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This paper integrates the contributions from different branches of technology transfer literature in order to identify enablers that drive the transfer of intermediate or appropriate technologies to recipients in rural areas of developing economies. An in-depth analysis of the literature shows that many enablers that have been identified in the literature that focuses on high-technology transfers are of limited relevance in the context of rural enterprises. Other important enablers in this specific setting are ignored or insufficiently considered. This paper proposes a framework comprising a specific set of enablers that facilitate technology transfer in rural enterprises in developing regional economies.

Keywords: technology transfer enablers, developing economies, rural enterprises, technology transfer, intermediate technology

Introduction

This paper examines the enablers that drive the transfer of intermediate technologies that takes place from transferors to recipients in the rural sector of developing economies. Intermediate technology, also known as appropriate technology, refers to technology that is "labour-intensive and will lend itself to use in small-scale establishments" (Schumacher, 1973). Specifically, in relation to the rural context, Wood (1984: 320) describes both concepts as "a level of technology better than the simple methods used in the rural hinterland, more productive than the traditional tools, but far simpler and less capital-intensive than the modern technology imported from the West".

Technology transfer refers to the process of moving established technologies, including tools (technoware), facts (infoware), skills (humanware) and routines (orgaware) (Smith and Sharif, 2007) from providers to recipients. This process depends of transfer on enablers such as the market for technology, government authorities,

human resources and training, or the technological abilities of providers and recipients, amongst others (Arora and Gambardella, 2010; Kaushik et al., 2014).

Prior research has shown that successful technology transfer contributes positively to the achievements of the goals of the technology recipients (Cooke and Mayes, 1996; Tisdell, 1990) and contributes to improving their competitive advantage and survival in uncertain and diverse markets. Illustrative is the work of Klevorick et al. (1995), which demonstrates the improvements taking place at different dimensions of recipients' organisations. A thorough understanding of enablers or mechanisms facilitating technology transfer process is important for organizing and facilitating the transfer and for the adaptation and improvement of the transferred technologies to the specific context of the recipient (Madu, 1989; Beddington and Farrington, 2007).

Many aspects of technology transfers are discussed in the literature (Lee, 1997; Chatterji, 1990, Hess and Siegwart, 2013) but the mainstream of this literature relates mostly to technology transfer between countries or organizations in established economies (e.g. Festel, 2013; Parry, 1984). Specifically, emphasizing high-tech environments, technology transfer research in the mainstream literature focuses on the inputs and deliverables of the transfer process, whereas the relatively limited literature in lower-tech contexts centres on the dynamics of the process and the interactions between participants (e.g. Saggi, 2002; Theodorakopoulos et al., 2014). Given the importance of intermediate technologies for the development of regional rural economies (Cimoli, Ferraz and Primi, 2005; Saad and Zawdie, 2011) and the paucity of research at this end of the spectrum, it is argued that the enablers facilitating technology transfer in this particular context merit further study (Rodrik, 1999; Spithoven, Clarysse and Knochaert, 2011). While many of the identified enablers in the literature are useful

in principle, they may require a degree of modification or extension to assure their relevance to the transfers of technology to rural contexts in developing economies.

Technology transfers in rural contexts are mainly documented for the agricultural sector (e.g. Lilleør and Lund-Sørensen, 2013; Ison and Russell, 2000; Campbell, 1990; Jedlicka, 1977). However, in this study the rural context is also understood to include activities such as eco-tourism, rural based manufacturing, production of traditional goods and handicrafts, rural service provision, fishing / forestry production or even small-scale mining, which are often important sectors in socio-economic terms.

The focus of this study is rural enterprises, defined as entities that are collectively operated by small scale producers, such as for example township village enterprises in China (Li and Karakowsky, 2001; Dacosta and Carroll 2001), community based enterprises (Peredo and Chrisman, 2006; Handy, Cnaan, Bhat, and Meijs, 2011), or community-based cooperatives (Li, Wang and Mooney, 2013). What sets these enterprises apart from traditional technology transfer recipients is the fact that they are not single entities, but rather collectives or networks of collaborating rural entrepreneurs. In this connection, we are not only interested in the interactions that take place between the rural enterprises and technology transferors, or intermediaries, but also in those that take place between the individual technology recipients.

This paper represents an effort to address this oversight by reviewing technology transfer literature and assessing enablers that are explicitly highlighted as facilitators of technology transfer process. Where their relevance for transfers to rural contexts in developing economies falls short additional enablers are proposed. These are mechanisms that are discussed, but not explicitly recognized as technology transfer enablers in technology transfer literature. The result is a framework with seven enablers that facilitate technology transfers to recipients in developing rural economies. Four of

these were identified explicitly in the literature and the other three emerged from the analysis of the literature.

The work presented here has two implications for research. Firstly, this paper merges two bodies of literature, that on the international horizontal technology transfer[1] and that on the domestic technology transfer that considers both horizontal and vertical transfers. Secondly, on the methodology front, it presents a review of the extant literature drawn from different databases, analysed using a qualitative assessment approach (Silverman, 2012). Finally, the paper presents seven enablers relevant for developing rural economies, which can guide further research and makes suggestions for future research into enabler-oriented technology transfers.

Moreover, this study has two important implications for practitioners. First, for transferors and recipients, it shows that technology transfer requires a learning process between the supply and demand side and it provides a framework of the key enablers that should be considered in the transfer processes. Second, for policy makers it demonstrates that a suitable institutional environment is required in which this learning process can take place.

In order to accomplish its purpose this paper first presents the theoretical approach that was taken and describes the technology transfer concept adopted for the present study. It then presents the methodology and criteria considered for the analysis of enablers acknowledged in the literature. Thirdly, it discusses four previously identified enablers deemed relevant in the specific setting of this paper and identifies three new enablers together with associated theoretical propositions. Finally, it

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[1] Horizontal technology transfer refers to the transfer of operational technology from one organization in a specific socio-economic context to another organization in a different context, through intra-firm, cross-industry, or cross-border channels.

discusses the findings of this research and presents a series of limitations and conclusions.

Technology transfers as a field of study in rural areas of developing economies

Technology transfer is defined as "the movement of technological and technology-related organizational know-how among partners (individuals, institutions and enterprises) in order to enhance at least one partner's knowledge and expertise and strengthen each partner's competitive position" (Abramson et al., 1997). In this definition technology refers to the knowledge and methods that are deemed necessary for the implementation and improvement of the existing ways of producing and distributing goods and services (Wong, 1995; Cannarella and Piccioni, 2011). Smith and Sharif (2007) argue that, conceptually, technology is a configuration of one or more among four components, namely physical facilities and tools (Technoware), codified knowledge and facts (Infoware), human talent and skills (Humanware) and operational schemes and routines (Orgaware).

The transfer of technologies to rural environments was first explored early in the second half of the last century. For example, Hayami and Ruttan (1971) describe transfer experiences between MNCs from the United States to Japan (still regarded as a developing country at that time). These experiences were mainly related to agricultural practices. Echavarría and Pray (1990) studied vertical technology transfer in the agricultural sector in Latin America for production of cotton, rice and sugarcane. Basu (2010) analysed vertical technology transfers in several Indian industry clusters (including pharmaceutical, agricultural, handcraft and medical) describing the role of the institutions from policy to application. Moulik and Purushotham (1986) studied vertical technology transfers in the agricultural sector of India, detecting a failing link

between policies and effort towards the creation of an effective decentralized sector technology.

There are multiple viewpoints on the transfer of technology. Ramanathan (1994), for instance, considers it a two-directional concept in which a differentiation can be made between vertical and horizontal technology transfers. Vertical technology transfer is explained as the flow of activities from scientific research to invention and commercialization, i.e. the transferor and recipient participate in a collaborative way in the process considering that the technology is not perfectly developed at the beginning. In horizontal technology transfers, the transfer occurs from one unit to another, provided that the recipient is ready to adopt the technology and the technology is at the appropriate level to be transferred.

Others differentiate between technology transfers from multinational companies (MNCs) to their subsidiaries (e.g. Young and Lan, 1997; Zhao, 2013) and technology transfers from university to industry (e.g. Swamidass and Vulasa, 2009; Ustundag, 2011). A lot has been written about technology transfers from larger (mainly western) MNCs to their subsidiaries, often located in low-cost countries. The majority, however, concerns the transfer of proven production technology to facilitate lower cost manufacturing (Waroonkun and Stewart, 2008; Thumanoon and Paul, 2006). More recently, the research field has broadened to embrace technology transfers from universities to industry that comprise a wider scope of technologies including new and still unproven solutions (Alessandrini et al., 2013). The focus of technology transfer from universities to industry has predominantly been on innovation (i.e. the introduction of new product/services/processes) rather than on the low-cost manufacture of goods. In both instances however, the recipients of the transferred technologies are assumed to

have an understanding of those technologies that matches that of the patrons (Kaimowitz et al., 1990; Basu, 2010).

Yet other research differentiates technology transfer by the location of transferor and recipient (e.g. Siler et al., 2006). Technology transfers studied in these papers includes both international and domestic transfers, although both are related and share similar characteristics (e.g. Mowery and Oxley, 1995). Whereas traditionally the international technology transfer comprised predominantly horizontal technology transfers, vertical technology transfers could also include international and domestic aspects.

In sum, the above three viewpoints respectively emphasize the direction of technology transfer (horizontal or vertical), the type of actors involved in technology transfer (e.g. individuals, organizations), and the location of these actors.

However, literature largely fails to distinguish between the enablers that facilitate the transfer of high-technology and the transfer of technologies that takes place at the much more elementary level, comprising mainly low-technologies and intermediate technologies aimed at enhancing the productivity of the rural sector in regional developing economies, which is the specific context of this paper. This is problematic because building a less-than-comprehensive understanding of the enablers influencing this type of technology transfer may lead to inaccurate conclusions and misplaced recommendations.

Low technology differentiates itself from high-technology by a less advanced level of sophistication or scientific knowledge involved in its operation (Czarnitzki and Thorwarth, 2011; Hirsch-Kreinsen, 2008). Indicative of this concept, the OECD (2011) has presented a classification of industries into categories based upon R&D intensity.

According to this classification food production, one of the most common activities in rural environments is considered low-technology.

The majority of papers written about technology transfer discuss hi-tech transfers. Much less attention is dedicated to the discussion of the transfer of low-tech solutions and intermediate technologies between actors.

Intermediate technologies as solutions that keep balance between the cost, performance and potential of recipients' participation were identified as one way to fill the gap created by the disparate knowledge between the participants in developing countries (Schumacher, 1972; Wicklein and Kachmar, 2001, Bennett et al., 2002). "Intermediate technologies were described as relatively small, simple, capital-saving, labour-intensive, and environmentally less-damaging technologies, suitable for local, small-scale application" (Wood, 1984).

Despite the lower level of sophistication and complexity of these solutions, the transfer process is often problematic for the context in which the transfer tends to take place, a context that is frequently characterized by similarly low levels of sophistication and development (Theodorakopoulos et al., 2012; 2014).

Some alternatives for the study of foreign technology transfer in the mining sector of developing countries were offered by Pogue and Rampa (2006) and Lorentzen and Pogue (2009) through the concept of lateral migration. One particularly relevant study shows a linear innovation process that involved researchers, suppliers, manufacturers and users of hydraulic systems in the South African mining industry. One of the main concerns in this study was the creation of engineering skills in the recipient country and a network of local and international organizations to support the diffusion of the technology. The term "lateral migration" was used to describe processes to apply technologies in a different context from the one in which the technology was developed.

While the literature identifies important enablers that facilitate the successful technology transfer, many of these enablers lose relevance when taken out of the specific context of high-tech environments. Specifically, in high-technology environments research focuses on the inputs and deliverables of the transfer process, whereas in low-tech or intermediate tech contexts it centres on the dynamics of the process and the interactions between participants. It is therefore argued that in particular the enablers facilitating technology transfer at this lower level merits further investigation.

Methods

The identification of the key enablers that facilitate technology transfer process in rural contexts of regional developing economies required a review of the field, in order to categorise the aspects discussed in the literature as significant. The conclusions presented in this article are the result of a 3-step analysis process (Venturini and Verbano, 2014) comprising:

(1) Selection of databases and definition of keywords.
(2) Selection of the articles for analysis.
(3) Analysing the final selection of papers and presentation of identified enablers.

Database Selection and Keyword Definition

Assembling the relevant body of literature for analysis involved three steps; i) definition of the literature scope, ii) specification of keywords and iii) generation of search strings by a Delphi group consisting of five experts in technology transfer; two experts in developing economies and three in international technology transfer. A Delphi group is a panel of individuals, as a whole, that is consulted in order to access expert opinion on a complex problem (Okoli and Pawlowski, 2004). The Delphi group during the process

developed a list of strings included the words: “technology transfer developing economies”, “international technology transfer”, “enablers of technology transfer”, “elements of technology transfer”, “aspects of technology transfer”, “transfer of technology”, and “technology transfer”. The initial search returned 5,147 papers. Of these, 4,816 were excluded because they were not peer-reviewed (to assure academic rigor), or they but did not treat technology transfer as the focus of the paper, or they were duplicates. This left a literature base comprising 331 papers.

Selection of the research articles

In the second stage, the Delphi group defined inclusion and exclusion criteria. Following the inclusion criteria papers with titles referring to technology transfer between countries, or firms, or University/Research Centre and Industry, or technology transfer that occurs in any developing country were maintained. Book reviews, non-peer reviewed/non-academic articles or articles without author´s name or affiliation were removed, leaving a total of 254 papers.

Analysis of papers and presentation identified enablers

The final review of enablers was based on a constant comparative method (Silverman, 2012) comprising three stages:

Stage 1 consisted of an in-depth review of the papers that discuss transfers, regardless of whether or not this was taking place in the rural context of developing economies. Nineteen papers explicitly mentioned and compared enablers for technology transfers. The enablers proposed in these papers were subsequently compared and contrasted.

In Table 1 these enablers are consolidated and reviewed in further detail. The concepts are then complemented with i) an identification of common enablers between

the nineteen articles, ii) an assessment of the relevance of the enablers in the context of developing economies.

Table 1. Enablers (Factors) of technology transfer identified in the literature and their relevance to developing economies

(Table 1)

In the second stage, 235 papers were identified that discuss a range of aspects related to technology transfer yet without explicitly referring to them as specific enablers facilitating the process. These papers were analysed and consolidated into themes such as type of technology (high/intermediate/low), sector, participants (e.g. regions, institutions, firms), transfer process, or type of country (developed/developing).

The third stage involved a search for patterns and themes in the data that were considered relevant to the study. Three comparative themes emerged: the connection of transferor and recipient through an organisation or office, institutions working in a collaborative way in an innovation system environment, and mechanisms for the progressive learning of the constituents involved in the transfer process (e.g. projects, training programs, etc.).

The common aspects mentioned in the literature on technology transfer were extracted and consolidated and their validity for the specific context of technology transfer in rural economies of developing countries was assessed. The analysis considered enablers as conditions that influence technology transfer process among transferor and recipient.

Enablers for the successful technology transfer in developing economies

The most commonly mentioned enablers in the literature were extracted and subsequently scrutinized. These are shown in Figure 1. More specifically, aspects such

as the mode of transfer (Tsang, 1994), components for relocation of R&D facilities (Rabino, 1989), direct effects of market and cultural environmental enablers (Cui et al., 2006), recipient firm's advantages (Chen and Sun, 2000), reasons for successful process (Walker and Ellis, 2000), and firm's capacity (Lichtenthaler and Lichtenthaler, 2010) were highlighted. Further on, the underlying concepts were determined, documented and their relevance in rural developing economies evaluated.

Previously identified relevant enablers for rural developing economies

Four relevant enablers for technology transfer in rural developing economies were identified:

- Absorptive capacity;
- Understanding of the technology source and market maturity;
- Cultural and geographic distance between transferor and recipient;
- Recipient's comprehension of the financial implications of technology transfer.

Absorptive capacity

Absorptive capacity is the ability of a firm to recognize the value of new, external information, assimilate it, and to apply it to commercial ends (Cohen and Levinthal, 1990). It is largely determined learning by activities which often relate to resources outside the firm (Deeds, 2001; Wahab, Rose and Osman, 2012).

The technical skills in the recipient to learn how to use the technology and extend its application to be innovative, is considered one of the most important aspects in technology transfer process (Purushotham et al., 2013; Mohamed et al., 2012; Tsang, 1994).

Understanding of the technology source and market maturity

To obtain a required technology, technology recipients tend to have two options: obtaining domestically or obtaining from overseas. In choosing between the two, they have to keep in mind i) the extent to which it is possible to acquire the required technology and ii) the level of their own technology at a given moment in time. Prior experience on the part of the recipient with the technologies available in the regional or national market will prepare them better to collaborate with foreign technology exporters (Chen and Shun, 2000; Vickery, 1986). Adopting the right mixture of technology will allow them access to other more profitable market environment and competition (Lee et. al., 2012; Theodorakopoulos et al, 2014).

Geographical and cultural distance

Geographical and cultural distance refers to the organizational cultural distance between the participants. Considering the fact that relationships between the actors in technology transfer at this level are oftentimes informal and personal, long distances (physical or cultural) inhibit the formation of trust and understanding necessary for the transfer (Kedia and Bhagat, 1988; Cannarella and Piccioni, 2011).

Comprehension of the financial implications of the technology transfer

In the context of this research, a comprehension of the financial implications of the technology transfer refers to the degree to which the technology recipients understand i) the relations between the costs and benefits of the transferred technology at present and in future, and ii) the related financial flows between the transferor and the recipient as well as between the recipient and its other stakeholders partners. A lack of insight into the financial implications of the transferred technologies hinders the adaptation of these technologies (Walker and Ellis, 2000; Schneider, Holzer and Hoffmann, 2008).

These aforementioned enablers constitute a part of the suggested enablers for technology transfer in developing economies in this paper. However, it is argued that they are likely to be insufficient to fully facilitate a successful technology transfer process due to the fact that in rural contexts the close and direct connection with the environment (e.g. local universities, government, other institutions) is needed (Premkumar and Roberts, 1999; Van Zwanenberg and Arza, 2013). Rather, additional enablers may need to be considered to meet expectations of a long-term and sustainable impact of technology transfer processes.

Additional, setting-specific enablers

An assessment of the literature considered in this study reveals that the bulk of this work features enablers that relate to generic aspects of technology transfer, which are as relevant in developing economies as they are for the contexts described in the original papers. However, for technology transfer to successfully take place in the specific context of rural developing economies it is argued that additional enablers that are not explicitly acknowledged in this field are important. Drawing from the literature base considered in this study, as depicted in Figure 1, further enablers were identified.

In developing economies, the collaboration between universities or university-related centres and industry is essential, particularly for low-technology driven rural enterprises that face severe challenges in obtaining these technologies. Therefore, universities (including university-related centres) play an important role in establishing the link between regional governments and rural industries and facilitate the transfer of intermediate technology to recipients (Theodorakopoulos et al., 2012; 2014).

Moreover, given that intermediate technology in rural enterprises is often characterized by limited availability of resources (e.g. human, financial and technological), such enterprises are embedded in networks comprising a multitude of

other organizations (Hung, 2006; Rickne, 2006; Trần Quang, 2014). In these networks, technology transfer from university to industry is usually analysed in enterprises with particular functional focus on legal constitution or deployment of specific functions, including marketing, management, research and development, and operations (Ezezika et al., 2009; Figueroa, et. al., 2013). Studies concerned with the transfer of intermediate technologies to rural enterprises share some of these focal areas, but also centre on the capability for effective interaction with other organizations (Van Zwanenberg and Arza, 2013).

In summary, this strand of literature highlights the following three enablers as important: i) intermediaries connecting transferor and recipient; ii) institutional network adapting the technology to the local needs; iii) prior experience in technology transfer projects on the part of the participants (transferors and recipients). These enablers are discussed below and raise theoretical propositions.

Intermediaries connecting transferor and recipient

The concept of intermediary is derived from the approach discussed by Shiau et al. (2001) and Li-Ying (2012). Its relevance for technology transfer in our particular context stems from the fact that in many developing economies it is necessary to have an external party (business incubators or R&D centres capable of bridging the gaps between producers, government institutions and universities) who develop collaboration strategies and implement new projects.

Technology transfers from a university to two rural organizations in Colombia were analysed (Theodorakopoulos et al. 2012). The implementation of environmentally friendly technologies for the production of coffee and farming trout (pisciculture) have shown one intermediary (Production and Innovation Regional Centre - PIRC) acting as a catalyst in nurturing three inter-organizational learning groups over a period of two

years. The members of this coalition were producers, researchers and members of the PIRC. This intermediary is an independent research and advisory centre associated with the University of Cauca in Colombia.

It is therefore proposed that:

The existence of an intermediary connecting transferor and recipient is an enabler in the successful technology transfer to intermediate technologies recipients in developing economies (*Proposition 1).*

Institutional network adapting the technology to the local needs

It is important to have an institutional network available that can support the collaborative arrangement among the parties involved in technology transfer (Ison and Russell, 2000) that structures the knowledge interchange in terms of possible overlays. This infrastructure is expected to be generated endogenously (Etzkowitz and Leydesdorff, 2000) consisting of representatives of the state, industry and academia.

The progressive development of projects creates an environment for learning and it allows the participants to solve problems and establish practices for innovation in different dimensions (e.g. organizational, technological, marketing, business model). A strong support network assures the effectiveness of technology transfer actions.

One study in a rural enterprise in Colombia (Theodorakopoulos et al. 2014) has described how the PIRC helped with configuration during the domestication of technology in the local production system of the pisciculture businesses by selecting the technologies most likely to be adopted. The institutional arrangements were considered an important role in the domestication and diffusion of the technology.

It is therefore proposed that:

The presence of an institutional network adapting the technology to the local needs is an enabler in the successful technology transfer to intermediate technologies recipients in developing economies (*Proposition 2).*

Prior experience in technology transfer projects

Prior experience in projects aimed at technology transfer is important, particularly in developing economies where oftentimes a complex relationship exists between agents of technology supply and demand. It is also important that the involved parties understand that technology transfer should be sought not as a 'short-term fix' for enhancing production and growth possibilities, but rather as part of a long-term strategy to establish a culture of innovation and technological learning (Saad and Zawdie, 2005). The projects have to become opportunities to integrate theory and practice.

The role of stakeholders in technology transfer interventions was considered successful based on the implementation of programmes in which different institutional arrangements prevailed in the two rural industries analysed during this intervention (Theodorakopoulos et al. 2012; Theodorakopoulos et al. 2014). The programmes included an agenda with goals to achieve them in a collaborative way by the participants. The agenda was deployed in various projects related to different technologies. In the development of the projects all the participants learned how to apply, adapt and adopt the new technologies.

It is therefore proposed that:

Accumulated experience of the participants in technology transfer projects is an enabler in the transfer to technology to intermediate technologies recipients in developing economies (*Proposition 3).*

Figure 1 shows the interaction between the members of the recipient, between transferors and recipients and between intermediaries and transferors or recipients.

(Figure 1)

Figure 1. Participants of the Intermediary Facilitated Technology Transfer

Figure 2 depicts a graphic overview of the afore-discussed enablers relevant to each of the participants in a technology transfer process and how they relate to each other with and without an intermediary. The first four enablers in this figure refer primarily to traits of the technology recipients (i.e. Understanding of the technology source and market maturity; Institutional network adapting the technology to the local needs; Absorptive capacity; Comprehension of the financial implications of the technology transfer). The remaining three enablers (Cultural and geographic distance, Prior experience in technology transfer projects on the part of the participants and Intermediaries connecting transferors and recipients) refer to the relationship between transferor and recipient.

(Figure 2)

Figure 2. Overview of Technology Transfer Enablers and How They Relate to Each Other

Conclusions and discussion

This article has presented a targeted review of the literature with the specific aim to identify the enablers that are said to facilitate successful technology transfer to the rural sector in developing economies. Four enablers were identified, mainly from the literature on international technology transfer. Three additional, though less explicitly articulated enablers were identified, mainly in the literature on technology transfer between university and industry. These enablers were subsequently assessed for their relevance in the instances of intermediate technology transfer solutions to rural recipients in developing economies.

Generally, this stream of literature considers technology transfer in terms of inputs and outputs. It tends to focus explicitly on the technology itself, considering the patents, licences, creation of technology transfer offices, investments in R&D, number of new products or services created by the technology recipient, the number of collaboration contracts between the actors in the transfer (industries, universities or government, in any possible combination), or the number of licences or patents created with the transferred technology by the recipient. In the specific research context of this study, technology transfer to intermediate technologies recipients in rural developing economies, this focus comes across as not fully appropriate. The reason for this is twofold. First, the recipients (such as small holders or craftsmen) are oftentimes incapable of understanding, managing, or investing in the higher technologies covered by patents and licences. Second, the vast majority of the recipients are incapable of generating the outputs that are traditionally used to measure the success of technology transfer that is used in the literature.

The enablers presented in this paper have been reviewed for their relevance in facilitating technology transfer to intermediate technology recipients in rural developing economies. They are different from many of the traditional enablers in that they i) emphasize aspects of the transfer process that are much closer to the daily reality of the recipients and the way these recipients interact with the technology; ii) highlight the experiential learning aspect of the transfer process and the degree to which acquired skills from previous and on-going transfers are likely to support actual and future transfers of technology; and iii) focus on aspects of technology transfer process at different organizational levels (ranging from individual to institutional). In so doing, they address an important gap in the literature where it concerns technology transfer to this specific, but increasingly important in socio-economic terms context.

Traditionally the success of transfers of technology has mostly been expressed in quantitative terms (e.g. number of patents or licences that are being transferred, or the number of new products or services that are developed using those patents or licences). In the context of this study, however, such quantitative data are rarely available, often hard to capture, or unreliable. The enablers discussed and proposed in this study allow for an assessment on qualitative measures in addition to quantitative measures and in so doing, they contribute to a better understanding of the transfer process and its determinants. Technology transfer is considered a highly relevant activity that generates learning and capabilities with the purpose of introducing and stimulating innovation on the part of the recipient (Breznitz, 2011; Cooke and Mayes, 1996; Van Zwanenberg and Arza, 2013). Given the paucity of literature focusing specifically on technology transfer in rural contexts (e.g. Kovic, 2010; Figueroa et. al., 2013), the strategy adopted by many developing economies generally follows the trend of that of developed countries though often without a thorough appreciation of how appropriate prescriptons are for their context. What becomes clear from the analysis of the enablers that facilitate technology transfer discussed in this strand of the literature, is that while they are relevant in the contexts in which they are considered, they either lack relevance in the context of intermediate technologies recipients in developing economies or they do not cover the full scope of issues relevant to this particular type of organization.

The sheer number of organizations classified as small rural enterprises in regions of developing economies, and their paramount significance in socio-economic terms suggests that the enablers that facilitate technology transfer to such organisations merit further research. This study contributes to the sparse body of literature currently available and the authors hope that it will trigger further research in this important, yet under-researched field of study.

Limitations of the study and suggestions for future research

The conclusions drawn from this study are subject to a number of limitations. First, the classification of the different levels of technology may not always provide an accurate picture of the real level of the transferred technology or the nature of the transferor or the recipient. For example, while the technology for agriculture/food production is generally classified as intermediate or low-tech, the state-of-the-art expertise and practice found in genetically enhanced plant material (seeds, seedlings or cutting), equipment and processes could hardly be considered low-technology. Consequently, it may at times be challenging to accurately distinguish between the levels and the enablers for successful transfer of high, intermediate or low-technology solutions.

Secondly, technology transfer experiences in rural regional contexts are mainly documented for the agricultural sector. However, the rural context could also include activities such as tourism or handicraft, which can be important sectors in socio-economic terms. Future research should look more closely into the enablers that facilitate technology transfer in these specific cases.

Moreover, future research should be driven by an explicit agenda that promotes testing the propositions advanced in this paper, but also stimulates the scrutiny of new elements and considerations pertinent to the transfer of intermediate technologies to and in developing rural economies.

References

Abramson, G., Encarnacao, J., Reid, P. and Schmoch, U. (1997) *Technology Transfer Systems in the United States and Germany: Lessons and Perspectives*, National Academies Press, Washington D.C.

Alessandrini, M., Klose, K. and Pepper M. (2013) 'University entrepreneurship in South Africa: Developments in technology transfer practices', *Innovation: Management, Policy & Practice*, 15, 2, pp 205-214.

Arora, A. and Gambardella, A. (2010) ‘Ideas for rent: an overview of markets for technology’, *Industrial and Corporate Change*, 19, 3, pp. 775-803.

Basu, J. (2010) *Technology Transfer and Assimilation in Rural Industrial Clusters*, LAP Lambert Academic Publishing, Saarbrücken, Germany.

Beddington, A. and Farrington, J. (2007) ‘Governments, NGOs and agricultural development: perspectives on changing inter-organisational relationships’, *Journal of Development Studies,* 29, 2, pp. 199–219.

Bennett, D. (2002) *Innovative technology transfer framework linked to trade for UNIDO action,* UNIDO, Vienna.

Breznitz, S. (2011) ‘Improving or impairing? Following technology transfer changes at the University of Cambridge’, *Regional Studies*, pp. 45, 4, 463-478.

Buono, A. (1997) ‘Technology transfer through acquisition’, *Management Decision*, 35, 3, pp. 194-204.

Campbell, M. J. (1990) *New technology and rural development: the social impact*, Psychology Press, London.

Cannarella, C. and Piccioni, V. (2011) ‘Traditiovations: Creating innovation from the past and antique techniques for rural areas’. *Technovation*, 31, 12, pp. 689-699.

Chatterji, M. (1990) *Technology transfer in the developing countries*, Macmillan, London.

Chen, X. and Sun, C. (2000) ‘Technology transfer to China: alliances of Chinese enterprises with western technology exporters’, *Technovation*, 20, 7, pp. 353-362.

Chiang, T., Lee, Y., Huang, C. and Chiang, S. (2007) ‘Examining the Future Development Trend of Long-distance Steep Turn Pipe Impelling Construction Method (LDSTPICM) through Technology Transfer’, *Journal of the Chinese Institute of Industrial Engineers,* 24, 2, pp. 166-181.

Cohen, W. and Levinthal, D. (1990) ‘Absortive Capacity: A New Perspective on Learning and Innovation’, *Administrative Science Quartely,* 35, 1, pp. 128-152.

Cimoli M., Ferraz, J. and Primi, A. (2005) *Science and Technology Policies in Open Economies: The Case of Latin America and the Caribbean*, United Nations, Santiago.

Cooke, I. and Mayes, P. (1996) *Introduction to innovation and technology transfer*, Artech House, INC. London.

Cui, A., Griffith, D., Cavusgil, S. and Dabic, M. (2006) 'The influence of market and cultural environmental factors on technology transfer between foreign MNCs and local subsidiaries: A Croatian illustration', *Journal of World Business*, 41, 2, pp. 100-111.

Czarnitzki, D. and Thorwarth, S. (2012) 'Productivity effects of basic research in low-tech and high-tech industries', *Research Policy*, 41, 9, pp. 1555-1564.

Dacosta, M. and Carroll, W. (2001) 'Township and village enterprises, openness and regional economic growth in China', *Post-Communist Economies*, 13, 2, 229-241.

Deeds, D. (2001) 'The role of R&D intensity, technical development and absorptive capacity in creating entrepreneurial wealth in high-technology start-ups', *Journal of Engineering and Technology Management*, 18, 1, pp. 29-47.

Echeverria, R., Pray, C. and Kaimowitz, D. (1990) 'Private sector agricultural research and technology transfer links in developing countries' in Kaimowitz (ed.), *Making the link, agricultural research and technology transfer in developing countries*, Westview Press, Inc., Boulder CO.

Etzkowitz, H. and Leydesdorff, L. (2000) 'The dynamics of innovation: from National Systems and `Mode 2' to a Triple Helix of university', *Research Policy*, 29, 2, pp. 109-123.

Ezezika, O., Thomas, F., Daar, A. and Singer, P. (2009) 'A Social Audit Model for Agro-biotechnology Initiatives in Developing Countries: Accounting for Ethical, Social, Cultural, and Commercialization Issues', *Journal of Technology Management and Innovation*, 4, 3, pp. 24-33.

Festel, G. (2013) 'Technology transfer by new ventures within the chemical and pharmaceutical industry', *Journal of Business Chemistry*, 10, 3, pp. 115-130.

Figueroa, P., Castillo, P., Vrsalovic, V., Gálvez, D. and Diez-de-Medina, S. (2013) 'Technology Transfer from Academia to Rural Communities: The Case of Caprines in vitro Fecundation and Local Livestock Market in Tamarugal Province in Chile', *Journal of technology management & innovation*, 8, 4, pp. 186-194.

Gopalakrishnan, S. and Santoro, M. (2004) 'Distinguishing between knowledge transfer and technology transfer activities: the role of key organizational factors', Engineering Management, *IEEE Transactions on*, 51, 1, pp. 57-69.

Handy, F., Cnaan, R. A., Bhat, G. and Meijs, L. C. (2011) 'Jasmine growers of coastal Karnataka: Grassroots sustainable community-based enterprise in India', Entrepreneurship & regional development, 23, 5-6, 405-417.

Hayami Y. and Ruttan V. W. (1971) *Agricultural development: an international perspective*, The Johns Hopkins Press, Baltimore.

Hess, S. and Siegwart, R. (2013) 'R&D Venture: proposition of a technology transfer concept for breakthrough technologies with R&D cooperation: A case study in the energy sector', *The Journal of Technology Transfer*, 38, 2, pp. 153-179.

Hirsch-Kreinsen, H. (2008) 'Low Tech Innovations', *Industry and innovation*, 15, 1, pp. 19-43.

Hung, H. (2006) 'Formation and Survival of New Ventures', *International Small Business Journal*, 24, 4, pp. 359-378.

Ison, R. and Russell, D. (2007) *Agricultural extension and rural development: breaking out of knowledge transfer traditions*, Cambridge University Press, Cambridge.

Jedlicka, A. D. (1977) *Organization for rural development. Risk taking and appropriate technology*. Praeger Special Studies in International Economics and Developmen, New York.

Kaimowitz, D., Snyder, M. & Engel, P. (1990) 'A conceptual framework for studying the links between agricultural research and technology transfer in developing countries' in Kaimowitz (ed.), *Making the link, agricultural research and technology transfer in developing countries*, Westview Press, Inc., Boulder CO, pp. 227-269.

Kaushik, A., Kumar, S., Luthra S. and Haleem, A. (2014) 'Technology transfer: enablers and barriers–a review', *International Journal of Technology, Policy and Management*, 14, 2, pp. 133-159.

Kedia, B., and Bhagat, R. (1988) 'Cultural constraints on transfer of technology across nations: Implications for research in international and comparative management', *Academy of Management Review*, 13, 4, pp. 559-571.

Kissell, F. (2000) 'Insights on Technology Transfer from the Bureau of Mines', *Journal of Technology Transfer*, 25, 1, pp. 5-8.

Klevorick, A., Levin, R., Nelson, R. and Winter, S. (1995) 'On the sources and significance of interindustry differences in technological opportunities', *Research Policy*, 24, 2, pp. 185-205.

Kovic, M. (2010) 'Investigating technology transfer projects and institutional development in developing countries', *Management of Environmental Quality: An International Journal*, 21, 6, pp. 761-772.

Lee, Y. (1997) *Technology transfer and public policy*, Greenwood Publishing Group, Westport CT.

Lee, S., Kim, W., Kim, Y. M. and Oh, K. (2012) 'Using AHP to determine intangible priority factors for technology transfer adoption', *Expert Systems with Applications*, 39, 7, pp. 6388-6395.

Lichtenthaler, U. and Lichtenthaler, E. (2010) 'Technology Transfer across Organizational Boundaries: Absorptive Capacity and Desorptive Capacity', *California Management Review*, 53, 1, pp. 154-170.

Lilleør, H. B., and Lund-Sørensen, U. (2013) *Farmers' Choice*, Practical Action Publishing Ltd, Rugby UK.

Li, J. and Karakowsky, L. (2001) 'The competitive strategy of China's township enterprises: understanding the sources for survival and success', *Business Process Management Journal*, 7, 4, pp. 340–348.

Li, Q., Wang, J. and Mooney, P. H. (2013) 'Strategies for Agricultural Cooperation in Contemporary China', *Journal of Rural Cooperation*, 41, 1, pp. 27-43.

Li-Ying, J. (2012). 'What do we need from intermediaries for technology transfer to China? A European firm perspective', *Prometheus*, 30(2), pp. 199-209.

Lloyd, J. and Milstien, J. (1999) 'Auto-disable syringes for immunization: issues in technology transfer', *Bulletin-World Health Organization*, 77, 12, pp. 1001-1007.

Lorentzen, J. and Pogue, T. E. (2009) *Knowledge intensification in resource-based developing economies: from technologies learning to lateral migration*, Working paper 4, Institute for Economic Research on Innovation, Pretoria.

Macdonald, S., & Turpin, T. (2007) 'Technology Transfer and IPR Policy for Small and Medium Firms in South East Asia 1', *Prometheus*, 25, 4, pp. 363-372.

Madu, C. (1989) 'Transferring technology to developing countries - Critical factors for success', *Long Range Planning*, 22, 4, pp. 115-124.

Mahboudi, M. and Ananthan, B. (2010) 'Effective Factors in Technology Transfer in the Pharmaceutical Industries of Iran: A Case Study', *IUP Journal of Knowledge Management*, 8, 1/2, pp. 98-110.

Mohamed, A., Sapuan, S., Megat Ahmad M., Hamouda, A. and Hang Tuah Bin Baharudin, B. (2012) 'Modeling the technology transfer process in the petroleum industry: Evidence from Libya', *Mathematical & Computer Modelling*, 55, 3/4, pp. 451-470.

Moulik, T. and Purushotham, P. (1986) *Technology transfer in rural industries: Cases and Analysis (CMA Monograph)*, Sangam Books Ltd, Michigan.

Mowery, D. and Oxley, J. (1995) 'Inward technology transfer and competitiveness: the role of national innovation systems', *Cambridge Journal of Economics*, 19, 1, pp. 67–93.

OECD (2011) *ISIC Rev. 3 Technology Intensity Definition*, OECD, Paris.

Okoli, C. and Pawlowski, S. (2004) 'The Delphi method as a research tool: an example, design considerations and applications', *Information & management*, 42, 1, pp. 15-29.

Parry, T. (1984) 'International Technology Transfer: Emerging Corporate Strategies', *Prometheus*, 2, 2, pp. 220-232.

Peredo, A. M. and Chrisman, J. J. (2006) 'Toward a theory of community-based enterprise', *Academy of Management Review*, 31, 2, 309-328.

Pogue, T. and Rampa, M. (2006) 'An analysis of hydraulic technologies in South Africa's mining sector' in Lorentzen et al. *Lateral Migration in Resource-Intensive Economies: Technological Learning and Industrial Policy*, Human Sciences Research Council, Pretoria, pp. 129-157.

Premkumar, G. and Roberts, M. (1999) 'Adoption of new information technologies in rural small businesses', *Omega*, 27, 4, pp.467-484.

Purushotham, H., Sridhar, V. and Sunder, C. (2013) 'Management of Technology Transfer from Indian Publicly Funded R&D Institutions to Industry-Modeling of Factors Impacting Successful Technology Transfer', *International Journal of Innovation, Management and Technology*, 4, 4: pp. 422.

Rabino, S. (1989) 'High-technology Firms and Factors Influencing Transfer of R&D Facilities', *Journal of Business Research*, 18, 3, pp. 195-205.

Ramanathan, K. (1994) 'The polytrophic components of manufacturing technology', *Technological Forecasting and Social Change*, 46, 3, pp. 221-258.

Rickne, A. (2006) 'Connectivity and Performance of Science-based Firms', *Small Business Economics*, 26, 4, pp. 393-407.

Rodrik, D. (1999) *The new global economy and developing countries: making openness work,* Overseas Development Council, Washington, DC.

Russell, D. B., and Ison, R. L. (2000) 'The research-development relationship in rural communities: an opportunity for contextual science' in *Agricultural Extension and Rural Development: Breaking out of Traditions,* Cambridge University Press, Cambridge, UK, pp. 10-31.

Saad, M. and Zawdie, G. (2005) 'From technology transfer to the emergence of a triple helix culture: the experience of Algeria in innovation and technological capability development', *Technology Analysis & Strategic Management,* 17, 1, pp. 89-103.

Saad, M., and Zawdie, G. (Eds.). (2011) *Theory and Practice of Triple Helix Model in Developing Countries: Issues and Challenges,* Taylor & Francis, New York.

Saggi, K. (2002) 'Trade, foreign direct investment, and international technology transfer: A survey', *The World Bank Research Observer,* 17, 2, pp. 191-235.

Schneider, M., Holzer, A. and Hoffmann, V. (2008) 'Understanding the CDM's contribution to technology transfer', *Energy Policy,* 36, 8, pp. 2930-2938.

Schumacher, E. F. (1973) *Small is beautiful: a study of economics as if people really mattered,* Blond & Briggs, London.

Schumacher, E. (1972) '*Work of the Intermediate Technology Development Group in Africa*', The. Int'l Lab. Rev., 106, 75.

Shiau, R.J., Smith, R. L. and Cesa, E. (2001) 'Role of intermediaries in technology transfer in the logging industry: A case study with portable timber bridges', *Forest Products Journal,* 51, 5, pp. 17-24.

Siler, P., Wang, C. and Liu, X. (2003) 'Technology transfer within multinational firms and its impact on the productivity of Scottish subsidiaries', *Regional studies,* 37, 1, pp. 15-25.

Silverman, D. (2012) *Interpreting Qualitative Data*. Sage Publications, Kindle Edition.

Smith, R. and Sharif, N. (2007) 'Understanding and acquiring technology assets for global competition', *Technovation,* 27, 11, pp. 643-649.

Spithoven, A., Clarysse, B. and Knochaert, M. (2011) 'Building Absorptive Capacity to Organise Inbound Open Innovation in Traditional Industries', *Technovation,* 31, 1, pp. 10–21.

Sung, T. and Gibson, D. (2005) ‘Knowledge and technology transfer grid: empirical assessment’, *International Journal of Technology Management*, 29, 3, pp. 216-230.

Swamidass, P. and Vulasa, V. (2009) ‘Why university inventions rarely produce income? Bottlenecks in university technology transfer’, *Journal of Technology Transfer*, 34, 4, pp. 343-363.

Tisdell, C. (2000) ‘Technology transfer from publicly funded research for improved natural resource management: analysis and Australian examples’, *Prometheus*, 18, 2, pp.149-160.

Theodorakopoulos, N., Sanchez Preciado D. J. and Bennett, D. (2012) ‘Transferring technology from university to rural industry within a developing economy context: The case for nurturing communities of practice’, *Technovation*, 32, 9, pp. 550-559.

Theodorakopoulos, N., Bennett, D. and Sánchez Preciado, D. J. (2014) ‘Intermediation for technology diffusion and user innovation in a developing rural economy: a social learning perspective’, *Entrepreneurship & Regional Development*, 26, 7-8, pp. 645-662.

Thumanoon, P. and Paul, H. (2006) ‘Technology Transfer Induced Technological Dependency in an Electric Power Plant: Effects on Efficiency, Reliability and Flexibility’, *Global Journal of Flexible Systems Management*, 7, 1/2, pp. 1-14.

Trần Quang T. (2014) ‘A Review on the link between nonfarm employment, Land and rural livelihoods in developing countries and Vietnam’, *Economic Horizons*, 16, 2, pp. 113 - 123.

Tsang, E. W. K. (1994) ‘Strategies for Transferring Technology to China’, *Long Range Planning*, 27, 3, pp. 98-107.

Ustundag, A., Ugurlu, S. and Kilinc, M. S. (2011) ‘Evaluating the performance of technology transfer offices’, *Journal of Enterprise Information Management*, 24, 4, pp. 322-337.

Van Zwanenberg, P. and Arza, V. (2013) ‘Biotechnology and its configurations: GM cotton production on large and small farms in Argentina’, *Technology in Society*, 35, 2, pp. 105-117.

Venturini, K. and Verbano, C. (2014) ‘A systematic review of the Space technology transfer literature: Research synthesis and emerging gaps’, *Space Policy*, 30, 2, pp. 98-114.

Verbano, C. and Venturini, K. (2012) ‘Technology transfer in the Italian space industry: organizational issues and determinants’, *Management Research Review*, 35, 3/4, pp. 272-288.

Vickery, G. (1986) ‘Technology transfer revisited: recent trends and developments’, *Prometheus*, 4, 1, pp. 25-49.

Wahab, S. A., Rose, R. C. and Osma, S. I. W. (2012) ‘The Theoretical Perspectives Underlying Technology Transfer: A Literature Review’, *International Journal of Business and Management*, 7, 2, pp. 277-288.

Walker, A. and Ellis, H. (2000) ‘Technology Transfer: Strategy, Management, Process and Inhibiting Factors. A Study Relating to the Technology Transfer of Intelligent Systems’, *International Journal of Innovation Management*, 4, 1, 97.

Waroonkun, T. and Stewart, R. A. (2008) ‘Modeling the international technology transfer process in construction projects: evidence from Thailand’, *Journal of Technology Transfer*, 33, 6, pp. 667-687.

Wicklein, R. C. and Kachmar, C. J. (2001) ‘Philosophical rationale for appropriate technology’ in Wicklein, R. C. *Appropriate technology for sustainable living, Council on Technology Teacher Education 50th Yearbook*, pp. 3-21.

Wong, J. K. (1995) ‘Technology transfer in Thailand: descriptive validation of a technology transfer model’, *International Journal of Technology Management*, 10, 7, pp. 788-796.

Wood, B. and Schumacher, E. F. (1984) *His Life and Thought*, Harper & Row, New York.

Young, S. and Lan, P. (1997) ‘Technology transfer to China through foreign direct investment’, *Regional Studies*, 31, 7, pp. 669-679.

Zhao, P. (2013) ‘Strategies Analysis of MNCs' Technology Transfer Based on the Asymmetric Evolutionary Game’. *Journal of Management Policy and Practice*, 14, 2, pp. 98-107.