future work are presented in Sect. 14.6.

14.2 Theoretical Framework and Related Work

This section presents the relevant concepts and similar work related to the model proposed in this chapter.

14.2.1 Innovation Systems

Innovation systems are institutional structures that support national, regional or local innovation. It requires interaction between the productive sector (firms), the government (policies, public organisms, and development agencies), the scientific sector (universities and research centers), technological mediators (technological clusters, incubators, technology transfer offices), funding (investors), and the public sector (Cooke et al. 1997; Dudin 2013; Lyasnikov et al. 2014; Trippl and Tödtling 2007) (Fig. 14.1).

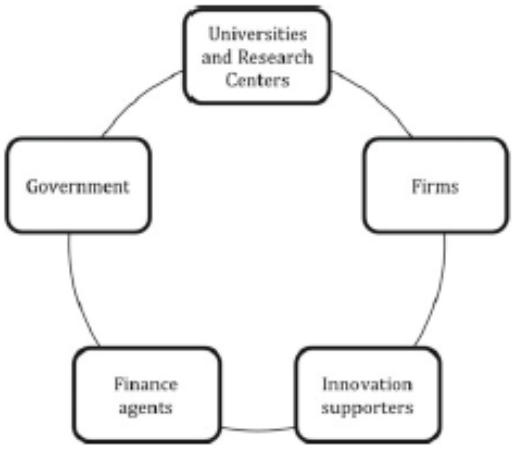

Fig. 14.1 Innovation system agents

In developing countries, national systems are characterized by a lack of absorptive and technological capabilities and the limited creation of new knowledge. Thus, it is important to analyze how innovation-related activities arise and how they adapt to economic and technological environments (Intarakumnerd et al. 2002). According to Llisterri and Pietrobelli (2011), technological change in developing countries is based on accumulative capital and, particularly in Latin American countries, comes from new equipment and machinery acquisition to improve the firm's processes—organizational and service innovations—rather than in product development—technological innovation. At the regional level, innovation systems fulfill the following functions: (a) supply of economic and human resources for innovation within companies; (b) knowledge generation carried out by institutions dedicated to science and technology; (c) interaction and collaboration between agents; (d) specialized knowledge of the companies in the region; and e) the demographics and socioeconomic indicators of the region (Crespi and D'Este 2011).

Aceytuno and Cáceres (2012) affirmed the study and analysis of regional innovation systems as follows: (a) Specialization patterns and innovation levels can vary significantly within different regions of a country or specific territory (De Fuentes and Dutrénit 2013) or transferred to the regions (Economía 2016). This is the case for Ciudad Juarez and the maquiladora industry, which will be presented in further sections.

14.2.2 University-Industry Collaboration

In recent decades, the creation and exchange of knowledge among innovative systems have evolved. First, knowledge is created due to the intrinsic academic aspirations in every discipline. Subsequently, knowledge is produced regarding the needs of industry, government, and society in general (Vega-Jurado et al. 2007).

Since their origins, universities have had two specific missions: (a) profession-oriented, which seeks to train students according to society's needs and opportunities offered by the labor market, and (b) science-oriented, which pursues the generation, application, and distribution of knowledge to improve society (Tocto-Cano et al. 2020; Abu-Naser et al. 2016; Renta Davids 2013).

On the other hand, globalization has changed a firm's perspective on conducting business, as it has been forced to continuously innovate to enhance its performance and quality by reducing its production times and costs (Audretsch et al. 2014). Some firms have not been able to acquire intellectual capital to develop innovation; therefore, they have generated links with research institutions to overcome this situation (Audretsch et al. 2014). Some authors affirm that university-industry collaboration is a subject of interest because it can represent a powerful source of knowledge and innovation (Ankrah et al. 2013; Santoro and Chakrabarti 2002).

Therefore, a third mission has arisen from universities: to become a source of economic and social development agents by supporting activities, such as patenting,

Table 14.1 Stages of U-I collaboration process

Stage	Description
Drivers	The main factors that attract researchers to collaborate with firms are gender and age, previous collaboration experiences, academic level, specialization subject, personal motivations and access to research funding. From the university perspective, relevant factors include the institutional affiliation, the university's mission and strategy, its experience doing TT and the resources (economic and human) that enable it to collaborate
Benefits	Researchers benefit from collaboration by obtaining funding to complete research, the acquisition of lab equipment and new ideas to develop more research that leads to new knowledge, which can result in academic publications, patenting, networking, graduating students, economic incentives and real-life problem solutions
Barriers	They are obstacles for TT to succeed. Technology transfer happens for a reason: the need to enhance the firm's performance through a product improvement or a more efficient process; economic, material and human resources are required to achieve this. Furthermore, barriers to U-I collaboration include different enterprise cultures, management styles, dynamics, goals, ineffective communication, leadership, entrepreneurship, mistrust among agents, the difference in the knowledge level of research groups, and the lack of policies, incentives, funding and appropriate infrastructure (technical and organizational) to perform R&D

licensing, firm incubations, and technology transfer, to take advantage of the knowledge created within non-academic environments (Berbegal-Mirabent et al. 2015; Cervantes 2017; Montecinos and Contreras 2021; Briones et al. 2018).

Universities and research centers are key agents in the innovative development of regions as creators of new knowledge and potential technological solutions to industrial problems; thus, governments have implemented various policies focused on supporting these relationships (Giuliani and Arza 2009). As a result, new university organizational structures have arisen to perform technological management activities, such as technology transfer offices; supporting activities, such as patenting, licensing, I + D contracts, audits, spin-offs creation, and business incubators; and assisting entrepreneurs' assessments, funding searches, and procedures to establish a business (De Fuentes and Dutrénit 2012; Tuunainen 2005).

Some authors have underlined three stages of the U–I collaboration process: drivers, channels, and benefits (Dutrénit et al. 2010). Because this study focused on technology transfer, other channels were not included in the description. Only the researcher/university perspective is described in Table 14.1 (Arza 2010; Bekkers and Freitas 2011; Bozeman et al. 2016; D'Este and Patel 2007; Giuliani and Arza 2009); this research does not include the analysis of the firms' processes and capabilities.

14.2.3 Technology Transfer

TT involves the assessment, adoption, and implementation of technology. TT is defined as the process of transferring technologies, knowledge, skills, and production

impact the region's development and the university. In this sense, this model is generated to take advantage of this opportunity by implementing the necessary policies and functions in the UACJ so that it is administratively prepared to conduct technology transfer projects when needed.

14.6 Conclusions and Future Work

Owing to the current level of rapid technological change and competitiveness, universities and research centers must introduce themselves in the production sector to develop advanced technologies; this is more relevant in developing countries because they are always economically and technologically speaking. In this sense, Mexican universities must design and adopt business-oriented policies and strategies to better understand firm dynamics and market trends. These policies and strategies must focus on results and have quality research control centered on applying the knowledge created by researchers.

The concept of a Smart City originates when technology permeates all human activities, modifying them to such a degree that it can also modify its environment so that the hypothesis proposed at the beginning is accepted. Ciudad Juarez has different challenges for the future and requires technology to solve water supply and electricity problems. In addition to seeking planning and design solutions through the use of new materials for construction, it also requires adopting sustainability criteria should be adopted in terms of solid waste management, wastewater treatment, emission control, implementing management systems, information control, and educational means to make a more efficient government.

An effort to document experiences and good practices in technology transfer is required, which will contribute to the professionalization and construction of a local theory of technology transfer management adapted to the conditions of the region and its institutions. This model is designed to define a robust process for technology transfer from the UACJ to firms in social and productive sectors, considering that Ciudad Juarez has a large manufacturing activity continually evolving technologically.

The next step is to develop recommended strategies, actions, and policies based on the collected information. These will be presented to UACJ to help them improve the institutional and researcher's performance on technology transfer, increasing the impact on local firms' technological development.

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