The Role of the ICTs in Knowledge Transfer:

A special focus on Fraunhofer AICOS

Mónica L. Azevedo
Univ Portucalense and Research on Economics, Management and Information Technologies - REMIT, Portugal

Óscar Afonso
University of Porto, Faculdade de Economia, CEFAGE_UBI and OBEGEF, Portugal

Paulo B. Vasconcelos
University of Porto, Faculdade de Economia, CMUP and OBEGEF, Portugal

ABSTRACT

The purpose of this chapter is to review the increasing importance of knowledge in society in general and in economy in particular. Knowledge transfer is more and more important at different levels (e.g., micro and macro-level). The authors also intend to show the role played by ICTs in knowledge transfer. To illustrate this, they use some examples of institutions in Portugal, specifically they explore the case of Fraunhofer AICOS. Under the umbrella of the ICT4D concept, it is analyzed as ICTs can be used to surpass some difficulties of the least developing countries. However, there are also difficulties related to the acceptance and adoption of ICT solutions, as well as special requirements imposed by the reality of the countries.

Keywords: eAgriculture, eBusiness, eGovernance, eHealth, Explicit Knowledge, ICT4D, Mobile Solutions, Open Innovation, Tacit Knowledge

INTRODUCTION

Information and knowledge have gained increasing importance in Economics and the emergence of the so-called knowledge-based economy highlights this. These concepts are closely related with knowledge because the latter only has a substantial impact on society transformation if it is shared and incorporated in new (or significantly improved) products, services, processes, organizational methods, … Information and Communication Technologies (ICTs) have been an important means of dissemination of ideas and knowledge. In particular, ICTs facilitate knowledge diffusion to more remote or less developed areas and they allow solving or alleviating some society's problems. In this sense, several institutions have dedicated efforts to develop ICTs solutions to address issues in diverse areas such as: health, environment, ageing population and the evolution of less developed countries.

The aims of this chapter are to present some literature insights about knowledge transfer, to demonstrate knowledge transfer importance, and to show some examples of institutions that play an important role in knowledge transfer in Portugal with special focus on the Fraunhofer Portugal case. It is important to discuss this topic because the kind of actions developed by these institutions can provide lessons for other countries.

The present chapter is structured as follows. After this brief introduction, a section with some literature review and background considerations will be presented. Then, it will be presented the main focus of this chapter: the vital part of some institutions in knowledge transfer in Portugal, with a special attention on Fraunhofer Portugal. Afterwards, a set of recommendations will be pointed out. Some future research directions are discussed and the last section concludes.

BACKGROUND

As information and knowledge become more and more relevant, in this section a brief overview on knowledge and innovation, presenting a bibliographic review and introducing the most relevant concepts,
Knowledge has become an essential resource for organizations (Gassmann, 2006) and, therefore, it has been considered one of the engines of the economy (Ancori et al., 2000; OECD, 2013; Silva and Neves, 2003). In fact, the term 'knowledge-based economy' has been frequently applied. According to OECD/EUROSTAT (2005), this expression is used to define trends in developed economies concerning a bigger dependence on knowledge, information and high skill levels as well as the growing necessity for ready access to the latter by the private and public sectors. Skyrme (1997) emphasizes the main differences between traditional economy and knowledge economy. The Portuguese Norm NP 4457:2007 (Instituto Português da Qualidade, 2007b) considers that knowledge is the basis of the wealth creation in advanced societies and I&D (investigation and development) are a way of creating that knowledge. Therefore, innovation is how that knowledge is transformed into economic development. From the recognition that knowledge is a more and more fundamental asset for organizations, it appeared the 'knowledge management' concept. Knowledge management can be considered as the series of procedures and means to generate, use and transfer knowledge in an organization (Silva and Neves, 2003). Lee and Yang (2000, p. 784) consider that knowledge management is *the collection of processes that govern the creation, dissemination and leveraging of knowledge to fulfill organizational objectives*.
However, after all, what is knowledge? According to Moran (1994), knowledge is the capture, the understanding and the expression of all dimensions of the reality in a broader and deeper way. Davenport and Prusak (1998) start by emphasizing that, although knowledge is neither data nor information, it is deeply connected to both. They define knowledge as *a fluid mix of framed experience, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms* (p. 5). Sarmento et al. (2000) also differentiate data, information and knowledge, enforcing the close relation among these terms and the consequent misunderstanding relatively their meaning. In spite of recognizing the difficulty and the lack of consensus about the knowledge definition, the authors resort to the definition of Davenport and Prusak (1998). Bearing in mind the glossary of the Manual de Apoio ao Preenchimento do Sistema de Innovation Scoring da COTEC (COTEC, 2010), knowledge is a set of specific information, values, experience and know-how, which provides a guideline to evaluate and incorporate new experiences and information. For the purpose of this chapter, the authors also follow the definition of Davenport and Prusak (1998).
There are different types of knowledge. Polanyi (1967) distinguishes tacit from explicit knowledge. Explicit knowledge is also called codified knowledge (Wright et al., 2008). The distinction between tacit and codified knowledge can be a complex but an important issue. Several authors have followed Polanyi's distinction and have presented definitions for each one of these types of knowledge, which can be summarized as follow. Tacit knowledge is not easily visible and expressible, is highly personal, and context specific. It is thus difficult to formalize and transfer; it cannot be codified (Foray and Lundvall, 1998; Nonaka, 1991, 2008; Nonaka and Takeuchi, 1995; Silva and Neves, 2003; Weidenfeld et al., 2010). About this kind of knowledge, Polanyi (1967, p. 4) refers that *we can know more than we can tell*. By contrast, codified knowledge is usually conveyed in a compact and standardized structure, and thus easily transferred through a formal language (Foray and Lundvall, 1998; Nonaka and Takeuchi, 1995; Silva and Neves, 2003). If skills (e.g., passed from master to apprentice), beliefs and modes of interpretation are examples of tacit knowledge, which can be obtained through several forms of experiences, explicit knowledge can be found in forms, documents (such as textbooks and technical documents) and electronic databases (Foray and Lundvall, 1998; Lee and Yang, 2000; Weidenfeld et al., 2010). Despite the lack of consensus, many authors consider that these two kinds of knowledge are complementary (Ancori et al., 2000; Foray and Lundvall, 1998; Nonaka and Takeuchi, 1995). However, there are other classifications. Baumard (1996) advocates that both tacit and explicit knowledge can be considered individual or collective. Quinn et al. (1996) present

four levels of knowledge: cognitive knowledge, advanced skills, systems understanding and self-motivated creativity. Whitehill (1997) gives six types of knowledge: encoded knowledge, habitual knowledge, scientific knowledge, collaboration knowledge, process knowledge and communal knowledge. Ancori et al. (2000) offer a synthesis of the main typologies.

Additionally, some authors highlight other characteristic of knowledge: on the one hand, its value grows when shared; on the other hand, knowledge weakens if it is not used (Prahalad and Hamel, 1990; Quinn et al., 1996).

From the distinction between tacit and explicit knowledge, Nonaka and Takeuchi (1995) identify four types of knowledge conversion or, in other words, four methods of knowledge transfer: socialization (from tacit to tacit), externalization (from tacit to explicit), combination (from explicit to explicit) and internalization (from explicit to tacit) – known as SECI process. For each one of these processes, it is possible to find several tools by which knowledge is transferred (see, for example, Gronau and Weber, 2004; Oliveira and Bonfadini, 2016; Torres et al., 2009). Being socialization a procedure where tacit knowledge (such as mental models and technical skills) is created and experiences are shared, brainstorming, informal meetings, face-to-face interactions, observation and imitation, on-the-job training and mentoring are examples of socialization tools (Finley and Sathe, 2013; Kaufman, 2001; Torres et al., 2009). Externalization can be defined as a method of converting tacit knowledge into explicit concepts; from now on individual knowledge is shared by a group; happens when a person's tacit knowledge is converted into understandable forms that can be recognized and conveyed by other people (Finley and Sathe, 2013; Kaufman, 2001; Torres et al., 2009). Cooper (2006) advocates that explicit knowledge corresponds to the knowledge capital that is appropriated by the organization, regardless of who works there. Creation of hypothesis and metaphors as well as concepts, analogies and graphic resources, two-way dialogue, active listening and the visual depiction of ideas and concepts are some examples of converting tacit into explicit knowledge (Finley and Sathe, 2013; Oliveira and Bonfadini, 2016). Note that Foray and Lundvall (1998) emphasize that, in line with Polanyi, there is only one way of transferring tacit knowledge: through a specific kind of social interaction similar to apprenticeship relationships. Therefore, these authors underline that tacit knowledge cannot be bought and sold, instead, its transfer is very influenced by the social environment. Combination consists in explicit knowledge systematization; explicit knowledge is transferred from the group to the organization; occurs when different bodies of explicit knowledge are exchanged and combined; it is related to information processing. This stage can be also characterized by the integration of new explicit knowledge. Combination examples comprise academic forums, research processes, face-to-face meetings, audio or web-based conversations as well as data manipulation (emails, documents, meetings) and its reconstruction in the form of reports (Finley and Sathe, 2013; Oliveira and Bonfadini, 2016). Internalization happens when explicit knowledge is converted into tacit. In this case, knowledge goes from the organization to the individual. That is, *when experiences through socialization, externalization and combination are internalized into individuals' tacit knowledge bases in the form of shared mental models or technical know-how, they become valuable assets* (Nonaka and Takeuchi, 2001, p. 74). Documents and manuals are important in this process and the concept of 'learning-by-doing' is also linked to it (Nonaka and Takeuchi, 2001). On-the-job training, practicums, simulations and experiments can also be considered examples of internalization (Finley and Sathe, 2013). Tacit knowledge accumulated by the individuals of an organization should be transmitted to other company's members to occur organizational knowledge creation, forming thus a kind of spiral – the 'spiral of knowledge' (Nonaka and Takeuchi, 2001; Oliveira and Bonfadini, 2016). This is another concept brought by Nonaka and Takeuchi (1995), which is formed by the previous four concepts. These authors believe that organizational knowledge creation is originated through a spiral process, which begins at the individual level and it is amplified through the four processes described above. Then, the tacit knowledge of the individuals is the basis of organizational knowledge creation (Nonaka and Takeuchi, 2001). The main engine of this spiral is the continual interaction of tacit and explicit knowledge (Nonaka and Takeuchi, 1995; Oliveira and Bonfadini, 2016; Silva and Neves, 2003).

Given that knowledge is a resource that grows when shared, knowledge transfer emerges as an important field (Silva and Neves, 2003). Knowledge can be transferred at different levels, for example: within the

firm, intra-firms and between universities and industry (Bekkers and Freitas, 2008; Weidenfeld et al., 2010). When knowledge transfer occurs in-house within organizations, it includes several types of individualized and collective learning. Although tacit knowledge can be passed on personally within organizations, the transformation of tacit into explicit knowledge enables an easier redistribution. On the other hand, at the macro-level, while explicit knowledge may be learnt from suppliers by technology, tacit knowledge is passed on in several forms, for instance, labor spillovers and observation of rivals. Tacit knowledge is gradually seen as a key to competitiveness because explicit knowledge is commonly believed easier for competitors to mimic. Between universities and industry, knowledge (and technology) transfer can also occur via different channels, for example: published papers and reports, public conferences, the mobility of students, collaborative R&D (Research and Development), patents and meetings, licenses and personnel exchange (Bekkers and Freitas, 2008; Wright et al., 2008). In fact, all of these relationships are considered in the innovation model (Modelo de interações em cadeia) presented in The Portuguese Norm NP 4456:2007 (Instituto Português da Qualidade, 2007a). According to the referred document, this model was developed to be a reference to organizations in the transition to knowledge economy. In this Norm, knowledge transfer is defined as the process of passing scientific, technological, organizational or marketing information as well as exploitation rights and means to others. From the model, it is possible to state that it takes into account the three levels of knowledge transfer mentioned above. Moreover, in line with this model, innovation is a consequence of a sequence of relations between central skills of the innovative company and skills which characterize the agents of its economic surroundings. The necessary knowledge to develop innovation projects can be available internally or can be obtained from the exterior. By considering the possibility to incorporate knowledge coming from the surroundings, this framework can be considered a model of open innovation (see more about this concept in the next section). Knowledge and innovation are, effectively, two inseparably concepts because knowledge creation (and, consequently, knowledge transfer) is a key element of the innovation process (Weidenfeld et al., 2010). Furthermore, knowledge management and transfer as nuclear elements of continuous learning and innovation are essential for acquiring and holding competitive advantage (Weidenfeld et al., 2010). Although knowledge management is not synonymous of information technology and technology itself cannot be a guarantee of competitive advantages, it can be a good tool of knowledge management and transfer (Sarmento et al., 2000; Silva and Neves, 2003). Foray and Lundvall (1998), for example, refer that deep changes in knowledge creation, storage and diffusion are being boosted by ICTs. According to Chetley et al. (2006) ICTs can be described as forms which simplify communication and the managing and diffusion of information by electronic means. This definition comprises all kind of ICTs such as radio, television, fixed and mobile phones, computers and the Internet.

ICTs have also been important for countries' development (e.g., Avgerou, 1998; Bhatnagar & Schware, 2000; Harindranath & Sein, 2007; Heeks & Arun, 2010; Madon, 2005). The World Bank extends access to ICTs and encourages their use in order to promote sustainable growth, enhance service delivery and encourage good governance and social accountability (The World Bank, 2017a).

Knowledge transfer is strictly linked to other concept: 'open innovation'. Moreover, open innovation is very dependent on knowledge transfer (European Commission, 2014). For the majority of the firms, the R&D activities are essential, but they can be internal or external (Berchicci, 2013; Sarkar, 2014). Despite the second type has gained forced in recent years, Berchicci (2013) highlights that firms adopting this behavior can achieve a superior innovative performance, but to a limited degree. Sarkar (2014) considers that in the large companies, R&D work can be carried out by their own workers. But for small and medium enterprises this is a great investment, given their structure. Bearing this is mind the open innovation concept emerged, related to the share of activities and innovation sources. Henry Chesbrough is considered the "father" of the concept of open innovation. Open innovation represents a new paradigm in opposition to closed innovation (the 'do-it-yourself' mentality) and it suggests that useful ideas can come from inside or outside the firm as well as can go to market from inside or outside the firm (Chesbrough, 2006; Gassmann, 2006). Sarkar (2014) gives an example of open innovation: if an organization develops a technology/innovation which will not use, it can give that technology/innovation to another external

organization (by a license) which will commercialize it and then both win. However, open innovation can be applied on any phase of the innovation process: research, development and commercialization. Several competitive advantages can be obtained with open innovation although its gains can occur at diminishing returns, which is in line with Berchicci (2013). De Backer et al. (2008) mention that open innovation can be developed through different forms including partnerships with external parties, acquiring/selling knowledge and corporate venturing. The open innovation concept can be synthetized in a simple statement: smart people do not work only in our own company (Chesbrough, 2006; Sarkar, 2014). In a globalized world, it makes sense to think in open innovation at a large scale: among countries. Consequently, the scope for open innovation becomes bigger and bigger, that is, there is an increase in the number of the potential partners. Firms connect in the global innovation networks with people, organizations (such as universities and government agencies, among others) and other firms in foreign countries to find solutions and new ideas (De Backer et al., 2008).

ICTs have also played an important role to the emergence of open innovation (Dodgson et al., 2006). In fact, ICTs have been very relevant to the different stages of innovation processes (stage of idea generation and development, design, testing and refinement of ideas into products and services and commercialization stage) and they are also a pillar of open innovation (Awazu et al., 2009). Moreover, it is considered that ICTs, namely Internet, fastened the knowledge distribution process and improved the personal mobility of knowledge workers (Gassmann, 2006). Also Sarkar (2014) underlines the relationship between internet and open innovation. This author also refers that as the open innovation model is based on the idea that the knowledge becomes more available through ICTs diffusion, companies should not be limited to their own research. Thus, they should be able to integrate and value external knowledge and skills.

KNOWLEDGE TRANSFER IN PORTUGAL

In this section, some examples of institutions which act in Portugal and play an important role in knowledge transfer will be presented. After that, ICTs will be tackled as tools of knowledge transfer, introducing the Fraunhofer Portugal case and giving a special emphasis on four fields: agriculture, very small enterprises, health and citizenship & government.

The role played by some organizations

Some institutions/organisms have played a relevant part in technology and knowledge transfer, between universities and companies, between countries (namely, from developed to developing countries), among others. In Portugal, Instituto Pedro Nunes (IPN), Instituto de Engenharia Electrónica e Telemática de Aveiro (IEETA), Instituto de Engenharia de Sistemas e Computadores (INESC), Parque de Ciência e Tecnologia da Universidade do Porto (UPTEC) and Associação Fraunhofer Portugal Research (Fraunhofer Portugal), among others, are good examples.

IPN is a non-profit private organization whose main goal is fostering innovation and technology transfer, making bridges between the scientific and technological context and the production sector. Moreover, its mission is empowering university-industry relationship to encourage innovation, accuracy, quality and entrepreneurship in private and public sector organizations in three interdependent fields (IPN website):

- Research and technological development, consultancy and specialized services;
- Incubation and acceleration of tech-based businesses;
- Highly specialized training and promotion of science and technology.

IEETA is a Computer Science and Engineering/Electronics and Electrical Engineering research unit organized in three groups:

- Biomedical Informatics and Technologies;
- Information Systems and Processing;

- Intelligent Robotics and Systems.

While the first two groups are more application oriented, the last one has a more fundamental nature. Intelligent Systems for Human Assistance is the thematic line in IEETA. The Biomedical Informatics and Technologies group, for instance, intends to provide more scientific developments in ICTs for translational health (IEETA website).

INESC is a non-profit association devoted to education, science incubation, research activity and technological consulting. This institute has also introduced itself as a best practice of the university-enterprise relationship. Under the umbrella of INESC, several ICTs solutions have been developed to be applied in different fields such as health, small and medium enterprises (SMEs) and agriculture (INESC website). Relatively to the latter case, INESC-TEC (Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência) has evolved technologies for the agricultural, agrifood and forest sectors (TEC4AGRO-FOOD). AGROB V14 and COTTOS-D are two examples of those technologies. ExpertBayes software is an example of technology developed by the INEC-TEC to apply to the health sector (INESC-TEC website).

UPTEC emerged with the aim of supporting the University of Porto's third mission - the social and economic influence of its created knowledge. Consequently, it provides a sustainable form to the progress of the North of Portugal. This structure of the University of Porto is devoted to incubate startups and host national and international Business Innovation and then it plays a vital role in sustaining a valuable transfer of knowledge and technology between university and markets. Different thematic centers form UPTEC: Technologies, Creative Industries, Biotechnology and Sea. The Technology Center of the Science and Technology Park of University of Porto (UPTEC TECH) gives assistance, infrastructure and technological tools which encourage the development and boost of technology-based projects. It also sustains the creation of new goods and services to market, focused on an effective inclusion of extremely qualified human resources as well as transfer of knowledge and technology (UPTEC website).

Fraunhofer Portugal is a non-profit private association which is incubated in UPTEC TECH. It is described as being a driving force in innovation. Furthermore, the development of scientific knowledge able of creating added value to its customers and partners, searching for technology innovations focused on economic growth, the social well-being and the increase of the quality of life of its end-users are pointed out as the main goals of this association.

The SECI model can be applied as a framework of knowledge creation (and dissemination) in these kind of institutions. Social interactions by face-to-face meetings, share of experiences and know-how, discussion and brainstorming sessions are typical within these organizations and can be pointed as examples of socialization. The feedback obtained by experimenting among the target population is also an extremely important knowledge to ICTs solutions development. Formalization of ideas and reports about previous experiences' results allows transforming tacit in explicit knowledge (externalization). The aggregation of diverse explicit knowledge in a set of specifications to a new product/ICTs solution can be considered an example of combination. Internalization can occur by different ways: not only the implementation of the developed methods and the usage of developed ICTs solutions by target groups but also the knowledge acquired by individuals involved in the ICTs solutions development through simulations and experiments. In both cases, knowledge is acquired through learning-by-doing. When the tacit knowledge accumulated by the organization's individuals is transmitted to other company's elements, organizational knowledge is created and socialization process happens. Thus, it is possible to recognize the spiral of knowledge referred in Background section. In fact, Nonaka and Takeuchi (1995, p.3) point that organizational knowledge creation consists in *the capability of a company as a whole to create new knowledge, disseminate it throughout the organization, and embody it in products, services and systems.* Analyzing the presented cases, it is possible to state that this process occurs and knowledge is not only disseminated into the organization and embodied in the developed solutions but, in some cases, the ICTs solutions also allow

transfer knowledge to users, especially in case of ICT4D. The adoption of ICTs solutions in agriculture, for example, can allow to transfer knowledge about the most suitable agricultural practices.

ICTs as tools of knowledge transfer – Fraunhofer Portugal case

ICTs are being used to increase organizational knowledge assets (Olomolaiye and Egbu, 2005). In fact, they facilitate the transfer of both explicit and tacit knowledge (Phang and Foong, 2010). Moreover, they can be crucial tools for knowledge transformation processes (Davidavičienė and Raudeliūnienė, 2010). However, this is not the main topic of the present section. The authors intend to underline how the development of ICTs solutions can be important channels in knowledge transfer, emphasizing the role played by Fraunhofer Portugal (FhP).

FhP is constituted by different research centers. With the purpose of developing applied research of direct benefit to private and public firms and of great advantage to community, FhP fosters and manages the collaboration between its research centers, other research institutions (such as universities) and industry partners. AICOS (Research Center for Assistive Information and Communication Solutions) is one of these research centers and it develops ICTs solutions in the areas of AAL (Ambient Assisted Living) and ICT4D (Information and Communication Technologies for Development). This organization considers that ICTs solutions for least developed countries are a main factor to a sustainable and self-created emancipation of people. FhP teams study several ways of addressing the demands of the increasing number of users who neglected extensively the 'PC-Age'. While they are focusing on the internet enabled skills of new gadgets and services, they concentrate on the existing experiences that their target groups have with 'old school' ICTs such as telephones and TV sets.

For the purpose of this work, the focus will be the second concept: ICT4D. According to Sutinen and Tedre (2010) this concepts denotes the prospects of ICTs as a mediator of development. Also Tomlinson et al. (2012) state that ICT4D is about the function and possible consequences of ICTs in assisting the developing areas. FhP describes ICT4D as a broad concept concerning to the ICTs application within the domain of social and economic development (Fraunhofer Portugal website). There are some well-known examples of ICT4D such as M-Pesa (the Kenyan mobile money service) and the NWNP (Nepalese Wireless Networking Project) (Renken and Heeks, 2013).

African continent is the focus of ICT4D activities developed by Fraunhofer AICOS (FhP-AICOS), being the populations in rural and developing areas the key target groups. In this scenario, the purpose is to give original solutions for mobile devices that serve local needs and can be a relevant contribution on the quality of life. However, it is necessary to pay attention to the existing differences between ICTs usage in industrial and developing countries such as the kind of gadgets and technology used when dealing with ICTs. While in developed areas contact with ICTs occurs chiefly by laptops, in developing regions the mobile phone has a significant impact as a main tool of access and contact with ICTs. Since African continent is the world's fastest increasing market for mobile phones, smartphones and mobile software solutions will perform a more and more relevant role. Therefore, FhP-AICOS has observed a strong necessity and opportunities for joint research and development of mobile ICTs solutions between European and African partners due to the following aspects (Fraunhofer Portugal website):

- A distinct legal, cultural, social and physical environment implies diverse conditions for mobile ICTs solutions, which most European mobile ICTs solutions do not consider and consequently do not serve the end user's needs;
- Africa is initiating its own outstanding mobile software solutions such as mobile money and mobile health.

FhP-AICOS provides its proficiency in mobile applications and services, mainly in smartphones based solutions. It has developed several ICTs solutions in order to attend special needs of least developed countries and, in 2013, it even started to develop the ICT4D Competence Center, a development of the very successful Android for Developing (A4D) project that FhP-AICOS performed in 2009/2010 with partners

from enterprises and science. The ICT4DCC is constituted by a team of international experts who work with international partners (Fraunhofer Portugal website).

Bearing in mind its institutional presentation (Fraunhofer Portugal, 2016) the main addressed fields by ICT4D are mGovernment, mHealth, mAgriculture and ICTs for Very Small Enterprises. In this sense, several projects about ICT4D have been developed, for example: ACP Street Libraries, Epidemiologic Surveillance, Hydroponic Farming, IZIDoc, MalariaScope, OurMoz and PostboxWeb. Nevertheless, in order to develop these solutions, it is necessary to pay attention to developing countries' reality. In fact, although ICTs solutions can be a good help for these countries, they cannot be neither expensive nor very complex. Another difficulty is the lack of electricity and internet in most areas. Then, these kind of solutions must consider all these aspects. From here, it is possible to understand the importance of the role played by ICT4DCC in analyzing all characteristics and challenges of the usage of the existing ICTs in developing areas and performing a group of activities regarding local requirements and key performance indicators assessment, human computer interaction and user experience, low cost networks, socio-economic impact of ICT4D and knowledge transfer (Fraunhofer Portugal website). Still according FhP-AICOS institutional presentation (Fraunhofer Portugal, 2016, p. 15), its strategic research agenda related to ICT4D includes:

- *Investigation of user demands for mobile ICT solutions in the fields of agriculture, urban micro enterprises, m-health and e-government and their potential socioeconomic impact in developing countries;*
- *Joint development of locally relevant solutions which might get incubated into new businesses;*
- *Knowledge transfer to ensure a sustainable benefit for an independent and uprising ICT industry in the partner countries;*
- *Enabling long-term partnerships between the developing countries and the European partners.*

According to the text above, FhP-AICOS intends not only to develop ICTs solutions, but also transfer knowledge to developing countries. This knowledge can be of two different kinds: that related to ICTs usage and that related to the area where ICTs solutions are used (agriculture, health, …). In order to conduct knowledge and technology transfer, FhP-AICOS has promoted initiatives such as contests, knowledge transfer days, workshops, studies, exhibitions, networking and the participation at international events (Fraunhofer Portugal, 2017a, 2017b). The set of initiatives which aims promoting scientific and technological knowledge transfer is known as Collective Transfer Fraunhofer Portugal (CTFhP). The main goals of the CTFhP initiatives are to reveal the results of the applied research projects and the impact of these investigations to the community development. Three types of continuous actions to knowledge transfer worldwide comprise the focus of this initiative, being two of them directly related to ICT4D:

- Fraunhofer Portugal Challenge and Fraunhofer Collective Transfer Day are developed to encourage cooperation and scientific knowledge transfer, taking into consideration the economic recovery, which includes network activities and domestic and global promotion;
- Initiatives which aim to deliver the ICT4D at African countries are also developed. The goal is to promote distribution actions of new skills and technology generated within the R&D activities promoted by FhP-AICOS, for both domestic and global business community.

Relatively to the latter topic, it is important to underline that the initiatives include actions to test and elaborate projects pilot demonstrators. Bearing in mind its own publication on 8th February 2017 (Fraunhofer Portugal, 2017a), the latest initiative of knowledge transfer was in January in Mozambique, where the idea and technology associated to the Sustainable Villages for Development (SV4D) project were shown. In that session, FhP-AICOS group traveled to that country to show the idea that is currently being employed within the SV4D project. In this initiative, it was performed a workshop which included, among others, a brainstorming session in which members could present their views about the work developed and about the citizens' reality as well as enquire about some characteristics of the project roadmap.

From the previous statement, it is possible to confirm the importance of understanding the reality of each country before solutions being developed. Namely, given that developing countries' reality is substantially different from the one of developed countries, solutions which are suitable for developed countries cannot be convenient for developing regions. Consequently, it is not enough to transfer ICTs solutions and related organizational ideas from developed to developing regions (Schuppan, 2009). Frequently, least developed countries face difficulties such as lack of infrastructures (e.g., electricity and telephone lines), high levels of illiteracy, lack of access to finance and lack of trust and honesty in the business culture (Ashrafuzzaman, 2014; Kaufmann and Parlmeyer, 2006; Lio and Liu, 2006; Modimogale & Kroeze, 2011; Wolf, 2001). As a result, they need different solutions suited to both their reality and needs. In this sense, Fraunhofer Portugal has been focused on areas such as agriculture, small enterprises, health and citizenship & government (Mozambique and South Africa have been partners of this institution to develop these kind of solutions). As it is possible to confirm by the following considerations, ICTs have potential to help developing countries in those areas.

Agriculture

Typically agriculture is a vital sector for developing countries (Aker, 2011; Moore, 2000; Munyua et al., 2009) and rural populations are very dependent on this sector (Stienen et al., 2007). Problems such as the decreasing of available natural resources (including water and soil fertility), the consequences of climate change and the reduction of fertile agricultural lands because of urbanization together with a growing demand for agricultural goods leave these countries in an uncomfortable situation (Stienen et al., 2007). This growing demand can be an opportunity for producers to enhance their living conditions. Therefore, Stienen et al. (2007) defend that ICTs can be a key factor to mitigate problems of efficiency, productivity and sustainability of small-scale farms which predominate in Africa (Deloitte, 2012). Other authors have found positive results of ICTs adoption in agricultural sector (Aker, 2011; Deloitte, 2012; Lio and Liu, 2006). Munyua et al. (2009) recognize the potential of ICTs in revitalizing small-scale agriculture in Africa by boosting agricultural productivity by transferring knowledge and information to rural agricultural populations, giving building, accessing markets and credit, reforming of extension and scaling up inter-linkages of development actions. Qaisar et al. (2011) stress that ICTs have been applied on agricultural activities in developing countries. In this context, Munyua et al. (2009) express that technological tools such as the FM radio stations and the mobile phone have become important in improving small-scale agriculture in rural areas. Also web-sites and web-based applications are becoming ever more vital in transferring agricultural information and knowledge and marketing of goods and services. Radio frequency identification technology, market information systems, geographic information systems, precision agriculture and public access facilities are other emerging ICTs applications for small-scale agriculture. Low technical ability and restricted ICTs infrastructure in the agricultural sector, especially in rural zones, are pointed as reasons for the low usage levels of these applications (Munyua et al., 2009). With the usage of ICTs as a tool to enable, support and enhance agricultural production emerged the concept of eAgriculture (electronic agriculture) (Deloitte, 2012). Given the particular potential of mobile technology usage in agricultural sector, other concept appeared: mAgriculture (mobile agriculture). eBanking and mBanking (electronic and mobile banking, respectively) services can also be important tools for farmers (Kirui et al., 2012). In addition to the potential benefits of ICTs for agricultural sector already mentioned, they can also contribute to knowledge transfer through, for example, their capacity to facilitate the diffusion of methods or mechanisms for soil preservation and preparation (using the internet and in partnership with research organizations); the encouragement of information shared (by the internet) about endangered

species, enhancing environmental control policies; the transmission of domestic information through geographical information service technologies; the creation of a domestic computer network linked to regional and international networks in order to foster reciprocity among nations and the experiences exchange; and the transfer of information worldwide (via internet) about the country's tourism potential and hence catch the attention of tourists and investors (Kapuya et al., 2011).

Very small enterprises

It is important to pay attention to small enterprises since they are prevalent in developing countries and thus play an important role in the economic development of these economies (Daniels, 1999; Qureshi et al, 2008; Southwood, 2004). Notwithstanding, there is a controversy around their effective contribution. Some authors consider that they are essential to domestic income, employment and poverty reduction (in spite of their low wages, households try to survive, to raise their children and usually to exit poverty), others disagree and state, for example, that these enterprises often develop low-income activities, are not efficient enough and usually do not endure a long time (Beck et al., 2005; Daniels, 1999; Gibson and van der Vaart, 2008; Ladzani and Netswera, 2009; McCormick, 1999; McPherson, 1996; Mead and Liedholm, 1998). Very small enterprises, or even home-based enterprises, work with few workers, sometimes only one person, and are usually located in rural areas (Delécolle, 2011; McPherson, 1996; Mead and Liedholm, 1998). But, what is the role played by the ICTs in small businesses? Qureshi et al. (2008) recognize that ICTs can be important to small businesses growth. In particularly, these authors state that information technology (IT) may be used by small enterprises to create new jobs, increase productivity and sales through access to new markets and obtain administrative efficiencies. Also Southwood (2004) points out that, by making smart investments in ICTs, African entrepreneurs can increase productivity, have access to international markets and provide better service to their customers. Additionally, Modimogale and Kroeze (2011) begin by recognizing that, given the vital role played by ICTs in the knowledge economy, it is crucial for small enterprises to take part in this economy to compete and flourish in the future. Moreover, these authors consider that knowledge is the key asset in this 'new' economy, it is what is bought and sold. In an increasingly global and digital world, the way business is done and the competition in the marketplace have experimented changes. According to Modimogale and Kroeze (2011), ICTs are the backbone of this change. They also consider that information gives SMEs a competitive advantage in the new economy, then small enterprises should take advantage of the ICTs potential so as to take on the competition. The competitiveness of the business relies on the conventional and the ICTs tools. Relatively to South African SMEs, Modimogale and Kroeze (2011) consider that they can obtain a great advantage from the use of ICTs such as internet connectivity and mobility. Additionally, given that a great part of South Africans have mobile phones, SMEs should mainly invest in mobile technologies. Qiang et al. (2006) also underline the importance of a good communication and information infrastructure to boost the connectivity between enterprises, suppliers and customers. They also create business opportunities, specifically for firms that are far from urban areas. Wolf (2001) highlights that the dissemination of ICTs and the reduction of the communication prices have enabled markets around the world to become more integrated. So, ICTs can also be a significant form to transfer important knowledge to enterprises, improving their competitiveness, given that: they provide ways of accessing the latest market opportunities and specialized information services (e.g., distance consulting and constant training and new advisory services; institutions can exchange real-time information and promote closer relationships with their customers, suppliers and

business associates; instantaneous customer feedback allows companies to answer faster to changing customer demands and find new market niches Fulantelli and Allegra (2003). In fact, information is vital to companies and ICTs can foster and enable information access which is usually achieved from entrepreneurs' personal contacts and media (where, for example, sales and purchase information is rare) (Wolf, 2001). eBusiness, eCommerce, eMarketing and even eLearning (electronic business, commerce, marketing and learning) are examples of systems through which ICTs can help small enterprises (Mazzarol, 2015; OECD, 2004).

Health

Health is a general concern, especially when the subject is the least developed countries. Inhabitants of these countries often suffer from many illnesses or health problems such as HIV/AIDS, malaria, tuberculosis and malnutrition (Müller and Krawinkel, 2005; WHO, 2017). Therefore, they are expected not to live long and the mortality rates are high (WHO, 2017). Moreover, it can be very difficult to benefit from healthcare, mainly in rural regions (Peters et al., 2008; Strasser, 2003). Health is an important issue in terms of countries' development, which is reflected in the 'Millennium Development Goals' where three of the eight goals are directly related to health: reduce child mortality, improve maternal health and combat HIV/AIDS, malaria, and other diseases (United Nations, 2015). Furthermore, several authors have analyzed the effect of health in economic growth arguing that health is strictly related to human capital and it is important to, for instance, productivity (Barro, 2013; Bloom et al., 2004). However, before enter in this virtuous cycle, countries need to exit from (or avoid) the opposite, the vicious cycle faced by several developing regions: as poor nations have a lack of financial resources, they apply them wisely, namely in a costly field such as healthcare (Hassibian, 2013) and then they have a poor healthcare sector which also does not contribute to growth. In fact, it is possible to find two ways of causality in the relationship between health and socioeconomic development. From one point of view, health status can encourage nations' development. For example, in nations with least developed healthcare services, inhabitants may face many health problems and hence they are not able to work productively. Therefore, the development of the healthcare delivery can stimulate nations' development. But then, economic performance can also benefit health as GDP growth enables nations to rise healthcare expenditures (Vital Wave Consulting, 2009). The need of finding alternative (and low-cost) solutions emerges from the previous arguments combined with the lack of healthcare professionals, particularly in rural areas. ICTs can be a good tool to mitigate these problems through, for example, the development of electronic health (eHealth) systems, and particularly mobile health (mHealth) ones. mHealth can improve the quality, effectiveness and efficiency of care because it can be used to, for instance, education and awareness, prevention, remote data gathering, delivering continuous care remotely, communication and training for healthcare workers, disease and epidemic outbreak tracking, diagnosis and treatment support as well as strengthening healthcare delivery systems (PwC, 2013; Vital Wave Consulting, 2009). Under the title 'Improving health, connecting people: the role of ICTs in the health sector of developing countries', Chetley et al. (2006) present seven conclusions about the use of ICTs in the health sector, underlining the complexity of putting them in practice guaranteeing, simultaneously, that health system, health professionals and patients get some advantage and the health level improves. These are (Chetley et al., 2006, p.5): *keep the technology simple, relevant and local; build on what is there (and being used); involve users in the design (by demonstrating benefit); strengthen capacity to use, work with and develop effective ICTs; introduce greater monitoring and*

evaluation, particularly participatory approaches; include communication strategies in the design of ICT projects; continue to research and share learning about what works, and what fails. In spite of focusing on the use of ICTs in the health sector, these conclusions can be applied to other fields.

ICTs in health area can also be considered a knowledge transfer tool because they (namely internet) allow, for instance, change how medicine is learnt by students and healthcare professionals, provide physicians access to latest information, best practices and patients' medical records (Kwankam, 2004; PwC, 2013).

Citizenship & Government

North (1990, p. 3) defines institutions as *the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction*. Oftentimes, developing countries face problems related to institutions' quality, which include government services, property rights and tax laws. Huang and Wei (2006) refer that several developing countries are affected by high levels of corruption weakening public institutions. This reality can constitute a barrier for their development (Acemoglu et al., 2005; Jütting, J., 2003; Rodríguez-Pose, 2013). The Worldwide Governance Indicators (The World Bank, 2017b) allow measuring the quality of institutions. They are composed by six aggregate indicators classified, for each country, with a value between -2.5 (weak) and 2.5 (strong): voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption. ICTs solutions can be used in order to improve institutions, government and citizenship and, consequently, they can influence the nations' development (Awotwi and Janowski, 2011; Casson et al., 2010). In this sense, some ICTs solutions have been developed related to this matter, in particular electronic and mobile government/governance (eGovernment/eGovernance and mGovernment/mGovernance) (Asenso-Okyere and Mekonnen, 2012; Basu, 2004; Oye, 2013). According to The World Bank (2015), eGovernment refers to the use by government agencies of information technologies (such as Wide Area Networks, the Internet, and mobile computing) that have the ability to transform relations with citizens, businesses, and other arms of government. These technologies can serve a variety of different ends: better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management. Bearing in mind this definition, Dada (2006) underlines that eGovernment is not only the computerization of a government system, but also a conviction on the technology capacity to reach high levels of development in several government fields, hence changing the nature of politics and the relations between governments and citizens. Many authors also define eGovernance. Oye (2013), for instance, consider that it is the use of ICTs to foster the purposes and service delivery of the Government, namely, to encourage more efficient and cost-effective government, more suitable government services, better public access to information and more government accountability to citizens. Matavire et al. (2010) describe eGovernment as the application of ICTs to change government such as it becomes more available, efficient and accountable. Effectively, ICTs can play an important role with regard to political participation through electronic voting (eVoting) and then it contributes to combat social exclusion (Chigona et al., 2009). This is in line with the indicator 'voice and accountability' (one of the Worldwide Governance Indicators stated above) which measures not only the extent to which a nation's citizens can contribute in choosing their government, but also freedom of expression, freedom of association, and a free media (The World Bank, 2017b). Moreover, The World Bank (2015) considers that less corruption, more transparency, better suitability, income growth and/or cost savings are examples of

eGovernment benefits. Oye (2013) considers corruption, jointly with poverty and inequality, as the greatest limitation to development. Moreover, in line with this author, corruption is a sign of institutional weakness, poor ethical values, distorted incentives and deficient enforcement. Additionally, the author stresses that although corruption itself does not create poverty, it has a direct effect on economic growth and good governance, which consecutively increases poverty levels. This scenario constitutes a barrier to the fulfillment of the 'Millennium Development Goals', being one of these goals the poverty reduction. Given the strong presence of ICTs in people's lives, their help in improving efficiency in several sectors as well as in raising the volume and quality of outputs in the majority of sectors, the author believe that ICTs can also improve the operational efficiency of Government agencies (by allowing, for example, faster communications and exchange of information). As the automation of the processes allows to reduce the need of person-to-person, Oye (2013) considers that there is less room for corruption. In fact, this author points out that ICTs such as cell phones, actually enable people to collaboratively collect and share evidence of corrupt actions, that is, ICTs can help citizens facing the systems that tolerate corruption. Besides the contribution to reduce corruption, increased automation boosts the quality of services delivered to the population as well as decreases the cost of doing business and, since the latter reduces and becomes expected, business development and investment is encouraged, and then increasing economic growth. Moreover, according to Oye (2013) ICTs enable citizen's right to information, increase citizen-government discussion and promote citizen's participation in the administrative process to guarantee justice, transparency, accountability and confidence in governance. Furthermore ICTs are useful instruments to achieve citizen's right to information through disclosure and they are supervising faster and better than ever.

Although the potential of ICTs in general, and eGovernment in particular, to mitigate some administrative and development problems is highlighted in literature, several authors also emphasize that some care is needed in order to reduce the failure risk (Dada, 2006; Schuppan, 2009). Gaps between the design and the reality of these kind of systems is considered to be one of the main reasons for its failure (Dada, 2006). Heeks (2001) breaks down eGovernance in three main domains: eAdministration (improving government processes), eCitizens and eServices (connecting citizens) and eSociety (building interactions with and within civil society). eDemocracy is another system which Backus (2001) described as being the procedures and structures that involves all kinds of electronic communication between the Government and the citizen.

In any of the fields previously focused, it is possible to find barriers (some of them common) related to the acceptance and implementation of ICTs solutions. The lack of ICTs infrastructure is a mutual problem in developing countries that limits information access (Modimogale and Kroeze, 2011). High cost, cultural resistance (including the doctors' resistance to change from paper-based systems to electronic ones), illiteracy, language, low connectivity rates, institutional weakness, human resources (lack of skilled people), funding arrangements, technology and information changes and legal inadequacy are some of the other barriers identified by the literature (Ashrafuzzaman, 2014; Basu, 2004; Hassibian, 2013). Moreover, taking into consideration what was expressed above, it is possible to state that besides the great potential of ICTs solutions in helping developing countries to solve some of these problems, ICTs solutions can also allow a faster and borderless knowledge transfer. Qureshi et al. (2008) underline that the ability of ICTs to provide information and knowledge has effects on both social and economic development. Aker (2011) refers that fast diffusion of ICTs in developing nations gives an exclusive chance to transfer knowledge through private and public information systems. Effectively, a publication of The World Bank (The World

Bank, 2017a) underlines that on the one hand, technological progress, in general, is considered to be an engine of economic growth, citizen engagement and job creation; on the other hand, ICTs, in particular, are restructuring several characteristics of the economies, governments and societies. In fact, many agents (particularly public officials, businesses and citizens) in the least developed nations can use the ICTs to offer more effective services, transform economic growth and reinforce social networks. Consequently, internet access can be an essential development instrument. The Fourth Industrial Revolution is a digital revolution that involves worldwide and truthful internet access, which is essential to several developing countries completely take part in a more and more mobile and digital-based economy (The World Bank, 2017a). In this context, mobile phones have revealed great potential: at the moment 95% of the world population live in a region with mobile phone coverage; more than half of Tanzanians living on less than $2 a day have access to mobile technology; over the first decade of this millennium, regions covered by mobile-cellular network are increasing in Africa, Asia and Latin America: mobile phone coverage was available to more than 60% of the inhabitants of sub-Saharan Africa, Asia and Latin America in 2009 (Aker, 2011; The World Bank, 2017a). At the same time, there was a rise in mobile phone adoption (Aker, 2011). Although the digital revolution is a worldwide event, there are still enormous inequalities between and within countries regarding penetration, affordability and performance of ICTs services. For example, even though almost 50% of the global population in 2016 could access to the internet, the penetration rate in the developing countries was only 15%. One of the reasons for these figures is the high price of internet access through mobile or fixed broadband in several developing economies, where absence of ICTs infrastructure and the existence of restricted laws hinder broadband increase. In December 2015, the cost of mobile-broadband services reached about 17% of the average monthly Gross National Income (GNI) per capita in the developing nations, compared to only 5% worldwide. Another problem faced by developing countries is related to broadband speed (here, disparities between developed and least developed countries are also noticeable. In the context of the Sustainable Development Goals, it was settled an ambitious goal: significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020 (The World Bank, 2017a). However, governments, the private sector and the international community have to combine efforts to attain this goal and reduce the digital gap. Development is possible, though. Adequate ICTs policy reform can stimulate bigger private investment in broadband infrastructure and make access to internet cheaper. Governments can also provide fair taxation for the telecom industry and apply global service funds to focus on broadband implementation, in collaboration with others and using open access values to encourage healthy competition. These actions will contribute directly to reduce poverty and increase prosperity (The World Bank, 2017a).

By addressing areas of crucial importance for developing countries, ICTs have potential to revitalize these areas and, consequently, these countries. The previous considerations are in line with the already referred concept of ICT4D. As a result, FhP-AICOS by focusing on the development of ICT4D solutions in such vital areas and by developing knowledge transfer initiatives is contributing to the development of the least developed regions. Moreover, FhP can also play an essential role as intermediary in the process of knowledge transfer between university and industry, a relationship focused by Bekkers and Freitas (2008) and Wright et al. (2008). Bearing in mind what has been said before, the authors believe that there are several institutions in Portugal which significantly stimulate knowledge transfer and open innovation. FhP-

AICOS, in particular, can be considered an example of having good performances of knowledge transfer as an intermediate of open innovation.

SOLUTIONS AND RECOMMENDATIONS

As developing countries differ from developed ones in several ways (including infrastructures, habits and culture), technologies conceived for the first are often incompatible with the latter. Consequently, customized integration of ICTs is imperative. This is underlined in the previous sections and sustained by literature. Madu (1998) highlights the need of transferring technologies which reveal more accordance with the necessities and skills of the least developed countries. Carluccio and Fally (2008) refer a stretch of literature which assume that technologies designed by developed nations are unsuited to factor endowments in developing countries. This idea is emphasized by Davison et al. (2000) who stress that problems will not be solved using just technology unless it is combined with the social background and the stakeholders. As a result, given that technology can help countries to develop and solve some of their problems which constitute barriers to development, its potential should continue to be explored but always taking into account the differences between countries in different stages of development.

FUTURE RESEARCH DIRECTIONS

This chapter leaves a number of open questions. Although it allows us to conclude that ICTs solutions can have a positive effect on countries' development, it also highlights the existence of several barriers to their adoption which imply additional care in their design. Therefore, it is a promising theme in terms of future work. An interesting study for further investigation is to verify whether these kind of solutions have been developed taking into account countries' characteristics and to evaluate the effects of those solutions in countries where they have been applied. This analysis can be made under some fields such as: agriculture, small enterprises, health and citizenship & government. In future research, it would be also interesting to analyze, for example, the way in which knowledge transfer occurs relatively to both technology and the previous fields, and if there is monitoring by those who developed the same technology.

CONCLUSION

The benefits of the ICTs have been widely recognized by the literature. These benefits can be visible in many areas and they can be particularly relevant to developing countries' development. By the use of ICTs solutions, it is feasible to transfer technology and knowledge, namely, from developed to developing countries. Nonetheless, after a brief review of the literature, it is possible to verify that this is not an easy path. Effectively, the reality of many developing countries is substantially different from that of the majority of developed ones. Lack of infrastructures, know-how and technological literacy are examples of the difficulties faced by developing nations, which makes the adoption of ICTs solutions difficult. Therefore, in order to be successful, these solutions need to be designed bearing in mind countries' features.

Additionally, the emergence of knowledge economy, given the increasingly importance of knowledge, constitutes an important ingredient to leverage open innovation. Specifically, knowledge transfer can be considered an intermediate of open innovation. Taking into consideration what has been said, the development of ICTs solutions by developed countries in collaboration with (or to be applied in) developing countries, and the transference of knowledge (and technology) which is inherent, promotes open innovation, not only among organizations but also among countries.

In this work, the authors present some examples of institutions acting in Portugal, which play a significant role in knowledge transfer in a context of open innovation, showing, therefore, that ICTs can be an important mean to achieve this goal. Fraunhofer Portugal is one of those institutions and, in this sense, it works in vital fields such as agriculture, small enterprises, health and citizenship & government, conceiving (innovative) ICTs solutions for developing countries. In this process, it works with partners of different

types (e.g., universities, enterprises and public entities), having an important contribute to knowledge transfer and open innovation.

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KEY TERMS AND DEFINITIONS

Explicit Knowledge: Knowledge that is easily codified and expressed.

ICT4D: The use of ICTs solutions to address issues related to countries' development.

Knowledge-Based Economy: An economy where knowledge is the key asset.

Knowledge Transfer: The flow of knowledge (tacit or explicit) between entities (including universities, organizations and individuals).

Open Innovation: A concept brought by Henry Chesbrough as opposed to Closed Innovation; in accordance with this concept organizations are encouraged to use external sources of research, development and/or innovation as well as to share these kind of resources with other.

SECI Model: A model proposed by Nonaka and Takeuchi in which knowledge is created in a spiral process that includes four modes of knowledge transfer: socialization, externalization, combination and internalization.

Tacit Knowledge: A term promoted by Polanyi to address that kind of knowledge which is difficult to express and formalize.