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INTER-ORGANISATIONAL TECHNOLOGY/KNOWLEDGE TRANSFER: A FRAMEWORK FROM CRITICAL LITERATURE REVIEW

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Abstract

This paper aims to provide, through a literature analysis, a solid theoretical foundation that allows identifying the critical factors for technology/knowledge transfer.

The literature review allowed to summarize the main contributions collected, to identify the main critical factors for technology/knowledge transfer and to frame them in a simple framework, carrying out a rationalization and classification. We built a reference framework, called "model of technology/knowledge transfer". The proposed structure considers six categories related to the actors involved (sources, recipients and intermediaries), the relationship between them, the object of the transfer, the channels and mechanisms and the reference context.

The factors represent all the main parameters and levers to consider in the design and implementation of an activity of technology/knowledge transfer. This can direct also future research by deepening these factors or the relationship among them.

1. INTRODUCTION

This paper deals with the literature on technology/knowledge transfer from an inter-organisational point of view, i.e. the transactions among different organisations (and not within the organisation) (Argote *et al*., 2003; Kumar and Ganesh, 2009; Autio and Laamanen, 1995; Grosse, 1996).

Technology transfer is considered an active process during which the technology (and the knowledge related to it) is transferred between two distinct entities (Autio and Laamanen, 1995; Amesse and Cohendet, 2001; Bozeman, 2000). According to Autio and Laamanen (1995): *"Technology transfer is intentional, goal-oriented interaction between two or more social entities, during which the pool of technological knowledge remains stable or increases through the transfer of one or more components of technology."* Technology transfer is therefore a process-oriented and purposeful interaction between two or more entities, with the objective to increase (or in the worst case stabilize) the transferred knowledge/technology. Despite the fact that technology transfer is a highly debated topic, literature presents many studies focused on specific aspects of technology/knowledge transfer and few comprehensive studies that propose a framework and highlight the main parameters and levers to consider in the design and implementation of an activity of technology/knowledge transfer.

In this paper, we will propose a literature review that helps in converging on shared definitions of the elements of technology/knowledge transfer and on a framework useful for future research.

Literature presents different reviews on technology/knowledge transfer as listed in Table 1, but few provide a comprehensive framework of inter-organisational technology/knowledge transfer.

Insert Table 1 about here

2. A CONTENT PERSPECTIVE ON MODELS OF TECHNOLOGY/KNOWLEDGE TRANSFER

Different authors (Bozeman, 2000; Davenport and Prusak, 2000; Malik, 2002; Cummings and Teng, 2003; Liyanage *et al*., 2009; Kumar and Ganesh, 2009) proposed models to describe and give an overview of technology/knowledge transfer. Table 2

From these models and related studies in the literature, we created a table that compares the concepts expressed by the various authors grouping them into seven dimensions. Literature agrees on these main dimensions to describe the technology/knowledge transfer process: the actors involved (sources, recipients and intermediaries), the relationship between them, the object, the channels and mechanisms of transfer and the reference context. We can notice that all the models take in consideration the source and recipient, the object and the channels and mechanisms of the transfer (the who, the what and the how), while less models highlight other possible actors (such as the intermediary) and the frame of reference, i.e. the context and their relationships.

Insert Table 2 about here

The transfer of technology/knowledge is represented by a double black arrow and typically involves two organizational entities, i.e. sources and recipients (which may be individuals, groups and/or business units, or organizations). The double arrow indicates that the transfer is not strictly unidirectional but involves reciprocity and feedback activities. The process involves interactions often intense among parties, to the point that a significant dimension of impact is formed by the relational context. The object of transfer can take many forms and types (knowledge, technology, know-how) and is characterized by different properties and characteristics. Channels and mechanisms through which the process takes place in a transfer are important dimension of analysis: in particular, it is possible to distinguish between process mechanisms (modes of organization and services) and output mechanisms (search results). The context includes the intrinsic design parameters (duration, cost, risk / uncertainty) and extrinsic aspects related to the external environment.

Insert Figure 1 about here

Source and recipient.

The first elements present in all frameworks are the entities involved in the transfer process, i.e. the sender and the recipient. Malik (2002) explains their relationship using the metaphor of the "broadcasting model". The classical terms of communication, such as sender, recipient and message are echoed by Malik to represent a technology/knowledge transfer within the firm. Malik also emphasizes how technology transfer is a bilateral process between sender and receiver: there is a "process of feed-back" from the sender to the receiver, which allows interested parties to obtain more information (knowledge) on the use of technology transferred. Cummings and Teng (2003) identify a source and a container as actors involved in the transfer process: the first have the knowledge to be transferred (in various forms) and the others have the need to acquire this knowledge gained from the

source. The goal of each project is to be able to successfully transfer knowledge to the container. Also Liyanage *et al.* (2009) propose a model where the authors identify the object as the knowledge and define two main actors (the source, who shares the knowledge, and the receiver, who acquires it). These entities have very specific properties (capacity) that allow them to exchange knowledge: the authors refer to "relevance of knowledge" and "spontaneity in sharing" with regard to the source, while they talk about "absorptive capacity" and "spontaneity in the acquisition", referring to the receiver.

Object.

These entities exchange a certain object, which represents a dimension identified by Kumar and Ganesh (2009) that is the transferred technology/knowledge, their properties and characteristics. The two different entities involved in the transfer process will exchange a certain object. Malik (2002) points out (in addition to transfer of people, knowledge and artefacts) the importance of the transfer of know-how, which is part of the message. Davenport and Prusak define also the different types and nature of knowledge and where it is preserved within an organization (embeddedness / repositories).

Intermediary.

Davenport and Prusak (2000) describe the transfer of knowledge as a not free exchange between the parties, i.e. the supplier is transferring units of knowledge in exchange of remuneration. This creates a market of knowledge. Moreover, according to Davenport and Prusak (2000), actors are also the intermediaries, i.e. the gatekeepers, who link buyers and suppliers. The intermediary (also called broker or gatekeeper) is an actor who may or may not be involved as part of the process. This actor is connected to a specific emerging body of literature (Howells, 2006; Roth, 2003, Lichtenthaler and Ernst, 2008, Hargadon and Sutton, 1997) where different authors analyse the role of these actors in the process of transfer: "intermediaries are agents that facilitate the process of knowledge/technology transfer across people, organizations and industries" (Hargadon and Sutton, 1997). Intermediaries are agents of the innovation system that facilitate the process of technology/knowledge transfer among people and organizations addressing factors enabling or constraining. Intermediaries play a very important role especially in the context of inter-organizational transfer, they intervene in the system acting as mediator/facilitator between the parties to facilitate the relational context, and with the objective of supporting the process.

Channels and mechanisms.

The type and quality of the message (object), combined with the intensity and effectiveness of the "modes" used to transmit it, are crucial (Malik, 2002). Kumar and Ganesh (2009) propose as further dimensions of interest those related to the mechanisms through which it is possible to implement a technology transfer and knowledge, and the contextual factors that influence it: they define different types of factors (cognitive, psychological, social, infrastructure and administrative) that affect and influence the transfer. Liyanage *et al.* (2009) identify the existence of certain "modes" through which to transfer knowledge: these are socialization, externalization, internalization and combination (Nonaka, 1994). These modes of transfer are derived from the different transformations of the form (tacit vs. explicit) of knowledge during a transfer. Furthermore, the transfer of knowledge involves a complex variety of factors, prerequisites and problems of context that influence the process, which

can enable or inhibit it. Also Davenport and Prusak (2000) cite some of the mechanisms through which the transfer takes place, and the various factors that influence the process.

Relationship.

For Kumar and Ganesh (2009), another dimension is represented by the relationship between the actors, called "flow": the authors describe the nature of the flow associated with the transfer, the process of implementation. Cummings and Teng (2003) define the success of a transfer according to the degree of "internalization of knowledge": the way the recipient obtained the knowledge, the degree of effort applied by the actors in the process and the satisfaction of the recipient on what has been transferred.

Context.

Bozeman (2000) proposes a model called "contingent effectiveness", through which he analyses the different aspects that characterize the technology/knowledge transfer. In particular his studies mainly relate to transfer between different organizations and he underlines the importance of the external context. Cummings and Teng (2003) provide a description of the various contexts that are involved in the transfer, by defining the context of the source, analysing some of the properties and characteristics of the object, the context of the relationship, the context of the recipient, and finally the context of activities referring to the mechanisms through which it is possible to implement the transfer. Kumar and Ganesh (2009) underline the importance of the context for the success of the transfer process. The dimension refers to the geographical context: the transfer can be divided into three categories according to the geographical context, i.e. within the company, between companies at national level and between companies at international level.

3. ACTORS OF TECHNOLOGY/KNOWLEDGE TRANSFER

The first dimension of analysis is the actors involved in the process of technology/knowledge transfer. The technology/knowledge transfer takes place between two entities, referring to a source (sender of the object to be transferred) and a recipient (the entity that receives the object of the transfer).

The broker, who is an actor who may or may not be involved as part of the process, is a third actor who assumes the role of facilitation between the parties in order to facilitate the relational context and with the aim of supporting the process, addressing enabling or constraining factors.

3.1 Sources and recipients

In particular, we can identify three categories of actors who can play the role of source or recipient of a transfer of technology or knowledge (Bozeman, 2000; Reisman, 2005): companies, universities/research institutions, other organizations. In the first category, we have suppliers, customers, firms in other sectors and in some cases competitors (Campbell *et al*., 2002; Howells, 1996; Amesse, Cohendet, 2001), in the second research laboratories, public and private research centres, academic and research institutions structures (Kingsley, Bozeman, Coker, 1996; Autio, Hameri, Nordberg, 1996; Caputo *et al*., 2002; Bozeman, 2000, Howells, 1996; Reisman, 2005), in

the third type organizations such as professionals and consulting firms (Campbell *et al*., 2002; Amesse, Cohendet, 2001; Argote , 1999; Albors, Sweeney, Hidalgo, 2005; Reisman, 2005). The transfer can happen between similar actors or different actors, where for example a large part of the literature on TT works on the relationship between universities and industries. Recent literature focused on recognising the importance of particular actors, who are also outside the boundaries of the company itself, for the technology/knowledge transfer process. The peculiarities of these actors are to be normally not those that propose innovation but those who use it, such as the user innovator proposed by von Hippel (2005). Another peculiarity refers to those actors who are not directly hired for R&D activities by the company but propose ideas from outside the company itself through connections, like in the concept of open innovation proposed by Chesbrough (2003). This is enabled also by the potentialities and the evolution of Internet technologies and open source software, permitting phenomena such as crowdsourcing or socio-technically distributed innovation.

Actors properties and characteristics

The source is characterized by its ability to transfer its knowledge and technologies, i.e. the *emitting capacity* - (Amesse and Cohendet, 2001). This requires possessing adequate technological, organizational and cultural skills. **Technological capabilities** concern the technical capacity (Autio, Hameri, Nordberg, 1996; Mowery et al., 1996) refer to possession of specific technology skills, the level of R&D, the ability to manage complex technical systems and the flexibility (Caputo et al., 2002; Bozeman, 2000) to cope with and adapt to the specific needs of the recipient, the advanced ability to design (and engineering) (Autio, Hameri, Nordberg, 1996). **Organizational skills** relate to the organization structure and management style (Caputo *et al*., 2002), available resources (Bozeman, 2000; Caputo *el al*., 2002), (Bozeman, 2000; Albors, Sweeney, Hidalgo, 2005) and motivation to transfer (De Long, Fahey, 2000; Canestrino, 2009; Argote, 1999; Cummings, Teng, 2003) and the *absorptive capacity*[1] (Bozeman, 2000; Mowery, Oxley, Silverman, 1996; Amesse, Cohendet, 200; Argote et al., 2003; Albors, Sweeney, Hidalgo, 2005; Cummings, Teng, 2003; Argote, 1999; Canestrino, 2009; Cohen, Levinthal, 1990). Finally, it is necessary an open organizational culture, for example with respect to learning processes[2] (Argote *et al*., 2003; Cummings and Teng, 2003; De

[1] The organizations differ in their ability to assimilate and replicate new knowledge acquired by other actors. This property is defined in the literature as *absorptive capacity* (Cohen and Levinthal, 1990; Zhara and George, 2002; Tsai, 2001; Malik, 2002; Argote *et al*., 2003; Argote, 1999). The absorptive capacity of an organization develops in a cumulative way, i.e. it is based on prior knowledge (prior related knowledge. According to Cohen and Levinthal (1990), prior knowledge increases both the ability to store new knowledge both the ability to recall and use it, the authors argue that the performance of learning of a unit are better if the purpose of transfer is related to what the actor already knows. It is clear that organizations with a relevant background of knowledge have a better understanding of new technology/knowledge transfer, resulting in the generation of new ideas and new product development (Tsai, 2001). Cohen and Levinthal (1990) show that absorptive capacity is the result of a prolonged process of investment and accumulation of knowledge: the absorptive capacity of an organization is positively related to its ability of innovate. In addition, the absorptive capacity may affect the economic performance of the company itself: it implies not only the ability to assimilate new knowledge, but also the ability to apply this knowledge for commercial purposes and create new revenue opportunities (Argote *et al*., 2003; Argote, 1999). In particular, a firm with high absorptive capacity is able to successfully market its new products, increase their economic performance and increase its knowledge base (Cohen and Levinthal, 1990; Zhara and George, 2002; Malik, 2002).

[2] A key property of the recipient is the *organizational learning*, a process aimed at having better knowledge and understanding and therefore improve actions (Fiol and Lyels, 1985). Individuals are the main agents of organizational learning, and it is therefore possible to consider them as primary actors of a knowledge transfer (Hong, 1999; Saban et al., 2000; Crossan et al., 1999; Crossan and Berdrow, 2003; Englehardt and Simmons, 2002; Malik, 2002; Argote, 1999; Davenport and Prusak, 2000). The organization enhances the performance of the individual or group acquiring their skills and knowledge and transforming them in routine (creating an organizational basis of knowledge), through which it is possible to implement new actions (Crossan *et al*., 1999; Berdrow and Crossan, 2003; Saban et al., 2000).

Long and Fahey, 2000; Canestrino, 2009; Cohen and Levinthal, 1990) and processes of knowledge management (De Long, Fahey, 2000; Caputo *et al*., 2002).

3.2 The relationship

The literature suggests that there are significant barriers to the transfer of knowledge between functional, geographical and organizational levels (Dougherty and Hardy, 1996). With the relationship, we consider the elements that define the relational context of the transfer. The first elements is the trust, a factor that is the basis of any interpersonal or inter-organizational relationship and if there is no trust, collaboration will probably fail (Amesse e Cohendet, 2001; Argote et al., 2003; De Long and Fahey, 2000; Stock et al., 2000; van Wijk et al., 2008; Davenport and Prusak, 2000). A second parameter that characterizes the relations between the actors is the intensity of the connections (Bozeman, 2000; Argote et al., 2003; De Long and Fahey, 2000; Stock et al., 2000; Amesse and Cohendet, 2001; Agrawal, 2001; van Wijk et al., 2008), understood as the frequency of contacts and communications, which promotes the degree of familiarity and reciprocity between parties. Other relational factors of interest in this study consider the distances that exists between parties, in particular the organizational distance, the physical distance, the distance of the knowledge base, the cultural distance and the normative distance (Cummings and Teng, 2003; Argote et al., 2003; Cohen and Levinthal, 1990; van Wijk et al., 2008; Amesse and Cohendet, 2001; De Long and Fahey, 2000; Canestrino, 2009; Bozeman, 2000; Argote, 1999).

Trust

Literature discusses that any initiative of transfer or development of knowledge without trust will fail. The level of trust that exists between organizations influences the ease of sharing and transferring knowledge (De Long and Fahey, 2000). Some previous studies verified that trust between parties involves transfer of organizational knowledge (van Wijk et al., 2008; Hansen, 1999; Reagans and McEvily, 2003; Szulanski et al., 2004). Trust "reflects the belief that the word or promise of a partner is reliable and that the partner fulfills the obligations in the relationship" (Inkpen, 2000). Trust facilitates the interorganizational knowledge transfer, as it increases the willingness of the source to commit to helping the recipients to understand new external knowledge (Lane et al., 2001). Within an interpersonal or inter-organizational relationship, in fact, it is necessary that trust between parties is visible, i.e. the decision to share knowledge must be recognized and properly valued, and it is necessary that this concept of trust is widespread. If some actors are not reliable, the transfer becomes an asymmetric process, less efficient and can fail (Davenport and Prusak, 2000; Argote et al., 2003).

To establish a relationship of trust, it is necessary to ensure a strong sense of reciprocity. The source is committed with time and resources to share its knowledge but, beyond the value established for this effort, only if recipients are motivated and capable, this can be done effectively (Davenport and Prusak, 2000; Amesse and Cohendet, 2001; Canestrino, 2009). In addition, the recipient acquires greater confidence in the success of the process when it feels real willingness and openness to sharing from the source (Cummings and Teng, 2003). McEvily et al. (2003) argue that the level of trust influences the diffusion of knowledge and the degree of commonality between the parties. From this point of view, trust is essential to overcome concerns about possible misconducts on the appropriation and misappropriation of knowledge. Trust also reduces the apprehension of the recipient about the quality of knowledge, thus decreasing the tendency to question the accuracy of the information

provided. In this sense, trust is strongly linked to reputation, an expression of the esteem that the recipient has for the source. In fact, the reputation of a source is reflected in the perception of the willingness to share knowledge (Davenport and Prusak, 2000) and influences the perception of the value that is assigned to the flow of information transmitted (Argote et al., 2003) and this happens at all levels (including individuals, groups or organizations).

Intensity of connections

Previous research argued that the social relationships between the actors play an important role in facilitating the exchange of resources and knowledge transfer (Bozeman, 2000; Argote *et al*., 2003; De Long and Fahey, 2000; Stock et al., 2000; Amesse and Cohendet, 2001; Agrawal, 2001; van Wijk et al., 2008). The links facilitate access to potentially useful knowledge, ideas or resources, and increase the likelihood and amount of organizational knowledge transfer (Reagan and McEvily, 2003). Various studies showed that a high number of relationships with other companies and units increases the probability of access to new relevant knowledge. Moreover, relationships improve the processing capacity of data, which allows a more effective flow of knowledge (Hansen, 1999).

While the number of links increases access to external knowledge, a central location within the general connections system determines whether this knowledge can be used advantageously. An actor who enjoys a central location creates a mediating position, allowing identifying relevant information and enabling the exchange within the social network (van Wijk et al., 2008). Therefore, units or organizations in a central location can easily access to other actors, or more easily share and acquire different knowledge (Tsai, 2001). The author, however, argues that absorptive capacity of an actor moderates the effects on economic performance and innovation capacity due to its position in the network.

Although a central position in the network provides a fundamental access to new knowledge, its impact on the performance of the unit may depend on the degree to which the same absorbs knowledge. Indeed, the more an entity can access to the knowledge of the other, much more it needs absorptive capacity to benefit from it. It is clear that the interaction between these two properties is a critical factor for the transfer of knowledge between organizations. The intensity of the connection reflects the close relationship between the partners, and increases with the frequency of interactions and communication (Hansen, 1999). Evidences suggest that strong ties lead to greater transfer of knowledge (Reagan and McEvily, 2003). Presumably, strong ties guide organizations to spend efforts to ensure that recipients understand enough what has been transmitted and are able to take advantage of new knowledge (Hansen, 1999). The importance of connections and their intensity is studied by different literatures, such as network analysis or applied in literatures of open innovation (Chesbrough, 2003) and strategic alliances (Lavie, 2006 and 2007).

Distance

Other factors of interest consider distance between parties, and in particular, the organizational distance, the physical distance, the distance of the knowledge base, the cultural distance and normative distance.

- Organizational distance. The organizational distance refers to the mode of organization through which the source and the receiver perform the transfer. Possible governance modes are occasional contracts, collaborations, strategic alliances and acquisitions. As regards the

impact of different forms of governance in the field of knowledge transfer, research showed that when transfer is towards recipients with whom the source is strongly related (such as franchising (Darr et al., 1995), chains (Baum and Ingram, 1998), federations (Ingram and Simons, 1997), strategic alliances (Powell et al., 1996) or networks (Uzzi, 1996)) this is done more effectively. For example, empirical studies found that tacit knowledge is more easily transferred between firms within a network than to independent firms (Uzzi, 1996).

The logic that supports the importance of the mode of organizational management concerns the fact that the organizational modes "are nominally used to define (a) the flow of goods, (b) the depth and breadth of interaction between two parties and (c) incentives for collaboration" (Baughn et al., 1997). Basically, the higher density of social ties between the parties (Tushman, 1977) facilitates all these elements, as it will allow for better opportunities to share knowledge and experiences, develop trust and cooperation (Granovetter, 1985). As observed by Argote (1999) "competition is usually minimized" by companies within franchising, chains and networks, and "organizations generally trust each other to a greater extent than those are not [strongly] supplemented."

Consistent with this line, it seems reasonable to assume that the strength of social ties, the free flow of communication, the consistency in administrative controls and the level of trust between the source and the receiver is greater if units are integrated from an organizational point of view (i.e., when organizational distance is less). Integration is higher between parts of the same organization (intra-firm), although lower for newly internalized unit (acquisition); it is minimal in inter-organizational relationships, although stronger when the relations are stable and formal (alliances) (Cummings and Teng, 2003).

- Physical distance. Physical distance is linked to the difficulty, the time and the cost of communication (Cummings and Teng, 2003). If organizations reduce physical distance, offer the opportunity to learn from each other even indirectly. The learning for observation is an example of such indirect learning. Instead of accumulating knowledge directly, an individual accumulates knowledge by observing another performing a task (Argote et al., 2003).

  The proximity also provides people with the opportunity to know "who knows what", so you know where to look for knowledge and relevant information (Davenport and Prusak, 1998). Some studies evaluating the impact of physical distance found for example that the citations of patents often cluster in certain regions (Almeida, 1996).

  The greater the distance between units, the slower and less effective technology transfer (Galbraith, 1990; Lester and McCabe, 1993). In support of this, other authors showed that face to face meetings are better than other methods for the transfer of topics of strategic importance (Davenport and Prusak, 1998) or for the transfer of know-how, which requires to go through several phases of intense iteration (observation, learning and application) that require physical proximity (Wheelwright and Clark, 1992).

  In fact, organizations draw on social capital in the context of regional or group relations, possibility that facilitates the development of good communication, and the social capital is more difficult to develop between physically distant parts (Allen, 1977; Cohendet et al., 1999). Informal networks play a similar function. By making knowledge nearer, informal ties promote indirect learning (Argote et al., 2003). Informal connections allow people to benefit from the knowledge accumulated by employees or contacts that could be even outside the organization (Hansen, 1999). For example, the movement of staff between organizations or between

organizational units also increases the possibility of a unit learning from others (Almeida and Kogut, 1999).

- Distance of the knowledge base. The distance of the knowledge base refers to the degree the source and receiver are in possession of similar knowledge (Cummings and Teng, 2003). For the transfer of knowledge and technology, a particular difficulty is that the context of research and development of the source and the recipient can be very different from each other. Often there is no overlapping between the activities of the two parties. In this case, in particular if it is an inter-functional or inter-organizational transfer, learning becomes more problematic. In literature, the common interpretation of knowledge is essential for collaboration in research and development (Dougherty, 1992). It was found that, in order to foster organizational learning, the distance of the base of knowledge between the two parties cannot be too large (Hamel, 1991). In fact, if the knowledge gap (or distance) is significant, too many steps of learning will be required. In this sense, redundancy of knowledge and the presence of overlapping areas of expertise facilitate the transfer of knowledge (Nonaka and Takeuchi, 1995).

  As Hamel argues (1991), "if the skills gap between partners is too much, learning becomes almost impossible", because the recipient may not be able "to identify, if not retrace, the intermediate steps of learning between its current level of expertise and that of its partner." Cummings and Teng (2003) argue that a certain alignment in terms of knowledge is necessary for the transfer of knowledge. The inter-organizational learning literature emphasized that firms differ in their ability to learn (Cohen and Levinthal, 1990; Szulanski, 1996) but this ability is "relative" (Lane and Lubatkin, 1998), linked to the correspondence between the knowledge of the source and of the recipient. It can be argued that when we are in the presence of a significant base of common knowledge (Dixon, 2000) (distance or lack of knowledge), the recipient shows a high absorptive capacity.
- Cultural distance. The cognitive dimension of social capital refers to those elements in the context of interpersonal relationships that provide representations, interpretations and shared meaning systems (van Wijk et al., 2008). This manifests itself in attributes such as a shared vision, values that facilitate a common understanding of collective goals or in an appropriate way to act in a particular social system (Tsai and Ghoshal, 1998).

  Previous studies suggest that both a vision and a shared reference system both the cultural distance are important elements which characterize the cognitive and social relations that influence the transfer of knowledge (Inkpen and Tsang, 2005; van Wijk et al., 2008). Shared systems and vision promote mutual understanding and provide a fundamental mechanism that helps to integrate the different actors' knowledge. The knowledge transfer is then facilitated in presence of similarities in the organizational structures and operational practices, the dominant logic (Lane and Lubatkin, 1998; Mowery et al., 1996) and in the way we work (Lane et al., 2001; van Wijk et al., 2008). Effective communication requires a sharing of knowledge and skills. At the broadest level, the elements that enable effective communication, both within and between units consist of a language, symbolism and a common background (Cohen and Levinthal, 1990). Therefore, systems and shared vision can contribute to the transfer of knowledge. Since the norms and values can widely differ (Lane et al., 2001), several studies have focused on the similarities or cultural differences between the partners. The cultural distance increases the cost of entry, and hinders the ability of the company to transfer the basic skills (van Wijk et al., 2008). The cultural distance also increases the operational difficulties

that arise from a lack of understanding of the norms, values and institutions and hampering the exchange of knowledge (Mowery et al., 1996). The cultural distance between foreign partners can lead to misunderstandings that may limit the sharing of important elements of knowledge (Szulanski et al., 2004).

- Normative distance. Normative distance is the extent to which the parties of knowledge transfer share social aspects of behaviour in their context. Social norms are implicit or explicit rules concerning the conduct of members of a particular social context (De Long and Fahey, 2000). Social norms prescribe how individuals and social groups should behave in certain situations. By virtue of their prescriptive size, rules are the set of expectations that the group has in regard to its members. Alongside the formal rules that organize and structure a given social field there are others informal practices which arise from the interaction of the social actor with a real situation enacting informal rules generated from formal ones. Early research on technology transfer showed that differences in work values, practices and organizational norms can significantly affect the transfer of knowledge (Cummings and Teng, 2003; De Long and Fahey, 2000).

  The reason is that similar practices and regulatory systems allow a smooth working relationship between the parties in knowledge transfer. After all, the shared norms define what is acceptable and unacceptable in a social context. Common standards not only ensure predictability and understanding between the parties, but will also ensure a common approach in the transfer process. As such, knowledge is partly embedded in the rules and routines of the organization (Argote, 2003). The recipient will draw on its experience with its previous routine to deal with the new knowledge (Louis and Sutton, 1991) and the ability to access a knowledge base created earlier is critical to the success of efforts to transfer (Garud and Nayyar, 1994). To the extent that these procedures are consistent with those of the previous source, the interaction can occur in a well-coordinated manner (Cummings and Teng, 2003). In contrast, significant misalignments, errors or misunderstandings can indicate that new knowledge will not be easily understood, accepted or internalized (Hackman, 1969).

3.3 Intermediary

The intermediary is an actor who may or may not be involved as part of the process of technology/knowledge transfer and acts as a third party agent assuming the role of facilitation / mediation between the parties in order to facilitate the relational context and with the aim of supporting the development of the process in its criticalities, addressing enabling or constraining factors. In the literature there is a distinction between studies that have focused on intermediaries as organizations and those focused on intermediation as a process (Howells, 2006). This leads to differences in approach and terminology. For this reason we maintain this distinction by treating separately the types of intermediary and possible roles / services they performed.

Typologies

There is a continuum of different types of intermediary, ranging from individuals (consultants and agents) that provide specialized professional services to organizations (agencies and institutions) that provide intermediary services and support to innovation (Lichtenthaler and Ernst, 2008). Individuals mainly include professional patent consultants, technical experts, agents, consulting firms (Bessant

and Rush, 1995, Morgan and Crawford, 1996). These offer services that are based on personal skills or their employees and are intended to meet specific needs, to complete the offer, as they often provide additional offer brokerage services by activating a network of personal contacts (Morgan and Crawford 1996). Consulting firms and external professionals make up the majority of this group, which also includes providers of brokerage services (Bryant and Reenstra-Bryan, 1998). Organisations provider of brokerage services typically offer advice similar in content and they provide a greater number of services to a broad market (Van Witteloostuijn and Boone, 2006). This category includes a number of public and private organizations of very different nature: the innovation agencies and regional development, the Industrial Liaison Office and Technology Transfer Office (active structures at universities and institutions of research that have as their purpose the development in economic results of scientific and technological research), the science and technology parks, centres for innovation, cooperation and transfer of science and technology. In fact, there is no clear differentiation between agents and providers of intermediary services, which represent the extremes of a continuum as "the technology brokerage activity is not well defined and the heterogeneous nature of the participants is characteristic of the industry" (Morgan and Crawford 1996). Possible types are:

- Consultants: independent professionals that support the process of innovation (Bessant and Rush, 1995), people or organizations involved facilitating the decision-making process (Mantel and Krueger, 1987), which facilitate the negotiation and interaction between parties with different domains of knowledge (Seaton and Cordey -Hayes, 1993).
- Technology broker: agents that facilitate the spread in a social system of new ideas from the outside (Aldrich and von Glinow, 1992), support innovation by combining existing technologies in new ways (Hargadon, 1998), fill information gaps and knowledge in industrial networks (Provan and Huma, 1999), seeking to develop new applications for emerging technologies outside the scope of their initial development (Turpin et al., 1996), figures are intermediaries between suppliers and users of proprietary technologies (Albors, Sweeney, Hidalgo, 2005).
- Agents of innovation: service companies that serve as intermediaries within the systems of innovation (Howells, 1999b), adapted solutions available on the market to meet the needs of the individual user (Stankiewicz, 1995), facilitate the measurement of intangible value of knowledge (Millar and Choi, 2003).
- Intermediation agencies: public and private organizations active in the formulation of policy research (Braun, 1993), in the promotion of change within scientific networks and local communities (Callon, 1994), in support of technology transfer (Watkins and Horley, 1986; Shohert and Prevezer, 1996; Cash, 2001; Guston, 1999).
- Innovation centre and other institutions: the organizational units that support local innovation and business development, for example by collecting the knowledge and skills necessary to enable the transfer process of innovation (Caputo et al., 2002), serve as a support functional for the lack of links in a network (McEvily and Zaheer, 1999); intermediary level organizations that help to steer the system towards scientific socio-economic objectives (Vanv der Meulen and Rip, 1998).

Roles / services

Assuming intermediation as a process, Lynn et al. (1996) and Wolpert (2002) have identified two major functions associated with the intermediation: a function of "scanning and gathering information" and "communication", both connected to the front end of innovation. These features are comparable to those Seaton et al. (1993) called phases of scanning and recognition and communication and assimilation and those who Hargadon *et al*. (1997) identify as phases of access and acquisition. Many studies focus on the primary role of intermediaries in the scan and the exchange of information. Other studies give a more complex role for intermediaries, focusing on support services for the transfer of knowledge/technology between businesses and organizations (Turpin et al., 1996; Shohert and Prevezer, 1996, Hargadon and Sutton, 1997) in this case connected to a phase of marketing innovation.

The services of most intermediaries are directed to extend the internal resources of a company in order to facilitate the identification of acquisition opportunities or technology commercialization, although normally the management of technology transfer is left to the industrial enterprises (Lichtenthaler and Ernst, 2008; Howells, 2006). In general, the catalogue of possible services is offered by a broad and includes, for example, the assessment of technology needs, the assessment of technologies and inventions, support to the management plan of research or innovation, market research, support business development, business planning and project management, etc. (Albors, Sweeney, Hidalgo, 2005). In general, studies that delineate the role of intermediaries in the transfer of technology do not detail the interactions of the intermediary with the various parties, but merely to consider the perspective linked to the support offered to provide or transmit existing knowledge on a specific technology (Howells, 2006). In summary, we outline two general roles of the intermediary: of "intermediation" (brokering, bridging) and of "service" (innovation consultancy services).

The role of intermediation is essential to support innovation as it provides the bridge (bridging) and mediation (brokering) between subjects and content: in fact the broker facilitates the connection between distant parts, coordinates cooperation between different organizations, and enables the integration of new knowledge and technologies (Howells, 2006; Albors, Sweeney, Hidalgo, 2005). We can then identify two functions:

- technology / knowledge brokering: the intermediary to make functional connections with existing technological solutions in other sectors or new ideas created or invented elsewhere (Hargadon and Sutton, 1997; Lichtenthaler and Ernst, 2008) and to facilitate the exchange of information between businesses (Wolpert, 2002).
- bridging innovation: services that enable the link between groups previously not related or not related (Bessant and Rush, 1995; Hargadon and Sutton, 1997; McEvily and Zaheer, 1999), for example, supporting members of a particular social system to connect and integrate with external actors in other domains. With the emergence of the phenomenon of outsourcing innovation (Howells et al., 2008), which refers to the paradigm of open innovation (Chesbrough, 2003), there has been a strong growth of technical knowledge intensive services (Tether et al., 2002), have become increasingly important in recent years. Howells (2006) carried out a very detailed analysis of services performed by intermediaries, and identifies ten macro-categories: foresight and diagnostic; scanning and information processing; knowledge processing, generation, combination; gatekeeping and brokering; testing, validation and training; accreditation and standards; regulation and arbitration; intellectual property; commercialisation; assessment and evaluation.

The role of the intermediary is functional innovation to support technology transfer activities not only in the middle stages of implementation, but also in the initial phase where skills are needed to gather information, identify and analyse the opportunities and assess the limits and the benefits of following the path of innovation.

4. THE TRANSFER PROCESS

The second macro dimension of analysis proposed is the elements of the process of knowledge/technology transfer (Nonaka, 1994; Argote, 1999; Argote *et al*., 2003; Ferdows, 2006), that we have defined "epistemological" dimension. This refers to the nature and characteristics of knowledge/technology transfer object, to the "channels" and "mechanisms" by which you can enable an effective and efficient transfer of technology/knowledge and contextual factors within which the process is carried out.

4.1 The object of the transfer

According to a goal-oriented perspective: *"The successful transfer of technology results in the receiving unit implementing new techniques of production."* (Zander and Kogut, 1995). From this definition it follows that the success of a technology transfer is achieved if the recipient of the transfer process implements (effectively) within its context, the new techniques learned. If the recipient does not learn the relevant knowledge, it is not able to take full advantage of the benefits. Cummings and Teng (2003) emphasize this concept: *"Knowledge embodied in technology can be used at best only if it is complemented by a number of tacit elements that have to be developed locally."* (Cummings and Teng, 2003).

One dimension of analysis given by "dimensional model" is that related to the object of the transfer (Autio and Laamanen, 1995; Howells, 1996; Bozeman, 2000; Davenport and Prusak, 2000; Argote et al., 2003; Canestrino, 2009). We will deepen the aspects of interest in this category: the possible types to be transferred, and the components repositories that can reside and the properties and characteristics that distinguish it.

Typology

The literature on the subject refers to the object of the transfer by identifying different types: technology (Flannery, Spivey, Alter, 1994; Autio and Laamanen, 1995; Autio, Hameri and Nordberg, 1996; Bozeman, 2000; Lichtenthaler and Ernst, 2008), knowledge (Howells, 1996; Szulanski, 1996 and 2000; Argote, 1999; Davenport and Prusak, 2000; Malik, 2002; Argote et al., 2003; Cummings and Teng, 2003; Liyanage et al., 2009); and know-how (Kogut and Zander, 1992; Zander and Kogut, 1995; Amesse and Cohendet, 2001; Carlile and Rebentisch, 2003; Ferdows, 2006).

Although most of the contributions generally focuses only on one of the above types, according to the focus and to the specific context of analysis, there is desire to maintain separate the concepts, also if the boundaries between them are often labile. This is because, in general, what is actually transferred is not only a particular technology, a patent or a physical artefact, but also the knowledge gained by the individual or by the company itself on the characteristics and use of these technologies, which are commonly spread at various levels in the corporate structures (Howells, 1996): it is clear that if an organization wants to acquire a certain technology, it must integrate internally not only its physical components but also the knowledge and skills needed to use them. It must therefore be

actually transferred also the know-how on how to deal with the technologies, their usage and practices (Howells, 1996; Malik, 2002; Cummings and Teng, 2003).

The transfer of know-how has become a concept that represents a binding between knowledge and technology. However, dealing with the nature of the object and its properties in a specific case, it is useful to take into account the differences that distinguish the different types presented: transfer a concept, an artefact or competence is certainly something different. Such differences, which occur mainly in different repositories and in the specific characteristics and properties (tacit or explicit nature, contextuality, uncertainty, codifiability, complexity, rate of change) are particularly relevant when the appropriate channels and mechanisms of transfer should be defined (Amesse and Cohendet, 2001; Ferdows, 2006).

In the literature, some specific industries require specific focus and studies for their peculiarities for technology transfer, in particular high-tech industries such as ICT or biotechnology and pharmaceutical.

Repositories / embeddeness

Knowledge can be made of different components and be in different repositories (Sharif and Ramanathan, 1987; Autio and Laamanen, 1995). Knowledge can refer to technological and physical characteristics of what is being transferred and reside in the object itself (*technoware* component). Knowledge can be relative to know-how of people on the use of technology, and is therefore inherent in individuals (*humanware* component). A component of the knowledge is created from the information: it typically resides in the documents and is the most easily transferable (*infoware* component). A final component is the knowledge embodied in the organizational structure (*orgaware* component), for example at the level of rules and practices and it is "rooted" in the context in which it is located and difficult to transfer.

According to Argote (1999) knowledge is inherent in individuals, and routine operating procedures of an organization, its processes and products, its technologies, its structures and layout, and its culture and norms. The author argues that knowledge embodied in individuals may decay or depreciate more rapidly than the knowledge possessed by the organization in its routines and systems. Also according to Cummings and Teng (2003) knowledge can reside in people (in combination with humanware component), tools (technoware component) in routine business and related subnetwork (orgaware component). The degree of depth with which knowledge is "immersed" (embeddedness) in these different parts of an organization affects the transfer of knowledge. At different levels of maturity, technology can take the form of a different component, or a variable proportion of these (Autio and Laamanen, 1995). During the initial phase of the process of technological development, we can assume that the tacit and humanware components tend to prevail in the composition of new technologies (development capacity is often tacit. When the technology becomes more mature, it is likely that the infoware, hardware and orgaware components assume greater importance (to develop tangible products often require a phase of formalization of the information and exploitation of products may require organizational skills).

4.2 Properties / Characteristics

There are many properties and characteristics that distinguish the object of the transfer and that may affect the transfer process. The substantial contributions on the subject (Kogut and Zander, 1992; Zander and Kogut, 1995; Gilbert and Cordey-Hayes, 1996; Argote, 1999; Davenport and Prusak,

2000; Rebentisch and Carlile, 2003; Cummings and Teng, 2003; Ferdows, 2006) have required a synthesis of multiple properties related to the object of the transfer emerged from the literature.

Nature

There are different classifications in the literature to describe the nature of knowledge (Howells, 1996; Malik, 2002; Argote *et al.*, 2003). In particular, we consider the traditional method (Polanyi, 1962; Nonaka and Takeuchi, 1991; Nonaka, 1996; Howells, 1996; Argote *et al*., 2003; Canestrino, 2009) between "tacit knowledge" (knowledge hardly articulated, expressed and then transferable, and "explicit knowledge", expressed in the form of documents or practices, which is easier to transfer and understand.

Tacit knowledge is the most difficult component to encode and transfer knowledge: "tacit knowledge is non-verbalised, intuitive and unarticulated knowledge that has a personal quality, which makes it hard to formalize and communicate." (Polanyi, 1962)

The author argues that this kind of knowledge is not articulated and unspoken, of intuitive and personal (individual) character: because of these characteristics it is difficult to formalize and communicate it. According to Nonaka and Takeuchi (1991), tacit knowledge resides in individuals, particularly in their minds and in their abilities and his transfer depends on the capacity of transmission and learning of individuals (Argote, 1999; Ferdows, 2006). Many elements of tacit knowledge can enable and represent business routines, which are transferred between individuals or groups of individuals, to be in a broad sense the characteristic elements of the corporate structure and the accumulated knowledge base of a firm. The assumption that such knowledge is difficult to replicate, making it potentially useful to the competitive advantage of the firm (Argote, 1999), organizations need a continuous regeneration of their skills and abilities, increasing the value of such knowledge at all levels of the company. This view is in line with the resource-based view of the firm, where the application of a bundle of valuable tangible or intangible resources at the firm's disposal is the basis for the competitive advantage of the firm (Penrose, 1959). To be sustainable, these resources should be neither perfectly imitable nor substitutable without great effort (Barney, 1991). This is even more true in dynamic and interconnected environments (Lavie, 2006 and 2007; Sirmon et al., 2007). Given that this type of knowledge is not the result of a process of static storage, but a process of continuous and dynamic construction, a constant change in the characteristics of the knowledge already stored is needed, which are continuously increased through the accumulation of new experience. Learning by doing and learning by using processes are crucial for the acquisition and accumulation of knowledge. These concepts are associated with a direct contact ("on-the-job") with the working practices and operations proposed by the introduction of new knowledge and innovations. Explicit knowledge is made from that part of knowledge more easily transferable between different actors and takes the form of knowledge which by definition is codified. Polanyi (1966) provided the definition: *"Explicit knowledge is the knowledge that con be articulated in formal language and easily be transmitted amongst individuals."* (Polanyi, 1966).

So the explicit knowledge turns out to be articulated in the form of language, and according to the author, is more easily transmitted between individuals. Nonaka (1994) adds that explicit knowledge is mainly composed of information that is recorded in documents or business information systems: the explanation of the procedures and characteristics about a particular business process or product is an example of explicit knowledge. Also according to Canestrino (2009), explicit knowledge can be expressed in a formal and systematic language and it is acceptable in the form of data, scientific formulas, symbols, etc. and is then formalized, transferable and loaded with relative ease. However,

the simplicity of managing this structured and explicit knowledge does not mean that it is easy to use just because it has been codified: it is necessary to subject it to evaluation and make it accessible to those who intend to use it with the aim of achieving sustainable advantage for the organization (Davenport and Prusak, 2000). According to Nonaka (1994), these two types of knowledge are mutually dependent on each other and together they reinforce the same quality of knowledge: tacit knowledge forms the background necessary to determine the most suitable structure to develop and interpret explicit knowledge. The firm also represents a particular context in which tacit and explicit knowledge are selected jointly interaction with the external economic reality and then stored in the routine business, and a context in which the creation of new knowledge is based on the interaction social between tacit and explicit knowledge (Nonaka, 1994).

4.3 Context

Recalling the concepts of tacit and explicit knowledge is clear that we know more than we can express or formalize (Polanyi, 1962). Often we consider only the explicit dimension of knowledge, even if it can be expressed in words and numbers it represents a small part of the entire body of knowledge, which includes elements of tacit and hardly graspable expressible but rooted in action and in experience (Nonaka and Takeuchi, 1995). In fact, the explicit knowledge becomes practical knowledge only when individuals can apply their experience and their understanding of the context to interpret the details and implications of the action, but only when it is integrated in the languages, in stories, in the rules and practices (tacit dimension) it produces a greater capacity for action (Roth, 2003). Thus, some authors point out that knowledge is often dependent on the context (Cohen and Levinthal, 1990; Howells, 1996; Argote, 1999; Canestrino, 2009) as immersed in the individual, collective or organizational processes. The context of knowledge is a barrier to the transfer (Canestrino, 2009): the more the knowledge is context-specific, the more difficult it can be used in different contexts.

Uncertainty

Since the activities of new product development are exploratory in nature, there is usually a high degree of ambiguity and uncertainty about the knowledge to be transferred. According to some authors (Cohen and Levinthal, 1990; Szulanski, 1996 and 2000; Argote, 1999; Argote *et al*., 2003; Cummings and Teng, 2003; Canestrino, 2009), replication of knowledge and skills is more complex if the skills and language factors (transfer objects) are presented in "ambiguous" and uncertain form. The transfer of knowledge is more difficult to implement if in the object a strong component of causal ambiguity is present (Szulanski, 1996). Knowledge that is not clear is more difficult to transfer than less ambiguous knowledge (Argote *et al*., 2003). Often technological capabilities are based on tacit knowledge and are subject to considerable uncertainty with respect to their characteristics and performance. Mowery et al. (1996) find that this fact makes it difficult to develop simple contracts that govern the sale or licensing of such capabilities; Cohen and Levinthal (1990) point out that technology could be nominally acquired but not used correctly as it lacks the appropriate contextual knowledge necessary to make it fully intelligible. Cummings and Teng (2003) argue that the replication of knowledge (in the form of a capacity) is more difficult to the extent that there is ambiguity about what factors, skills, languages, elements and connections, interactively define the function of interest. The higher the causal ambiguity, the more difficult is to identify the elements of

knowledge and connections that support the functional activity. The causal ambiguity, therefore, is often identified as an important factor in the transfer of knowledge.

Codifiability

There are also other properties that characterize the object and express the degree of communicability and understanding: the codifiability (Zander and Kogut, 1995; Howells, 1996; Davenport and Prusak, 2000; Malik, 2002; Argote et al., 2003; Ferdows, 2006) and complexity (Zander and Kogut, 1995; Howells, 1996; Argote, 1999; Szulanski, 2000). The easier knowledge and technologies are inherently transferable, the easier it will be a fast transfer (Zander and Kogut, 1995).

The level of codification of knowledge expresses the degree of translation of the knowledge (documents, software, etc.), i.e. the ease with which the operator can understand: it is easier to transfer codified knowledge than non-codified one (Ferdows, 2006). The ease of teaching, conversely, expresses the degree of difficulty with which it is possible to transmit knowledge, i.e. the degree to which workers can be trained to learn certain skills. This property reflects the personal training of individuals (Zander and Kogut, 1995). Other property identified by some authors (Howells, 1996; Argote, 1999; Davenport and Prusak, 2000; Cummings and Teng, 2003; Argote *et al.*, 2003; Roth, 2003) is the articulation, i.e. the degree to which knowledge can be verbalized, written or represented. This property concerns the nature of knowledge, which, if presented in the form tacit (unarticulated) is much more difficult to transfer than explicit knowledge (and articulated). Another property considered by some authors (Kogut and Zander, 1992; Zander and Kogut, 1995; Argote, 1999; Davenport and Prusak, 2000) is the observability of knowledge to be transferred: the ability to "observe" and innovation "see" its effects, influence its degree of assimilation. The observability also identifies the degree with which the competitors can copy the capacity of the organization, in particular this property is related to the very concept of imitability of knowledge or technology (Zander and Kogut, 1995), it is referred to a network of competitors (in this case it is preferable to be less observable and imitable in order to maintain a position of advantage over competitors) or refers to the reverse engineering process, i.e. the process of feed-back relative to a given product (clearly in this case greater observability has advantages for the enterprise).

Complexity

Another characteristic of knowledge found in the literature (Zander and Kogut, 1995; Howells, 1996; Argote, 1999; Szulanski, 2000; Stock *et al.*, 2000) is the level of complexity of the transferred information, which considers the variations that knowledge can suffer when they combine different skills: knowledge is in fact more complex when it is constituted through multiple and different experiences and when it involves internal and external interdependencies (Stock *et al*., 2000).

Argote (1999) argues that increased complexity reduces the diffusion of innovations and notes that efforts to transfer complex technologies are associated to an initial loss of productivity in the recipient. Similarly, some authors (Kogut and Zander, 1992; Davenport and Prusak, 2000; Ferdows, 2006) consider the "viscosity" characteristic referred to the wealth (or thickness) of the knowledge being transferred. Davenport and Prusak (2000) argue that tacit knowledge, personal experience and skills of individuals represent a kind of knowledge with a high degree of viscosity, while the knowledge which can be accessed through documents, articles, databases (essentially explicit knowledge) is less "thick" and therefore less rich and less complex .

Speed of change

Even the concept of "news" is part of the object's characteristics, and impacts on the effectiveness of its transfer (Gilbert and Cordey-Hayes, 1996; Stock *et al.*, 2000; Carlile and Rebentisch, 2003). Rebentisch and Carlile (2003) found that organizations often find themselves having to manage a lot of innovative technologies and knowledge, as characterized by a high degree of change than previously experienced (Stock *et al.*, 2000). This is precisely one of the characteristics of the object, i.e. the amount of novelty introduced between stored knowledge and transferred knowledge. In a "stable" context, the amount of novelties turns out to be not very important, but in contexts characterized by turbulence and sudden changes, the company need to understand and integrate useful knowledge to consistently meet and satisfy the needs or demands of its stakeholders (Carlile and Rebentisch, 2003).

The rate of change of knowledge/technology (Kogut and Zander, 1992; Davenport and Prusak, 2000; Ferdows, 2006) is a very important feature. It refers to the speed with which knowledge evolves, i.e. the speed at which knowledge becomes obsolete (Davenport and Prusak, 2000). This concept is also taken by Ferdows (2006), who studied the transfer of know-how, given the rapid rate of "change". The pace of change in knowledge in fact affects the effectiveness of the transfer. When know-how is changing rapidly, both due to external forces (in relation to new scientific discoveries) or internal forces (for an aggressive policy of introduction of new technologies) and it is not possible or economic to codify the rapid evolution, there are more problems. Basing on manuals and equipment may be counterproductive in terms of rapid and uncertain technological change. The absorption capacity of the company depends on individuals that are at the interface between the firm and the external environment. In such circumstances, it is better for the organization to exhibit a fairly wide range of potential "receptors" to the environment (Cohen and Levinthal, 1990). The front line employees are a key source for the assessment of new methods and new technologies, to suggest how they might be implemented, as part of the tacit knowledge is transferred mainly by moving people and through direct observation (Argote, 1999). A good solution is to establish complementary skills network and create mutual interdependence between the parties involved.

4.4 Channels and mechanisms

It is also possible to classify the transfer of technology from two perspectives, horizontal technology transfer and vertical technology transfer (Autio and Laamanen, 1995; Grosse, 1996). The first perspective (horizontal TT) concerns the transfer within a given process phase inside a company or between the same phases of the process of technological innovation of one or more organizations. The vertical perspective concerns the transfer of technology from one phase of the innovation process to another (generally refers to the transfer of a product from research and development phase to production and marketing one). According to Kogut and Zander (1992), in the horizontal transfer the problems due to the different specializations of the people involved are attenuated due to the presence of individuals who facilitate communication between staff. In the vertical transfer, there are much more difficulties, because the shared languages of organizations, groups or functions differ a lot.

Laamanen and Autio (1995) first provide a definition of "mechanism" of transfer: "a technology transfer mechanism is any specific form of interaction between two or more social entities during which technology is transferred" to include in the range of mechanisms for technology transfer all the possible forms of interaction through which it is possible to transfer knowledge and technology. When the interaction is continuous between the parties a stable connection through which knowledge

and technology flows is established; Autio and Laamanen call this type of connection "channel" giving it a meaning similar to the one of a mechanism. Finally, if the relationship is defined in a formal way by establishing an appropriate organizational structure that governs the relationship between the parties typically makes reference to "ways" to transfer (Argote, 1999; Laamanen and Autio, 1995; Cumming and Teng, 2003). It must be stressed that in the literature there is a full sharing of these nuances in terminology and the terms are often used without distinction. In general terms, the knowledge can be transferred by moving people, technologies or the structures of the "source" of recipient organization or changing people (e.g. using training activities), technology (development activities) and structures (Argote, 1999). To rationalize the large number of different mechanisms, channels or modes presented in the literature, we rely on the classification proposed by Laamanen and Autio (1995). The authors divide the transfer mechanisms in three categories:

- Mechanisms of process (service)
- Mechanisms of process (organizational modes)
- Mechanisms of output (search results)

The classes show the difference between process activities that take place during the work and procedures based on the results of previous development activities. They also emphasize the difference between one-way mechanism (based on the dissemination of research results) and bi-directional mechanisms, which involve development and interactive service. In addition to this preliminary division, the mechanisms of the process are further divided into "services" and "organizational modes" to emphasize the difference between the activities carried out in existing units and the creation of new and appropriate organizational structures.

Phases of TT

The transfer of technology/knowledge between two distinct entities is an intentional, dynamic and interaction-oriented process, during which the technology (and the knowledge related to it) is transferred from one entity to the second with the objective to increase skills and experiences.

The transfer process is conducted through well-defined phases: it is in fact possible to study the transfer according to a temporal logic. Some authors (Flannery et al., 1994; Szulanski, 1996 and 2000; Gilbert and Cordey-Hayes, 1996) have identified the different temporal phases that compose a "transfer process" and identify a series of steps that each actor involved in the transfer of technology/knowledge should address.

The "transfer process" involves the whole company in a dynamic and continuous cycle of phases along an axis of time (Szulanski, 2000).

- Start-up. In the start-up phase, the difficulties lie in recognizing transfer opportunities and act on them. The opportunity to initiate a transfer occurs for the recipient as soon as a "seed" is created. The seed is the need of technology and the need of knowledge to meet the need. The discovery of a gap can derive in searching timely solutions externally; alternatively, open and systematic research processes can lead to discovering unexpected opportunities, revealing reveal gaps not previously considered or create new ones (discovery of superior external knowledge). The initial stimulus may also arise from a process initiated by the source application that tries to exploit the results of the internal research. This is followed by an assessment analysis of the feasibility of the identified opportunity.
- Implementation. Once the decision to transfer knowledge, the focus shifts to the exchange of information and resources between the source and the receiver. Specific relationships and

interactions are established between the parties and the information and resource flows generally increase and reach a peak at this stage. Much attention is paid to the prevention of problems through careful planning, in particular in order to prevent the recurrence of difficulties that arose in previous transfers of the same knowledge / technology and to contribute in making the introduction of new knowledge less difficult to the recipient. The problems in the implementation phase depend on how it is difficult to bridge the communication gap between the source and recipient (communication) and to bridge the technical gap of the recipient through the systems and mechanisms for transfer prepared (transfer modality). The effectiveness of planning, coordination and mutual compensation is likely to depend on the quality of the relationships between the source and the receiver.

- Ramp-up. Once the recipient starts using transferred knowledge (e.g. for example, it starts a new production, it launches a new process, it introduces a new system), the main concern becomes to identify and solve unforeseen problems (identify and resolve unexpected problems) that may arise due to the different context in which knowledge is inserted, and that prevent the recipient to meet or improve performance. The ramp-up phase has a relatively short window of time for further discussion (communication) to correct errors and allow the recipient to accelerate smoothly to a satisfactory level of performance, often with external assistance. The difficulty in this phase depends on the number and severity of unexpected problems and effort required to solve them, which may require activating additional transfer mechanisms, such as make up for inadequate or incomplete staff training (transfer modality).
- Integration. Once the recipient gets satisfactory results, the use of new knowledge gradually becomes routine (gradual routinization of transferred knowledge). This progressive institutionalization (institutionalization of new practices) is typical of any social pattern where new technology and knowledge is integrated into the reality of the organization, gradually losing the character of novelty and joining shared meaning and behavior. However, when the receiver encounters difficulties, they may be abandoned to return to the ex-ante status quo. The difficulty at this stage can be high and depend on organizational balances and how easily it is possible to overcome any internal resistance to change.

Mechanisms of process (services)

The role of human capital and training in the transfer of technology is becoming more recognized (Bozeman, 2000). In this category we therefore include a variety of mechanisms, such as:

- the training of the members of the recipient organisation, that allow them to observe the performance of the source organization's experts and provide an opportunity to open a bi-directional communication channel (Argote, 1999; Grosse, 1996; Bozeman, 2000; Amesse and Cohendet, 2001; Argote et al., 2003; Caputo el al., 2002; Autio and Laamanen, 1995; Cummings and Teng, 2003; Caputo et al., 2002; Davenport and Prusak, 2000; Szulanski, 1996; Szulanski, 2000);
- the use of consultants (Bozeman, 2000; Autio and Laamanen, 1995; Argote, 1999; Caputo et al., 2002) that play a role in the diagnosis and articulation or technical and managerial support; research projects (Autio, Laamanen, 1995, Bozeman, 2000; Amesse and Cohendet, 2001) carried out as a contract (contracts for design) or in cooperation between universities and industry;

- the formal and informal relationships (Bozeman, 2000; Autio and Laamanen, 1995; Cummings and Teng, 2003; Davenport and Prusak, 2000; Argote et al., 2003; Argote, 1999) such as lab demonstrations, visits and company presentations, meeetings, networking events and the sharing of resources (Bozeman, 2000; Autio and Laamanen, 1995; Canestrino, 2009) as the common use of space or laboratory equipment.

Mechanisms of process (organizational modes)

The importance of the organizational mode is evident in the fact that the definition of formal organizational structures is useful to define the flow of goods, the depth and breadth of interaction between the two parties and incentives for collaboration (Cummings and Teng, 2003). The greater density of social ties between the parties facilitates these elements, as it will allow for better opportunities to share knowledge and experiences, develop trust and cooperation. The possible modes of organization through which the source and the recipient shall transfer such contracts are occasional market conditions (Argote, 1999; Amesse and Cohendet, 2001; Reisman, 2005; Stock et al., 2000) to acquire non-key technology ; collaborations (Autio, Laamanen, 1995; Argote, 1999; Bozeman, 2000; Reisman, 2005; Stock et al., 2000; Cummings and Teng, 2003; Flannery, Spivey, Alter, 1994; Canestrino, 2009; Mowery, Oxley, Silverman, 1996), for example with clients or suppliers for joint development activities; intermediaries (Autio, Laamanen, 1995; Bozeman, 2000; Caputo el al., 2002); networks (Bozeman, 2000; Argote et al., 2003; Canestrino, 2009; Cummings and Teng, 2003; Albors, Sweeney, Hidalgo, 2005); consortia R & D (Amesse and Cohendet, 2001; Stock et al., 2000; Autio and Laamanen, 1995, Argote, 1999) and the movement of human capital (Autio and Laamanen, 1995; Argote, 1999; Bozeman, 2000; Caputo el al., 2002; Argote et al., 2003; Canestrino, 2009; Agrawal, 2001; Howells , 1996; Szulanski , 1996 and 2000), spin-offs (Autio and Laamanen, 1995, Bozeman, 2000; Canestrino, 2009), strategic alliances (Amesse and Cohendet, 2001; Cummings and Teng, 2003; Argote, 1999; Autio, Laamanen, 1995; Mowery, Oxley, Silverman, 1996), and acquisitions (Amesse and Cohendet, 2001; Cummings and Teng, 2003; Reisman, 2005; Flannery, Spivey, Alter, 1994). Regarding the impact of different forms of governance in the field of knowledge transfer, research has shown that when the transfer is among strongly related parties, this happens more effectively. Argote (1999) notes that competition is less between companies within franchises, chains and networks and organizations generally trust each other to a greater extent than those who are not organizationally integrated. Consistent with this line, it seems reasonable to assume that the strength of social ties, the free flow of communication, consistency in administrative controls and the level of trust between the source and the receiver is greater to the extent that the units are integrated from an organizational point (i.e., when the organizational distance is less). Integration is minimal in the case of casual contracts in market conditions and maximum in the case of acquisitions (Cummings and Teng, 2003).

Mechanisms of output (research results)

As some of knowledge of the source could be incorporated in hardware, software in artefacts or in the products, a useful mechanism is to make available those outputs (Argote, 1999). The products and technological artefacts in fact “contain” knowledge, extrapolated for example through observation or activities of “reverse engineering” (Argote, 1999; Ferdows, 2006; Autio and Laamanen, 1995; Amesse and Cohendet, 2001; Malik, 2002). To transfer the information encoded

instead as a result of research the best system is the transfer of manuals, documents, project plans, descriptions or disclosure through publications, seminars, workshops (Argote, 1999; Ferdows, 2006; Davenport and Prusak, 2000; Szulanksi, 1996 and 2006; Bozeman, 2000; Amesse and Cohendet, 2001; Kingsley, Bozeman, Coker, 1996; Cummings and Teng, 2003; Caputo et al., 2002). A formal mechanism commonly used to regulate the transfer of knowledge is defining the contractual terms of the passage of intellectual property (Autio, Laamanen, 1995, Bozeman, 2000; Argote, 1999; Amesse and Cohendet, 2001; Caputo et al., 2002; Agrawal, 2001; Autio, Hameri, Nordberg, 1996; Lichtenthaler, Ernst, 2008; Mowery, Oxley, Silverman, 1996). As part of the contracts which have as their object patented technologies, we can distinguish contracts for the sale of patent and license agreements patents. The distinction consists essentially in the fact that with the contract for the sale of a patent, the assignor is deprived of the ownership of the patent in favour of the transferee, upon payment of a price; instead with the agreement of the patent license, the licensor is limited to granting the licensee the right to use only temporary patent, retaining ownership.

4.4 Context

Exchanges of knowledge of inter-organizational context are always placed in a context of reference. Its characteristics may influence its beginning, evolution and success. A same type of transfer could take place effectively in a particular context, but could have difficulties in another or even fail in a third case. Szulanski (2006) considers the organizational contexts that facilitate the development of transfer as "fertile". Previous research (Szulanski, 1996) show that the structure and formal systems, sources of coordination and expertise, and the framework that characterizes the attributes of the internal and external organizational context, influencing the efforts needed for the transfer of knowledge and the outcome of the activity. In fact, the organizational context in which the transfer takes place can affect the functioning of the operations, as it affects the willingness and ability of the actors to complete the planned activities. In a context of inter-organizational transfer, considerations should be divided between those related to the design context and those relating to factors inherent to the external environment.

Context of design

According to a perspective that considers the activity of transfer of knowledge and technology as a project (Stock et al., 2000), the main parameters of reference that must be considered (as they constitute constraints) are : time - the duration of the project (Teece, 1977; Stock et al., 2000; Bozeman, 2000; Reisman, 2005; Howells, 1996), the resources (costs) required (Teece, 1977; Caputo el al., 2002; Stock et al., 2000, Szulanski, 1996; Bozeman, 2000; Reisman, 2005; Albors et al., 2005) and the risk / uncertainty for the achievement of objectives (Campbell el al., 2002; Stock et al., 2000; Albors et al., 2005; Bozeman, 2000). The time constraint indicates the amount of time required to complete the project. The cost constraint is the available budget for the project and at the same time the set of available resources. The constraint goal / risk is what needs to be done to achieve the results expected from the project both in terms of requirements uncertainty on performance. These three constraints are closely related: to increase the target typically means increasing the project time and cost / resources (Stock et al., 2000), reducing the time often requires higher costs (Teece, 1977); less resources may involve longer time and / or increased uncertainty in the results (Caputo et al., 2002). The literature on technology transfer rarely delves into these issues, which are more close to the project management, but equally important. In support of this, Bozeman (2000): "In general, the

process of commercialization of intellectual property is very complex, high-risk, time-consuming, it costs much more than it is expected, and generally can not-succeed ... “

External context

The external environment has some reference factors (market and not only) that affect the transfer (Bozeman, 2000): on the demand side relevant factors are the need of the market for the purpose of the transfer (Kingsley et al., 1996), the possible secondary effects and the overall economic potential, in addition to these price trends for the technology, its substitution, the added value compared to the technologies used today (Kingsley et al., 1996), government subsidies, legislation, barriers and protections of the market must also be considered (Bozeman, 2000). More generally, Peest factors (Political, Economic, Environmental, Social and Technological forces) should be considered (Liyanage et al., 2009). The environmental uncertainty adds elements of complexity. In fact, both the evolution of the technological and industrial changes in the political and social impact on how an organization can relate to and create strategies to compete in its reference environment (Flannery et al., 1994; Caputo et al., 2002). The influence of external factors on the learning environment of enterprises is a current topic (Argote et al., 2003): the environmental turbulence, the degree of competition and customer characteristics affect the success of such learning strategies and organizational models. Understanding these interactions has important implications for the competitive behaviour of firms. More generally, the understanding of learning “ecologies” or of how organizations can better learn from other organizations is an important issue of research still open (Argote et al., 2003).

5. DISCUSSION AND CONCLUSIONS: CRITICAL FACTORS OF TECHNOLOGY/KNOWLEDGE TRANSFER

The following part highlights the positive and negative factors for technology transfer. They are subdivided into factors related to the actors and factors related to the process.

Literature underlined that technology transfer derives in different benefits, mainly: encouraging the use of technology to benefit society; demonstrating research program relevancy and value; permitting in the university-industry relationship, a more responsive action to the needs of the companies, giving increased visibility to the source and reinforcing the relationships between the actors of the technology transfer. Finally, employees can benefit intellectually and professionally through working collaboratively with their peers in the industrial sector.

The factors that refer to the actors involved in the technology/knowledge transfer include (Table 3): technical factors (flexibility, familiarity with technology, technological skills, planning skills), organizational factors (motivation, absorptive capacity, resources, organizational structure, status / reliability), cultural factors (NIH syndrome, learning cultures), relational factors (intensity of connections, confidence, cultural, organizational, physical, knowledge base and normative distance). Factors influencing the transfer that relate to the process include (Table 3): factors related to the characteristics of the object to be transferred (tacit or explicit nature, codifiability, contextuality, uncertainty, complexity, rate of change), the choice of channels and mechanisms and factors related to the context.

The analysis of the literature allowed us to investigate major dimensions of technology/ knowledge transfer, to identify key elements and critical factors that influence, positively or negatively, the success of technology transfer and frame them in a simple framework. The factors identified represent

the main parameters and levers on which action is necessary or appropriate to consider in the design and implementation of a transfer. The proposed structure considers six categories (Properties and characteristics of the source - Properties and characteristics of the recipient - Characteristics of the relationship - Properties and characteristics of the object - Choice of channels and mechanisms - Characteristics of the context) that represent the general areas where the critical factors influence the process of technology/knowledge transfer (Table 4). Table 5 shows the possible convergence relations among the factors.

Insert Table 3 about here

Insert Table 4 about here

Insert Table 5 about here

Properties and characteristics of the source

Factors identified contribute to an overall ability to transfer their knowledge and technologies - emitting capacity - and include: (1) the technological capabilities (e.g. technical skills, technology skills, the R&D level, the ability to manage complex technical systems, the flexibility, the ability to design and engineering), (2) organizational skills (e.g. organization design and management style, status and reliability, the resources and motivation to transfer), (3) organizational culture (e.g. the opening to the processes of knowledge management and open innovation).

Properties and characteristics of the recipient

The recipient is instead characterized by its ability to acquire new knowledge and technologies, therefore the factors identified were: (4) the technological capabilities such as technical capacity, technological skills and familiarity or experience with technology, (5) organizational skills (e.g. organizational structure and management style, the available resources, the motivation to transfer and absorptive capacity), (6) organizational culture (openness to learning processes).

Characteristics of the relationship

The relationship between the actors of the transfer is characterized by the presence of possible significant relational barriers. The factors that define the relational context of the transfer are: (7) trust (it is a factor that is the basis of any interpersonal or inter-organizational relationship and if there is no collaboration is doomed to fail), (8) the intensity of connections (defined as the frequency of contacts and communications, which promotes the degree of familiarity and reciprocity between the parties); certain parameters that consider the distance that exists between the parties, and in particular (9) organizational distance (which measures the degree of organizational integration between the units taking part in the transfer), (10) the physical distance (binds to the difficulty, the time required and the cost of communication, the ability to meet face -to-face), (11) the distance of the knowledge base (refers to the degree to which the source and receiver are in the possession of knowledge, etc.), (12) the cultural distance (refers to the presence of representations, interpretations and logical systems

of shared meaning), and (13) the legislative distance (the extent to which the parties to the transfer of knowledge sharing aspects of social behaviour in the context of reference).

Properties and characteristics of the object

The factors identified intend to consider the differences which distinguish the different types. These differences occur mainly (14) in embeddeness (other repositories - humanware, infoware, technoware, orgaware - on which lie the components of the object of the transfer) and the specific characteristics and properties (15) nature (in reference to "tacit knowledge", or knowledge hardly articulated, expressed and therefore transferable, and "explicit knowledge", expressed in the form of documents or practice - so articulate - which is easier to transfer and understand), (17) contextuality (knowledge is often dependent on the context as immersed in the individual, collective or organizational processes: the more knowledge is context-specific, the more difficult it can be used in different contexts), (16) codifiability (the degree of translation/translatability of knowledge in documents, software, etc., the degree to which knowledge can be verbalized, written or represented), (18) complexity (the level of complexity, depth, diversity, interdependence of information transferred), (19) the rate of change (in reference to the amount of such novelty introduced between stored knowledge and knowledge retrieved or the rapidity with which knowledge evolves - the speed at which knowledge becomes obsolete), (20) uncertainty (the degree of ambiguity and uncertainty about the elements of the knowledge to be transferred).

Choice of channels and mechanisms

Knowledge can be transferred by moving people , technologies, or the structures of the source to the recipient organization or changing people (e.g. using training activities), technology (development activities) and facilities. The factor is: (21) transfer mechanisms (we distinguish between: a) unidirectional mechanisms, based on the dissemination of the results of research; b) bi-directional mechanisms that involve b1) an interactive development and the creation of new and appropriate organizational structures or b2) service activities.

Context characteristics

The characteristics of the context may influence the evolution and the success of exchanges of knowledge. Compared to the characteristics of the context identified factors relate to design issues, such as (22) the duration of the project (indicates the amount of time needed to complete the project), (23) the cost of the project (the budget available for the project and at the same time the set of available resources), and (24) the risk of the project (what is to be done to achieve the results expected from the project both in terms of requirements both uncertainty on performance). Secondly, they consider some general parameters: (25) a fertile / sterile context (the degree to which the internal and external organizational context supports the transfer depends on the characteristics of the structure and formal systems, sources of coordination and expertise, and the framework that are the attributes of the context itself), (26) the environmental uncertainty / turbulence (the degree to which the external environment is uncertain / turbulent depends on the state and evolution of market factors, competitive environment and, more in general, the Peest factors).

The present work helped in finding a framework for technology transfer analysis and highlighted the critical factors presented in literature for the management and organisation of technology/knowledge transfer. The work highlighted that the technology/knowledge transfer can be described, designed and implemented through six different elements: actors involved (sources, recipients and intermediaries), the relationship between them, the object of the transfer, the channels and mechanisms and the reference context. For each of these categories, the paper describes the main elements and at the end proposes the critical positive and negative factors for the implementation of a technology/knowledge transfer process. Future research could be directed to analysing with more depth single elements and/or to empirically testing the validity of the proposed framework derived from literature.

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Table 1- Previous literature reviews

Author	Year	Title of the paper	Focus	Method
Geisler	1993	Technology transfer: Toward mapping the field, a review, and research directions	Technology transfer	Narrative literature review
Bozeman	2000	Technology transfer and public policy: a review of research and theory	Domestic technology transfer from universities and government laboratories	Narrative literature review
Malik	2002	Aiding the technology manager: a conceptual model for intra-firm technology transfer	Intra-firm technology transfer	Narrative literature review
Reisman	2005	Transfer of technologies: a cross-disciplinary taxonomy	Technology transfer	Taxonomy
Cottril *et al.*	2010	Co-citation Analysis of the Scientific Literature of Innovation Research Traditions Diffusion of Innovations and Technology Transfer	Diffusion of innovations and technology transfer	Bibliometric analysis
Hsieh *et al.*	2014	A Literature Review with Citation Analysis of Technology Transfer	Technology transfer	Citation analysis

Table 2- Dimension analysis of the technology/knowledge transfer

Dimensions of analysis		Bozeman 2000	Davenport and Prusak 2000	Malik 2002	Cummings and Teng 2003	Kumar and Ganesh 2009	Liyanage *et al.* 2009
Actors	Source	x	x	x	x	x	x
	Recipient	x	x	x	x	x	x
	Intermediaries		x				
	Relationships				x	x	x
Process	Object	x	x	x	x	x	x
	Channels and mechanisms	x	x	x	x	x	x
	Context	x				x	x

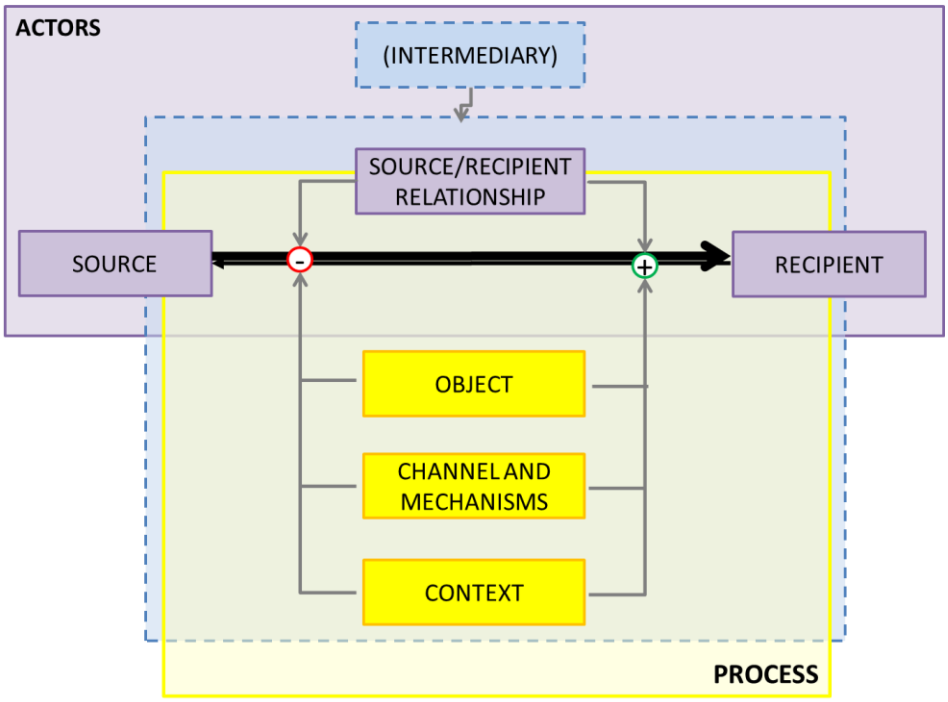

Figure 1 - Technology/knowledge transfer dimensions

Table 3 - Factors affecting the transfer of technology/knowledge

	Argote et al 2003	Malik 2001	Szulanski 1996	Autio et al 1996	Canuto et al 2002	Autio Lamanen 1995	Bozeman 2000	Aalbors et al 2005	Milton 2009	Cohen Levinthal 1990	Davenport Prusak 2000	Argote 1999	Zander Kogut 1995	Canestrino 2009	Livanage et al 2009	De Long Fahey 2000	Ferdows 2006	Roth 2003	Cummings Teng 2003	Stock et al 2000	Mowery et al 1996	van Wijk et al 2008	Howells 1996	Flannery et al 1994	Reagan et al 2003	Hansen 1999	Amesse Cohender 2001
Actors																											
Technical skills																											
Flexibility					x		x																				
Familiarity with technology	x	x					x			x		x				x											
Technological skills				x	x										x												
Project design skills				x																							
Organisational skills																											
Motivation	x	x	x						x			x		x	x	x			x								
Absorptive Capacity	x	x	x				x	x		x	x	x		x	x	x			x		x						x
Resources							x	x	x																		
Organizational structure					x		x								x												
Status, reliability	x		x						x			x															
Culture																											
NIH sindrome	x	x	x									x		x		x			x								
Learning culture	x				x		x		x	x				x	x	x			x								
Relationship																											
Connection intensity	x	x	x				x		x		x	x		x	x	x			x	x		x			x	x	x
Trust	x	x	x						x		x	x		x	x	x			x	x		x	x		x	x	x
Cultural distance	x	x					x			x		x			x	x					x	x					
Organisational distance												x							x								
Physical distance	x										x								x							x	
Distance of the knowledge base	x	x							x	x				x					x								
Normative distance																x			x								
Process																											
Object																											
Codifiability	x	x	x								x	x	x	x		x	x	x	x			x					
Nature	x	x	x	x		x					x	x		x		x	x		x		x	x					x
Contextuality									x	x				x				x			x	x					
Uncertainty	x		x							x	x	x		x					x		x						
Complexity			x									x	x			x				x			x				
Change speed										x	x					x				x			x				x
Channels and mechanisms																											
Channels and mechanisms						x			x			x					x										

Context																										
Time, cost, risk		x		x		x	x	x											x			x				
Fertile context	x					x							x										x			x
Environmental uncertainty		x		x										x												

Table 4 - The critical factors for technology/ knowledge transfer

Dimension	Critical aspects
Properties and characteristics of the source	(1) Technological capabilities of the source
	(2) Organisational capabilities of the source
	(3) Organisational culture of the source
Properties and characteristics of the recipient	(4) Technological capabilities of the recipient
	(5) Organisational capabilities of the recipient
	(6) Organisational culture of the recipient
Characteristics of the relationship	(7) Trust
	(8) Connection intensity
	(9) Cultural distance
	(10) Organisational distance
	(11) Physical distance
	(12) Distance of the knowledge base
	(13) Normative distance
Properties and characteristics of the object	(14) Repositories
	(15) Nature
	(16) Codifiability
	(17) Contextuality
	(18) Complexity
	(19) Speed of change
	(20) Uncertainty
Choice of channels and mechanisms	(21) Mechanisms
Characteristics of the context	(22) Time of the project
	(23) Cost of the project
	(24) Risk of the project
	(25) Fertile context
	(26) Environmental uncertainty / turbulence

Table 5 – The relationship among critical factors for technology/ knowledge transfer

Dimension	Critical aspects	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
Properties and characteristics of the source	(1)																										
	(2)																										
	(3)		x																								
Properties and characteristics of the recipient	(4)																										
	(5)																										
	(6)					x																					
Characteristics of the relationship	(7)		x	x		x	x																				
	(8)		x	x		x	x																				
	(9)			x			x	x																			
	(10)		x	x		x	x	x																			
	(11)	x			x																						
	(12)		x	x			x	x	x	x																	
	(13)			x			x	x	x	x	x																
Properties and characteristics of the object	(14)																										
	(15)																										
	(16)																										
	(17)																										
	(18)																										
	(19)																		x								
	(20)																		x	x							
Choice of channels and mechanisms	(21)	x	x		x	x																					
Characteristics of the context	(22)																	x	x	x	x						
	(23)																	x	x	x	x		x				
	(24)																	x	x	x	x		x	x			
	(25)	x	x	x	x	x	x	x	x																		
	(26)																	x	x	x	x				x	x	