

# University-Industry Technology Transfer and Technology Transfer Offices in Emerging Economies

José Carlos Rodríguez, Mario Gómez

**Abstract**—The aim of this paper is to get insight on the nature of university-industry technology transfer (UITT) and technology transfer offices (TTOs) activity at universities in the case of emerging economies. In relation to the process of transferring knowledge/technology in the case of emerging economies, knowledge/technology transfer in these economies are more reactive than in developed economies due to differences in maturity of technologies. It is assumed in this paper that knowledge/technology transfer is a complex phenomenon, and thus the paper contributes to get insight on the nature of UITT and TTOs creation in the case of emerging economies by using a system dynamics model of knowledge/technology transfer in these countries. The paper recognizes the differences between industrialized countries and emerging economies on these phenomena.

**Keywords**—University-industry technology transfer, technology transfer offices, technology transfer models, emerging economies.

## I. INTRODUCTION

THIS paper analyzes the process of UITT and TTOs activity in emerging economies. In this regard, some authors have examined the resources needed to achieve optimal conditions for transferring technology from universities to industry [1]. The Technology Transfer Office Model, for example, offers an adequate explanation on the process of UITT phenomenon emphasizing the role played by TTOs in this process [2], [3]. In addition, the Technology Transfer Office Model defines the role played by university scientists, university technology managers and administrators, as well as firms/entrepreneurs when transferring commercial knowledge (technology diffusion) through licensing patents and other forms of intellectual property [2], [3]. The Technology Transfer Office Model is analyzed in this paper to develop a system dynamics model of knowledge/technology transfer in the case of emerging economies.

The main objective of this research is thus to get insight on the barriers found when transferring knowledge/technology from universities to industry in the case of emerging economies. It is assumed in this paper that the stakeholders participating in the process have different motives and behaviors within different environments at the time of transferring technology/knowledge [2], [3].

The research question conducting this study is as follows: How the formation of relationships, networks, or boundary

spanning behavior affects the process of UITT and TTOs performance in the case of emerging economies? In the case of these countries, some forms of collaboration between universities and firms are more important to guarantee successful practices to transfer technology/knowledge from universities to industry [4], [5]. In addition, it is important to keep in mind that intellectual property regimes and TTOs at universities in these countries have had a reactive rather than a proactive approach to technology transfer due to the differences in maturity of technologies [5], [6].

## II. LITERATURE REVIEW

### A. Context of University-Technology Transfer

The Bayh-Dole Act of 1980 focused on two main issues [3] [7]: (i) patenting activity at universities and public research centers, and (ii) the establishment and operation of TTOs. Since then, many universities in the world have established TTOs to manage and protect their intellectual property to exploit and transfer technology/knowledge to industry [8]. Some authors have pointed out that the process of commercializing university technology (e.g. patent and license negotiations with industry) requires substantial resources for intellectual property assistance [1], [9]. In this sense, these authors have suggested the resources needed by TTOs to successfully transfer technology from universities to industry are [1]:

1. A larger multidisciplinary team with commercial experience and links to the financial community;
2. Close public/private contacts willing to invest small to medium-sized amounts of resources;
3. An organization organized as a separate entity with control over triggers to motivate professors to work with it;
4. Sufficient contacts to support the research team during the process of spinning off new companies.

On the other hand, it is possible to find in the literature some theoretical models to explain the process of UITT and TTOs activity at universities [10]. The Technology Transfer Office Model, for example, offers an adequate explanation on these phenomena emphasizing the importance of TTOs to successfully transferring technology/knowledge to industry [2] [3]. In this model, a crucial function of the university-industry technology management should be to identify key organizational issues that promote successful technology/knowledge transfer [2] [3]. Accordingly, the Technology Transfer Office Model defines the role played by TTOs to facilitate commercial knowledge transfers and technology diffusion. In this process, licensing patents and other forms of

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intellectual property resulting from university research (inventions) are at the core of these analyses [2], [3]. The main objective in these analyses is thus to get insight on how some barriers found when transferring technology/knowledge (e.g. stakeholders with different motives and behaviors operating within different environments) can slow down this process [2] [3]. However, the main stakeholders in the process of technology transfer are as follows [2] [3]:

1. University scientists who discover new technologies;
2. University technology managers and administrators who serve as a liaison between academic scientists and industry, and manage the university's intellectual property;
3. Firms/entrepreneurs who commercialize university-based technologies.

On the other hand, the Technology Transfer Office Model agenda raises four important questions [2] [3]:

1. How stakeholders participating in UITT define the outputs of this process;
2. How the formation of relationships, networks, or boundary spanning behavior affect UITT;
3. What are the organizational/managerial barriers to UITT;
4. How organizational factors and managerial behaviors can improve to help facilitate UITT.

In the case of emerging economies, some forms of collaboration between universities and firms are becoming more important to guarantee successful practices in the process of technology transfer to industry and TTOs activity at universities [4], [5]. In these countries, universities are increasingly being viewed as engines of innovation through TTOs [5], [11]. In the same way, in the case of emerging economies, intellectual property regimes and TTOs at universities have had a reactive rather than a proactive approach to technology transfer due to the differences in maturity of technologies [5], [6].

It is worth saying that some authors have pointed out the importance of time and how commercialization practices are carried out to explain the difference between successful (and not successful) TTOs practices at universities in developing countries [5], [12]. In this case, TTOs learn through experimentation and failure and eventually by sharing experiences with other TTOs to improve the technology transfer process [5], [12].

The case of some countries in Latino America, for example, reveals how the process of UITT has been developed in the case of emerging economies, and how TTOs operate at universities in these cases to facilitate the process of technology transfer. However, this paper shows the nature of the stakeholders participating in the process of UITT, the relationships and links between stakeholders participating in this process, and the organizational and managerial barriers found when developing this process. However, this paper contributes to get insight on how some qualitative and quantitative issues characterize the process of UITT and TTOs in the case of emerging economies [13], [14].

### *B. Two Models of Technology Transfer*

Two primary models in relation to UITT and TTOs have emerged to support the technology transfer process:

1. The establishment of an internal institutional department or office (TTOs);
2. The formation of an external company (Commercializing Companies).

The adoption of a specific functioning financial scheme for developing UITT activities at universities define how these models within these activities are carried out at universities [15]. For example, the establishment of an internal office or TTO for transferring technology to industry concerns some specific goals, mainly (i) to provide services to researchers (inventors), (ii) to promote regional economic development, and (iii) to generate incomes to stakeholders participating in this process. The establishment of TTOs at universities implies thus four reasons to advance academic technology transfer [16]:

1. To facilitate the commercialization of research results for the public good;
2. To reward, retain, and recruit high-quality researchers;
3. To build closer ties with industry;
4. To generate income for further research and education, and thus to promote economic growth.

When centralized TTOs are incapable to meet these goals, there are four alternative options for supporting and facilitating technology transfer to industry [15]:

1. An external organization;
2. An individual and small internal TTO;
3. One TTO able to serve a consortium of several public research organizations in a region
4. An office funded by the national government or a philanthropy institution that could serve as TTO for several public research institutions.

However, if the establishment of an internal office for technology transfer does not fulfill its objectives, the commercializing company model emerges as an alternative scheme to facilitate UITT activities [17].

As some authors have already suggested, the commercializing company model explains the generation of cash flow through a variety of related business activities (e.g. consulting, conference management, professional development courses, and so forth) [15]. In this scheme, commercializing companies and TTOs activities should be understood as complementary in the process of technology transfer. The commercializing company model has been adapted to the process of UITT in many countries such as Australia, India, Japan, South Africa and Russia [17]. In this sense, from the perspective of the commercializing company model, there are four main participating actors involved in the process of technology transfer:

1. University scientists who discover new technologies;
2. University technology managers and administrative personal who serve as a link between academic scientists and industry;
3. Commercializing firms that manage university's intellectual property;

4. Entrepreneur firms who commercialize university-based technologies.

Importantly, comparing to TTOs, commercializing companies are for-profit corporations owned by universities and driven by business objectives. Their mission is to generate added value from research results obtained by university researchers. In this sense, the main functions of the commercializing companies are as follows [17]:

1. Identification of the most promising technologies;
2. Evaluation of commercial potential;
3. Intellectual property protection;
4. Design of a plan to create added value;
5. Early investments toward commercialization;
6. Search for investors;
7. Create spin-offs;
8. Negotiate licenses;
9. Manage the patent portfolio.

However, there must be a link between TTOs and the commercializing companies. In fact, collaboration between the TTOs and the commercializing companies is a key issue to successfully transfer technology from universities to industry.

### C. Complex Systems

In this paper, a systemic approach is adopted to discuss the process of technology transfer and TTOs creation. This approach allows exploring the theoretical and empirical basis of these phenomena in that it contributes to get insight on the nature of the relationships established between stakeholders. In this sense, complex systems are characterized as self-organizing, interdependent, and co-evolving systems [18]. Self-organizing system means that systems are formed by a large number of elements that make up a system [18]-[20]. Interdependent system means that decisions and actions of one agent may affect other agents' decisions and actions [18]-[20]. This feature also suggests that the behavior of every individual depends on the behavior of other individuals within the same system [18]. Finally, evolution of a system is always to some extent dependent on the evolution of other systems or agents [18]. Four components set up a system and its structure [21]:

1. They are processes created through using stock-flow chains;
2. They are characterized by information feedbacks;
3. They are subject to several policy implications;
4. They contain many time delays.

The challenge when modelling system dynamics models is to establish the boundaries of a system to capture and reproduce the actual behavior of it.

### III. A THEORETICAL FRAMEWORK OF UITT AND TTOs

The Technology Transfer Office Model emphasizes the role played by TTOs in the process UITT [2], [3]. A crucial function of the university-industry technology management should be to identify key organizational issues that promote successful knowledge transfer. University management of intellectual property through TTOs is however a relatively

new phenomenon. The role played by TTOs as the activities that facilitate commercial knowledge transfers (or technology diffusion) through licensing patents or other forms of intellectual property resulting from university research (inventions) [2], [3]. The main objective in this model is thus to get insight on cultural and informational barriers found when transferring knowledge, given that the stakeholders in this process have different motives and behaviors operating within different environments [2], [3]. In relation to this approach, the main stakeholders in the process of UITT are as follows [2] [3]:

1. University scientists who discover new technologies;
2. University technology managers and administrators who serve as a liaison between academic scientists and industry, and manage the university's intellectual property;
3. Firms/entrepreneurs who commercialize university-based technologies. Fig. 1 shows a general model of UITT and TTOs creation from the perspective of the Technology Transfer Office Model [2] [3].

The Technology Transfer Office Model considers that the primary motive to technology transfer is to safeguard and to market the university intellectual property to private firms [2], [3]. In addition, this model includes the analysis of securing additional research funds for universities via royalties and licensing fees, sponsoring research agreements, and promoting technological diffusion [2], [3]. Consequently, the Technology Transfer Office Model contributes to get insight on how stakeholders participating in UITT, how the formation of relationships, networks, or boundary spanning behavior affect UITT, what are the organizational/managerial barriers to UITT, and how organizational factors and managerial behaviors can improve to help facilitate UITT [2], [3]. To gain insight on these questions, from the Technology Transfer Office Model can be established some important propositions [2], [3]. Nevertheless, the model developed in this paper may also support the propositions resulting from the Technology Transfer Office Model [2], [3].

### IV. CONCLUSIONS

This paper analyzes the process of technology transfer and the creation of TTOs in emerging economies. In this regard, this paper discusses the resources needed to boost TTOs' activities. However, these phenomena are quite different in the case of emerging economies. It takes into account the Technology Transfer Office Model as a theoretical framework to develop a system dynamics model of UITT and TTO activity in emerging economies. This model allows establishing some important propositions in relation to these phenomena. Finally, in relation to the question raised in this paper, the structure of the technology transfer and TTOs system in the case of emerging economies, suggests that the structure of the system determines its behavior.

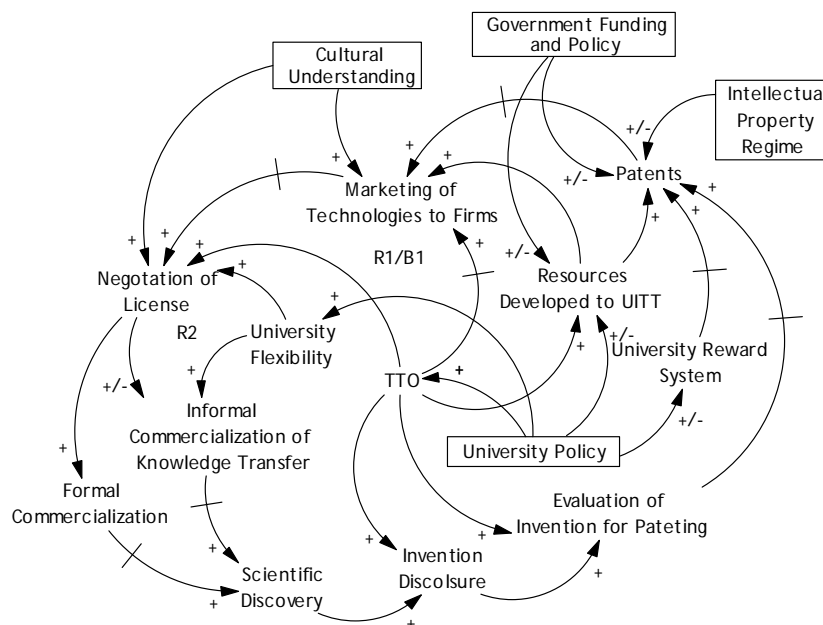


Fig. 1 A CLD of UITT and TTOS in Emerging Economies

REFERENCES

[1] B. Clarysse, M. Wright, A. Lockett, E. van de Velde, and A. Vohora, "Spinning out new ventures: A typology of incubation strategies from European research institutions", *Journal of Business Venturing*, Vol. 20, pp. 183-216, 2005.

[2] D. S. Siegel, D. A. Waldman, L. E. Atwater, and A. N. Link, "Commercial knowledge transfers from universities to firms: improving the effectiveness of university-industry collaboration", *The Journal of High Technology Management Research*, Vol. 14, pp. 111-133, 2003.

[3] D. S. Siegel, D. A. Waldman, L. E. Atwater, and A. N. Link, "Towards a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies", *Journal of Engineering and Technology Management*, Vol. 21, pp. 115-142, 2004.

[4] M. Guerrero, D. Urbano, A. Fayolle, M. Klofsten, and S. Mian, "Entrepreneurial universities: emerging models in the new social and economic landscape", *Small Business Economics*, Vol. 47, No. 3, pp. 551-563, 2016.

[5] G. Secundo, C. De Beer, and G. Passiante, "Measuring university technology transfer efficiency: a maturity level approach", *Measuring Business Excellence*, Vol. 20, No. 3, pp. 42-54, 2016.

[6] J. C. Rodríguez, and M. Gómez, "Innovation trends in NAFTA countries: an econometric analysis of patent applications", *Journal of Technology Management & Innovation*, Vol. 6, No. 3, pp. 116-125, 2011.

[7] A. N. Link, and J. T. Scott, "Opening the ivory tower's door: an analysis of the determinants of the formation of U. S. university spin-off companies", *Research Policy*, Vol. 34, pp. 1106-1112, 2005.

[8] A. D. Lockett, and M. Wright, "Resources, capabilities, risk capital and the creation of university spin-out companies", *Research Policy*, Vol. 34, pp. 1043-1057, 2005.

[9] C. G. Brush, P. G. Greene, and M. M. Hart, "From initial idea to unique advantage: the entrepreneurial challenge of constructing a resource base", *Academy of Management Executive*, Vol. 15, pp. 64-78, 2001.

[10] J. C. Rodríguez, *University-Industry Technology Transfer in Canada: An Analysis of Stakeholders' Performance Using System Dynamics*. Thesis Dissertation, École des Sciences de la Gestion, Université du Québec à Montréal (UQAM), 2010.

[11] G. D. Libecap, Introduction, *University Entrepreneurship and Technology Transfer*, Series on Advances in the Study of Entrepreneurship, Innovation and Economic Growth, Emerald, 2005.

[12] D. A. Weckowska, "Learning in university technology transfer offices: transactions-focused and relation-focused approaches to commercialization of academic research", *Technovation*, Vols. 41-42, pp. 62-74, 2015.

[13] E. G. Carayannis, T. D. Barth, and D. F. J. Campbell, "The Quintuple Helix innovation model: global warming as a challenge and driver for innovation", *Journal of Innovation and Entrepreneurship*, Vol. 1, No. 2, 2012.

[14] M. Del Giudice, M. Nicotra, M. Romano, and C. E. Schillaci, "Entrepreneurial performance of principal investigators and country culture: relations and influences", *The Journal of Technology Transfer*, Vol. 42, No. 2, pp. 320-337, 2017.

[15] T. A. Young, "Establishing a Teleology Transfer Office", in A. Krattiger, R. T. Mahoney, and L. Nelson (eds.), *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices* MIHR/PIPRS, Oxford/Davis, 2007.

[16] AUTM, *AUTM Canadian Licensing Survey, FY 2004 Survey Summary*, Northbrook, 2004.

[17] A. Afshari, "The Academic Technology Transfer Landscape in Canada and Quebec in Particular", Proceedings of the 7th National Congress on Government-University-Industry Relations for National Development, 2007.

[18] I. P. McCarthy, "Technology management: A complex adaptive system approach", *International Journal of Technology Management*, Vol. 25, No. 8, pp. 728-745, 2003.

[19] I. P. McCarthy, C. Tsinopoulos, P. Allen, and C. Rose-Anderssen, "New product development as a complex adaptive system of decisions", *Journal of Product Innovation Management*, Vol. 23, No. 5, pp. 437-456, 2006.

[20] E. Wolstenholme, "Using generic system archetypes to support thinking and modelling", *System Dynamics Review*, Vol. 20, No. 4, pp. 341-356, 2004.

[21] J. D. Sterman, *Business Dynamics*. McGraw-Hill/Irwin, 2000.