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THE DIFFUSION OF KNOWLEDGE, TECHNOLOGY AND INNOVATION IN NETWORKS

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ABSTRACT

Successful knowledge, technology and innovation diffusion is a complex practice crucial for the organization's success and survival in todays globalized world. This paper wants to understand what are the conditions that mostly influence this practice and the managerial that firms can implement to promote it. A substantial amount of literature has been written on each of these three transfer processes on their own, but few articles linked them together highlighting their similarities and differences. This thesis aims to shed some light on the correlations that tie together knowledge, technology and innovation diffusion.

Keywords: knowledge, technology, innovation, diffusion, transfer, network.

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CHAPTER 1
INTRODUCTION

This systematic literature review studies the existing literature on knowledge, technology and innovation diffusion. This research was made because these processes are really important in the current state of time, since more and more firms are collaborating in shared projects in order to implement their knowledge bases, exchange information and experiences, and improve their innovativeness. Indeed, especially with the increasing globalization, the ability to modernize and transform obtained through the transition of knowledge, technology and innovation is a vital characteristic for economic success, and organizations have to master it in order to survive in the always changing environments in which they are operating. Therefore, a better understanding of the variables which influence these practices and the managerial strategies needed to foster them is very useful.

Although the literature on these topics is extensive, the essential elements of knowledge, technology and innovation diffusion have not been analyzed and compared by a single paper. This is the reason why this work of research has been conducted: pointing out the trends, relations and inconsistencies in the existing literature dealing with transfer in collaborative environments.

The second chapter wants to create the foundations from which this thesis is built upon. It starts explaining the basic assumptions and key concepts: the main words, which constitute also the title of the dissertation, “knowledge”, “technology”, “innovation”, “diffusion” and “network” are explained in detail (2.1). This section goes on stating the research questions, explaining which database was selected for the study, the motive behind that specific choice and the search terms which have been looked for (2.2). Then, it follows a description of the practical screening criteria: which and how papers have been selected and ignored from the study following specific objective rules (2.3). In the next part, limitations of this research have been pointed out: even if this work wants to be as objective as it can, it is humanly impossible to eliminate every single source of bias, such as the dataset choice, timeframe and language barriers (2.4). At the end of this segment, the reasons for which this paper should be considered as valid and objective are delineated.

The third chapter is a brief overview of what are the actual results of the research, the number of articles found, how they are located in time, what journals published them and the differences between the three research processes (diffusion for knowledge, technology and innovation).

The fourth chapter states the theoretical results of the research process: in order to answer the research questions, every subsection was divided into three parts. The first one presents the specific diffusion (knowledge, technology or innovation) in general, the following one clarifies the variables which influence the single processes and finally, in the last part of each paragraph, some managerial techniques and practices are suggested in order to facilitate these transfer procedures.

On the fifth chapter, the main similarities and differences between these processes are pointed out and the gaps found in the literature are denoted. Also, some suggestions for further research are recommended.

This work ends with the final conclusions and references.

CHAPTER 2
RESEARCH METHOD

A systematic literature review is a procedure in which a body of literature is gathered, examined and evaluated using standardized and transparent techniques that can be replicated, as a way to minimize bias. The main goal is to uncover trends, associations, discrepancies, and gaps in the analyzed works[1].

This chapter first aims to define the basic terminology that will be at the base of the whole thesis; then, it continues delineating the research questions, the database used and how the research was actually carried out, explaining how the analyzed papers were included or excluded using practical screening criteria.

2.1 BASIC CONCEPTS

The aim of this section is to establish a framework of basic terminology and notions which are needed to have a better understanding of the next chapters. In order to start a research on knowledge, technology and innovation diffusion, it is necessary to indicate what these concepts represent and how they are defined.

2.1.1 KNOWLEDGE

The Oxford Dictionary describes knowledge as "*facts, information, and skills acquired through experience or education*[2]*"*. It is the major drive for economic growth and innovation[3] and new knowledge is generated through a creative innovation process that will result in new products, machines and/or production techniques[4]. Knowledge can show very different characteristics depending on which school of thought is studying it. On one hand, the Neoclassical theory, by Kenneth Arrow, sees knowledge as a public good, implying qualities such as non-excludability and non-rivalry (respectively the impossibility to avoid that an individual consumes a good even when he/she did not pay for it and the possibility for different people to consume the same good simultaneously)[5].

[1] "Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review", David Tranfield, David Denyer and Palminder Smart. British Journal of Management, Vol. 14, pp. 207–222
[2] Oxford Dictionary
[3] "Schumpeter's View on Innovation and Entrepreneurship", Karol Śledzik. Social Science Research Network
[4] "Creative Knowledge Environments", Carl Martin Allwoodb, Sven Hemlina and Ben R. Martinc. Research Policy
[5] "Kenneth Arrow on Public Goods, Public Policy, and Environmental Economics", Partha Dasgupta. Econometrics Society

Another important feature is represented by technological spillovers, meaning that only one company bears the cost of producing new knowledge, because this is able to leak and be absorbed at zero costs by other firms which did not contributed to the research and development expenditures[6]. The supporters of this theory think that it is very challenging to stipulate a complete contract and to engage in a fair transaction when dealing with knowledge exchange for several reasons: moral hazard, which is the threat a firm faces when entering a contract because its associates could have signed it with bad intentions, giving dishonest information concerning the assets, debts or competences, or bearing more risks as a way to earn a greater share of profits than the merited one[7]; free-rider (or appropriability) problems, which occur when one partner of an exchange exploits less resources or pays less than what it was settled[8] and also the impossibility for the buying party to really know the actual value of the knowledge without essentially knowing it first. However, the outtake on knowledge by Neoclassicals is not only negative: spillovers generate also positive side effects, such as encouraging a quicker diffusion and avoiding the inefficient double-inventing problem[9].

On the other hand, for the economists following the Neo-Schumpeterian theory, with Joseph Alois Schumpeter as the main advocate, knowledge is considered a latent public good[10]. To explain this concept, this school of thought refers to the idea of communication theory, according to which knowledge exchange is based on the sending and receiving of signals and which responds to three fundamental complications[11]. Firstly, there are some parts of knowledge, called tacit, which cannot be codified, meaning that they cannot be written down, and, for this reason, it is not easy to exchange them between different firms. Since tacit knowledge is thus excludable and rival, it is not considered a public good. Secondly, the receiver has to be able to actually comprehend and re-interpret the signal: he can acquire some information but this does not automatically convert into knowledge if the receiver does not have an own stock of knowledge base. For this reason, knowledge is thought as a cumulative process: even though it is freely accessible, it depends from the

[6] "Kenneth Arrow on Public Goods, Public Policy, and Environmental Economics", Partha Dasgupta. Econometrics Society

[7] "A Model of Moral-Hazard Credit Cycles", Roger B. Myerson. Journal of Political Economy, Vol. 120, No. 5, pp. 847-878

[8] "The Freedom to Contract and the Free-Rider Problem", Zvika Neeman. The Journal of Law, Economics and Organizations, Vol. 15, No. 3, pp. 685-703

[9] See note 6

[10] "What Is Private and What Is Public About Technology?", Richard R. Nelson. Science, Technology & Human Values, Vol. 14, No. 3, 229-241

[11] "Lectures on Communication Theory", Dennis Gabor. Techincal Report No. 238

recipient's absorptive capacity if the new knowledge will be valuable or not[12]. Finally, even if the recipient understands the new external information, it is not always possible to actually use it: thinking about the K-L diagram, the movement from one real production isoquant to another is limited from the absence of in-between meaningful solutions[13]. For example, in an actual manufacturing process, it is not always accurate that one unit of capital can be substituted for one unit of labor, but some more adjustments may be needed. Additionally, knowledge diffusion is affected by local technological progress, which implies that only those organizations that make use of the same technology may benefit from the new, freely available knowledge[14].

It is important to notice how, even if with different intensities, in both theories spillovers are present and play a major role, especially in the context of networks.

2.1.2 TECHNOLOGY

Technology is defined as "*the application of scientific knowledge for practical purposes*[15]" and it is associated with the concepts of employing knowledge, achieving pre-determined goals, solving problems, realizing tasks that involve specific skills and exploiting assets[16]. For these reasons, technological strength is a crucial determinant of productivity development and international competitiveness.

Technology entails two main components: the physical one, which consists of products, equipment, drafts, machines and processes; and the informational one, involving the savoir-faire in administration, management, advertising, production, supervision and consistency[17]. These two components are indissoluble because when a technological product is diffused, the knowledge that served as a base to produce it is also transferred[18].

[12] "Strategic Management Knowledge Transfer, Absorptive Capacity and the Attainment of Strategic Objective of MNCs' Chinese Subsidiaries", Ling Hu. Modern Economy, Vol. 3, pp. 424-428

[13] "Learning to learn, localized learning and technological progress", Joseph E. Stiglitz. Economic Policy and Technological Performance, Chapter 5, pp. 125-153

[14] See note 13

[15] Oxford Dictionary

[16] "International Technology Transfer Examined at Technology Component Level: A Case Study in China", Ping Lan and Stephen Young. Technovation, Vol. 16, No. 6, pp. 277-286

[17] "Building Technological Capability through Importing Technology: The Case of Indonesian Manufacturing Industry" Vinod Kumar, Uma Kumar and Aditha Persaud. Journal of Technology Transfer, Vol. 24, No. 1, pp. 81-96

[18] "Technology Transfer and Public Policy: A Review of Research and Theory", Barry Bozeman. Research Policy, Vol. 29, No. 4-5, pp. 627-655

As with knowledge, also technology can be perceived as tacit, difficult to codify, transfer and reproduce, or generally cumulative within organizations[19]. When it is tacit, it is said that technology is firm-specific, constituting an intangible asset deeply rooted in the firm's practices, which gives competitive advantage[20]. It is difficult to transfer because of the gradual learning process which is necessary to integrate the new technology[21]. Also when talking about technology diffusion, as with knowledge, it is important to notice that absorptive capacities have to be present: the physical object cannot be utilized if the recipient does not have an already existent and inherent knowledge and technology base[22]. Technology can be tangible, for example when dealing with proposals, working instructions and prototypes, or intangible, in case of consultancy, problem-solving, and training and evaluation practices[23].

Another classification sees technology as general, containing practical information which can be applied in more firms working on the same field or environment, and system specific, concerning the know-how relevant for the solution of certain industrial complications. Moreover, company specific technology deals with all the corporate skills and competences generated from day-to-day accomplishments and experience of each individual organization[24].

1.3 INNOVATION

Innovation is "*the action or process of innovating*[25]"and it is considered essential for the survival and success of an organization. This process of innovating translates in techniques, ideas, consumer goods and services which are recognized as completely new by a third-party[26]. An innovation is thus characterized by several variables: the human capital component, referring to the individual or business which is going to adopt the new product or system and will contribute to its diffusion process when using it, and the degree

[19] "Patent Statistics as Indicators of Innovative Activities: Possibilities and Problems", Keith Pavitt. Scientometrics, Vol. 7, No. 1-2, pp. 77-99

[20] "Alternative Channels and Modes of International Resource Transmission", John Harry Dunning, in T. Sagafi-Nejad, Perlmutter, H. and Moxon, R. Controlling International Technology Transfer: Issues, Perspectives and Implications.

[21] "International Technology Transfer and Catch-up in Economic Development", Slavo Radosevic. Nothampton, MA: Edward Edgar Publishing

[22] See note 20

[23] "The Contribution of Intangible Technology Controls in Controlling the Spread of Strategic Technologies", Ian J. Stewart

[24] "The Technology Factors in International Trade", George R. Hall and Robert E. Johnson. Colombia University Press

[25] Oxford Dictionary

[26] "Diffusion of Innovations", Everett M. Rogers. The Free Press

of novelty, which are closely interconnected because the first one depends on the latter[27]. Other features of an innovation are its relative advantage, meaning the benefits that the innovation brings with respect to the ones introduced by a previous innovation; its comparability, to indicate the affiliation between an individual needs and values with the estimated benefits; its complexity, how easily an idea can be understood; its trial-ability, the extent to which an innovation can be experimented before its introduction in the market; and its observability, the easiness to observe the consequences that an innovation might have[28]. All of these variables, expect from the complexity, are directly proportional to the rate of adoption of an innovation.

Regarding the way they are carried out, innovations can be divided into two categories: incremental versus radical[29]. The first type gathers innovations which are built on existing technologies or products, improving them and following well-specified technological trajectories. They are the result of a long-term and cumulative process where the former accomplishments establish the building blocks for the future progress[30]. The second category collects innovations which bring major changes, introducing something completely new based on new knowledge. This type of innovation is also called as a major breakthrough[31].

J. A. Schumpeter, the most famous innovation economist and the one who most firmly went against the Neoclassical theory, in his *Die Theorie der wirtschaftlichen Entwicklung*, states that innovations could be divided in five categories, depending what field they will affect: product, process and organizational innovation, new raw material sources and new business markets[32].

2.1.4 DIFFUSION

Continuing with the definitions given by the Oxford Dictionary, diffusion is presented as "*the spreading of something more widely*[33]", and, applying this description to the concepts of knowledge, technology and innovation, it suggests their dispersion within one

[27] "Diffusion of Innovations", Everett M. Rogers. The Free Press
[28] See note 27
[29] "Organization strategy and structural differences for radical versus incremental innovation", John E. Ettlie, William P. Bridges and Robert D. O'keefe. Management science, Vol 30, No. 6, pp. 682-695.
[30] "Innovation network", Daron Acemoglu, Ufuk Akcigit and William R. Kerr. Proceedings of the National Academy of Sciences, Vol 113, No. 41, pp. 11483- 11488
[31] "Innovation diffusion categories and innovation-related needs", Vishal Singh. International Conference On Engineering Design, ICED13
[32] "Schumpeter's View on Innovation and Entrepreneurship", Karol Śledzik. Social Science Research Network
[33] Oxford Dictionary

organization or among different firms. A crucial element, without which the diffusion process cannot take place, is communication. Without it, important knowledge, necessary technologies and needed innovation are not shared among and within firms[34]. The rate at which diffusion takes place is dependent on different variables[35]. The social system in which it occurs specifies the structure of the associations among the members of the society, which can be crucial for a successful diffusion. Uncertainty is caused by the possible skepticism of people engaging in an exchange, and it can be overcome by providing broad and valuable information as a way to increase the perceived level of trust. Related to this, the adoption level refers to how many actors are actually affected by the diffusion[36] (for example, which firms will use new leaked knowledge). Finally, diffusion is influenced also by time, because this process occurs over a time frame.

2.1.5 NETWORK

Last but not least, a network is "*a group or system of interconnected people or things*[37]". The major driver for organizations to work together in innovation networks is the production of high quality outputs, especially in R&D[38]. These structures allow the contribution to the creative process to a great number of different participants such as other organizations, consumers, suppliers, governments, universities and other investors like consultants[39]. The principal gain for firms to collaborate in a network is the large opportunity to understand and acquire different knowledge and competences made available by other associates, and consequently, to improve their competitiveness. In doing so, organizations can trade information in a fast way, complement each other and improve production thanks to their different ideas and resources[40], usually managing to reach the perfect allocation of resources, decreasing costs and avoiding the inefficient double-inventing[41]. In order for the network to succeed, it has to be a learning network:

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[34] "Diffusion of Innovations: Communication Evolution and Influences", Jatin Sivrastava and Jennifer J. Moreland. The Communication Review, Vol. 15, No. 4

[35] See note 34

[36] "An agent-based model of innovation diffusion: network structure and coexistence under different information regimes", Giovanni Pegoretti, Francesco Rentocchini, and Giuseppe Vittucci Marzetti. Journal of Economic Interaction and Coordination, Vol. 7, No. 2, pp. 145-165.

[37] Oxford Dictionary

[38] "The Impact of Research Collaboration on Scientific Productivity", Barry Bozeman and Sooho Lee. Social Science Studies, Vol. 35, No. 5, pp. 673-702

[39] "Collaborative Innovation: Developing Health Support Ecosystems", Mitsuru Kodama. Routledge.

[40] See note 39

[41] "Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge", Bjørn T. Asheim and Arne Isaksen. The Journal of Technology Transfer, Vol. 27, No 1, pp. 77–86

the working environment has to be elastic to make the trade of knowledge, technology and innovations faster and easier.

Collaborative innovation networks are social systems which allow the highest level of innovation and diffusion[42], using several internet platforms such as e-mails, social networks, chats and blogs to encourage communication and innovation between virtual teams that do not need to stay physically close. This type of networks usually has five features[43] that can be observed: associates are dispersed (geographically distant) and interdependent (they chase the same goal and cooperation is essential for reaching it); the chain of command is not simple because it is a decentralized and self-organized construct; the various parties commit to cooperate and spontaneously share information and, last but not least, mutual confidence is required in order to collaborate efficiently (dependence on trust).

The most important structures are small worlds and scale free networks.

Duncan Watt and Steve Strogatz[44] are the economists that first studied and introduced the concept of small worlds, described as networks extremely effective in letting knowledge, technology, innovations and other resources move freely, encouraging organizational learning and the creation of competitive advantage[45]. In these systems, the clustering coefficient, which is the value that specifies if nodes are likely to cluster together, is quite high, indicating that it is usual to locate cliques (sub-networks that are linked with almost any two nodes inside them). The path length, which represents the communication delay in the network[46], is low, making information flow easier and quicker. That is why two characteristics of small worlds are information reliability (the probability that new knowledge, technology or innovation is spread between all the partners is elevated) and high speed of diffusion.

Scale free networks were presented by Albert-László Barabási[47], and he studied how these structures present high densities due to some of the members, the hubs, which are more active and have more connections than the others, facilitating fast information diffusion

[42] "Swarm Creativity: Competitive Advantage through Collaborative Innovation Networks", Peter A. Gloor. Oxford University Press

[43] See note 42

[44] "Collective dynamics of 'small-world' networks", Duncan Watt and Steve Strogatz. Nature, Vol. 393, pp. 440-442

[45] "Where do small worlds come from?", Joel A. C. Baum, Andrew V. Shipilov and Tim J. Rowley. Industrial and Corporate Change, Vol. 12, No. 4, pp. 697–725

[46] "Average path length in random networks", Agata Fronczak, Piotr Fronczak and Janusz A. Hołyst. Physical Review E70

[47] "Emergence of scaling in random networks", Albert-László Barabási and Réka Albert. Science, Vol. 286, No. 5439, pp. 509–512

and general network improvements. In these networks, "*the probability that a new entrant will choose to link with an incumbent node is proportional to the number of links the chosen node already has*"[48]. The clustering coefficient drops as the node degree (the number of connections a node has) increases, suggesting that the associates with a lower number of relations are a part of very dense sub-networks and these sub-networks, in turn, are connected to each other through hubs[49].

In both these networks, with respect to a random one, knowledge, technology and innovation diffusion is facilitated because, due to the short average path length, they present only few discontinuities among different nodes and they both develop various hubs and strategically important relations, named isthmuses, between really dense and intensely linked clusters[50].

Even if both small world and scale free networks are optimal regarding the diffusion of information, the latter performs more efficiently, because the existence of strong hubs diminishes the resistance faced when transferring knowledge, technology and innovations[51].

These are the main concepts representing the foundations on which this essay is built upon.

2.2 RESEARCH QUESTIONS, DATABASE, AND SEARCH TERMS

The main objective of this paper is to present an overview of the present-day state of research on knowledge, technology and innovation diffusion in networks, trying to enlighten what could be the possible trends, causes and relations, and to answer the question of what are the main (in)consistencies between these different processes. Another question is which managerial techniques can firms apply in order to foster these diffusion practices. Also, it was evaluated if there were some major gaps in the literature.

The literature analyzed in this essay was found on the Journal Storage[52] (JSTOR) database, chosen because of its broad coverage of economics journals, more than 2'600, across 60

[48] "Network Dynamics and Field Evolution: The Growth of Interorganizational Collaboration in the Life Sciences", Walter W. Powell, Douglas R. White, Kenneth W. Koput and Jason Owen-Smith. American Journal of Sociology, Vol. 110, No 4, pp. 1132–1205

[49] "Evolution of networks", Sergey N. Dorogovtsev and José F. F. Mendes. Advances in Physics, Vol. 51, No. 4, pp. 1079–1187

[50] "Models of the small world", Mark E. J. Newman. Journal of Statistical Physics, Vol. 101, No. 3-4, pp. 819- 841

[51] See note 50

[52] https://www.jstor.org/?refreqid=search%3Ae3ef3c8bb912f37a6021a982faf6379a

disciplines, from business (207 journals) and management (35 journals) fields to development studies (22 journals).

In order to answer to the research questions scrupulously, three separate analyses have been conducted, one for each type of diffusion. The common key words used for the three researches are: “diffusion*”, “flow*”, “spreading”, “network*”, “collaborative network*”, “web*”, “system*”, “small world*”, “scale free network”, “spillover*”.

Then, accordingly, the words “knowledge”, “technology” and “innovation*” were introduced.

2.3 APPLYING PRACTICAL SCREENING CRITERIA

The time period set for all the three searches were the years spanning from 2000 to 2017, in order to gather quite recent results until the last completed solar year. The analysis was done only on papers written in English; books reviews, research reports and pamphlets were excluded. Furthermore, only certain disciplines, of economic nature, were taken into account, such as business, development studies, economics, management & organizational behavior and marketing & advertising, excluding not relevant fields such as archeology, astronomy, criminology, geology, law, music, religion, zoology, and many more.

The research for “knowledge” first showed 2’716 works of literature, which were reduced to 1’003 after setting the selected time frame and then again to 511 after the language and type of work filters. The end result, after the selected disciplines, was a set of 113 papers.

For “technology”, the analysis started with 2’210 papers, dropping to 781 for years 2000-2017 and consequently to 419 articles written in English. Lastly, within the selected fields of relevance there were 78 works.

Last but not least, the research for “innovation” at the beginning presented 2’158 works, then diminished to 785 for the chosen time period and to 468 using the language and item type screening criteria. At the end, 104 papers were found among the preferred subjects.

Some of the same papers showed up in more than one analysis, meaning that they appeared when searching knowledge, but also technology and innovation, and so, at the end, the total number of articles was 248. Each work has been screened in order to judge if its content was actually relevant for this study. This process resulted in approximately 154 articles considered of important significance and they were therefore included in the following review.

2.4 LIMITATIONS OF THE RESEARCH PROCESS

In order to achieve objectivity, the selection process of the papers to include has to be the most unbiased as possible[53]. To do so, the research was carried out in the most systematic and structured way as explained above (2.2 and 2.3).

As anyone can imagine, even with the best intentions, the research procedure cannot be without limitations.

One of these limits can be represented by the database choice. Nevertheless, JSTOR is a database of major importance and it should guarantee a comprehensive variety of papers. Also the language barrier is a limitation, because, by selecting only articles written in English, some other potential important documents could have been being excluded. However, economic and management papers are written prevalently in English, also when coming from authors of not Anglophone countries, so it is improbable that major answers and dramatic breakthroughs have been neglected due to language issues. Additionally, one last limit could be the selected time frame, since of course there are works of literature published before the year 2000, but a period of 17 years can still represent an extensive basis from which conclusions are being drawn.

2.5 OBJECTIVITY

An important characteristic of a literature review is validity: the degree to which the analysis methodology is able to precisely measure what it aimed to study[54]. This research used the validity guidelines given by Fink[55], since they have previously been followed in other systematic literature reviews. Moreover, choosing the Journal Storage database provides to ensure validity due to its widespread set of high-influence and peer-examined journals because analyzing peer-reviewed literature is considered to be have positive consequences for the research validity[56].

Another feature to obtain when writing a systematic literature review is reliability, meaning that it should be possible to replicate the research and obtain the same results by

[53] "Research methods for business students", Mark Saunders, Philip Lewis and Adrian Thornhill. 6th ed. Pearson Education

[54] See note 53

[55] "Conducting research literature reviews: From the internet to paper", Arlene Fink. 3rd ed. Sage Publications

[56] "The influence of management journals in the 1980s and 1990s", Philip M. Podsakoff, Scott B. MacKenzie, Daniel G. Bachrach and Nathan P. Podsakoff. Strategic Management Journal, Vol. 26, pp. 473–488

different people[57]. In this essay, reliability is ensured due to the practical screening criteria applied as discussed in the previous sections.

Last but not least, generalizability defines how much the research results can be shifted to other fields different to the original one, being useful for a larger group of people or situations[58]. Even if generalizability cannot be fully ensured, this essay (even if the research behind it was concentrated on the economic aspects of knowledge, technology and innovation) could be a possible starting point for other researches in different fields, since the basic concepts can be exported in other disciplines.

[57] "The influence of management journals in the 1980s and 1990s", Philip M. Podsakoff, Scott B. MacKenzie, Daniel G. Bachrach and Nathan P. Podsakoff. Strategic Management Journal, Vol. 26, pp. 473–488

[58] See note 57

CHAPTER 3
DESCRIPTIVE ANALYSIS

39 articles were issued by journals in the business field; 27 in journals related to development studies; 42 are from the economics discipline; 30 from the management & organizational behavior one and 16 papers were published in the marketing & advertising area. Generally, this widespread distribution of articles in different fields suggests that these themes are treated with the same importance in journals publishing a variety of topics.

The number of articles for knowledge increased more or less constantly over the years spanning from 2000 to 2017, denoting the fact that this topic is one of major interest for organizations because the number of firms that are collaborating together to boost productivity is following a raising path.

For the other two researches, technology and innovation diffusion, the situation was a little different. A lot of relevant articles was published in the '90s so it was a bit more difficult to gather all the useful information. This might have happened because many articles about knowledge contained valuable data regarding also technology and innovation, since these aspects are strongly connected.

Out of the 154 articles selected, the majority of them, 97 presented real life case studies, while the rest of them was purely theoretical. This literature review wants to sum up all the results of the individual studies, enhancing the academic parts also of the case studies encountered. To do so, the whole paper was analyzed: the introduction was important to give context on what paper deals about and the actual case study was useful to understand and interpret the ending results. Even if in this dissertation real life cases are not specifically mentioned, they were a substantial part for the research and collection of data and information.

CHAPTER 4
RESULTS

In this section, the main findings of the literature review are presented in an analytical way.

4.1 KNOWLEDGE DIFFUSION

Knowledge diffusion is the transferring or spreading of knowledge within one firm or across different organizations. This process aims to generate, seize or disseminate knowledge, guarantee its availability for possible upcoming users, develop competences, increase skills and resources and foster innovation by incorporating new knowledge from the external environment into the already existent own knowledge base[59].

Knowledge transfer is a challenging procedure in which firms assume simultaneously two roles: they are both imparter and learner. During the exchange, an organization will share its superior knowledge to the other partners and, in turn, it will acquire additional useful information that wasn't previously available. The party who is trading its knowledge with the others will not lose it once the transaction is done, and, for this reason, knowledge transfer is called a self-duplicating process[60].

Of course, the transfer is way more complicated than just a mere communication problem, and it cannot be resolved with a simple message, mail or conference[61]. Indeed, some knowledge basis is already present in the parties involved in the transaction and it will affect their ability to receive and absorb the new knowledge. Furthermore, a lot of the knowledge used from organizations is tacit, difficult to codify and/or to transmit. Moreover, especially when dealing with international transfers, the cultures and languages of the firms are often very different, slowing the overall process[62]. This last cultural aspect is extremely important also during mergers and acquisitions, because when two firms fuse together, they will inevitably exchange knowledge and information, and they will have to

[59] "From knowledge transfer to knowledge sharing? Towards better links between research, policy and practice", Brian Head. Bridging the 'Know-Do' Gap

[60] "Knowledge Diffusion in Complex Networks", Cyrille Bertelle, Yichao Zhang and Jihong Guan. Conference Paper

[61] "Knowledge Transfer: A Basis for Competitive Advantage in Firms", Linda Argote and Paul Ingram. Organizational Behavior and Human Decision Processes, Vol. 82, No. 1, pp. 150–169

[62] "The importance of language in international knowledge transfer", Lawrence Welch and Denice E. Welch. Management International Review, Vol. 48, No. 3

understand how to put them in good use in the new environment[63]. Firms will trade managerial know-how, market experience, administrative skills, corporate culture, and additional types of intellectual capital that are used to develop the organizations' proficiency and to boost their competitiveness[64].

Unsuccessful knowledge diffusion has a strong negative effect on the firms that engaged on the exchange, depleting resources and wasting time without bringing the benefits of the creation of added value for the parties[65]. For this reason, it is very important to understand which variables can affect the knowledge diffusion and which are the managerial techniques that can be used to implement it.

It can be difficult to assess whether the transfer process has been successful or not. The diffusion is detected through alterations in the knowledge base or performance of the firms which receive new information[66]. In order to measure these changes correctly, it is necessary to control also other factors that can influence the performance other than the actual knowledge transfer, and this task can be very challenging. Also measuring the changes due to the diffusion can be hard: some parts of the knowledge can be tacit and so difficult to evaluate[67]. Another struggle to be faced is that knowledge is present in many different sources: individual employees, job positions, specific activities and the overall organizational culture. While the majority of knowledge measuring techniques, such as surveys and verbal protocols, measures changes on an individual level, to carry out a meticulous knowledge transfer assessment, changes in all these aspects should be evaluated[68].

4.1.1 VARIABLES AFFECTING KNOWLEDGE DIFFUSION

Knowledge diffusion is strongly affected by some variables that influence how the network in which the transfer is taking place works and performs[69].

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[63] "Knowledge transfer across dissimilar cultures", Wai Fong Boh, T. T. Nguyen and Yun Xu. Journal of Knowledge Management, Vol. 17, No. 1

[64] "Acquired, transferred and integrated knowledge: a study of M&A knowledge performance", Rachel Calipha, David M. Brock, Ahron Rosenfeld and Dov Dvir. Journal of Strategy and Management

[65] "How Knowledge Transfer Impacts Performance: A Multilevel Model of Benefits and Liabilities", Sheen S. Levine and Michael J. Prietula. Organization Science, Vol. 23, No. 6 pp. 1748-1766

[66] "Measuring Knowledge Management Performance", Rifat O. Shannak. European Journal of Scientific Research, Vol. 35, No. 2, pp. 242-253

[67] "Measuring Knowledge", Matošková Jana. Journal of Competitiveness, Vol. 8, No. 4, pp. 5-29

[68] "Knowledge management performance evaluation: a decade review from 1995 to 2004", Mu-Yen Chen and An-Pin Chen. Journal of Knowledge Management, Vol. 34, No. 2

[69] "Collaborative innovation network and knowledge transfer performance: A fsQCA approach", Xuemei Xie, Liangxiu Fang and Saixing Zeng. Journal of Business Research, Vol. 69, pp. 5210–5215

A bigger network size, which refers to the number of associates, which can be organizations, universities, research societies and the government, helps knowledge to be transferred more easily. The various parties, indeed, have the opportunity to access to a high amount of different external information, data, and viewpoints[70]. This is not the only advantage, because the members of a large size network can also share resources, making them able to cut costs, such as transaction ones, and enabling the development of economies of scale[71]. Another variable affecting knowledge transfer is the network tie-strength: the different kinds of connections and linkages that are present, their level of reciprocal trust and their duration[72]. Also in this case, knowledge diffusion grows together with the level of tie-strength, because firms collaborating with trustable partners can take advantage from a depletion of risk and uncertainty of transaction, making the sharing of information easier and faster. Trust is certainly a must when creating partnerships with the scope of transferring knowledge in order to establish motivation especially when the knowledge to be transferred is of tacit nature and it accumulates over time being history-dependent. Another advantage, is that partners may be more willing to help each other to understand the received new knowledge[73]. Other tie characteristics involve the level of commitment between partners and their cultural distance. The first one deals with the actual willingness to collaborate in a fair way, building and preserving a healthy long-term relationship[74]; the latter one explains how deep the differences embedded in organizations' values, cultures, practices, activities and environments are: when they are elevated knowledge transfer results more difficult[75]. Knowledge diffusion is also facilitated by a higher heterogeneity of the network, meaning that when the differences in the members' dimensions and in their competences are high, the transfer is more likely[76]. This happens because firms working in a more heterogeneous system have greater opportunities to enter in contact, understand and learn new and different knowledge from

[70] "Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology", Joel A. C. Baum, Tony Calabrese and Brian S. Silverman. Strategic Management Journal, Vol. 21, No. 3, pp. 267–294
[71] "Collaboration networks, structural holes, and innovation: A longitudinal study", Gautam Ahuja. Administrative Science Quarterly, Vol. 45, No. 3, pp. 425–455
[72] "The emergence of cooperation in tie strength models", Xu Bo and Yue Yunpeng. Chaos Solitons & Fractals, Vol. 91
[73] "The Impact of Trust on Knowledge Transfer in International Business Systems", Yannis Hajidimitriou, Nikolaos Sklavounos and Konstantinos Panayiotis Rotsios. Economic Sciences, Vol. 11, No. 2
[74] See note 73
[75] "Collaborative innovation network and knowledge transfer performance: A fsQCA approach", Xuemei Xie, Liangxiu Fang and Saixing Zeng. Journal of Business Research, Vol. 69, pp. 5210–5215
[76] "Knowledge Transfer Capacity and Its Implications for the Theory of the Multinational Corporation", Xavier Martin and R. Salomon. Journal of International Business Studies, Vol. 34, No. 4, pp. 356-373

the neighboring environment[77]. In these networks, acquiring complementary resources is less challenging. Last but not least, also the partners' positions within the network (network centrality) affect the knowledge transfer across them. A member which is located in the middle of the system is privileged, since it usually has a high number of relationships and links, which give him the maximum knowledge transfer ability. It can also supervise the information flow more easily and gain access to critical information and resources putting into use less effort[78].

As stated before, knowledge is pictured as a cumulative process, meaning that even in the case that it is freely available, it depends on the stock of already existent knowledge base of the recipient and on his absorptive capacity if it will be useful or not[79].

Knowledge diffusion is easier when firms have a precedent experience collaborating, because in this way they already know each other's cultures, values and norms and the transaction will result smoother and less risky, strengthening the relationship and making it long-term[80].

Another variable that affects knowledge diffusion is the way in which interactions are carried out. Effective communication between associates is extremely significant in order to maintain good relations and obtain successful transactions. Doing so, the goals, guidelines and responsibilities will be clearly understood by each member which will gladly share their outcomes and experiences fostering organizational learning[81].

Also the organization culture plays an important role: it has to make individuals feel comfortable to share their knowledge and help them during this process. Culture can affect various parts of the individuals' behaviors when dealing with knowledge foundation, transfer, and utilization in different ways[82]. Firstly, it creates the attitude toward knowledge sharing in general, making it feel important and useful for organizational success. Then, it states who are the employees which have to engage in knowledge transfer

[77] "Knowledge and Learning in Online Networks in Development: A Social-Capital Perspective", Sarah Cummings, Richard Heeks and Marleen Huysman. Development in Practice, Vol. 16, No. 6, pp. 570-586

[78] "How Central Is Too Central? Organizing Interorganizational Collaboration Networks for Breakthrough Innovation", John Qi Dong, Killian J. McCarthy and Wilfred W. M. E. Schoenmakers. The Journal of Product Innovation Management, Vol 34, No 4, pp. 526-542

[79] "Strategic Management Knowledge Transfer, Absorptive Capacity and the Attainment of Strategic Objective of MNCs' Chinese Subsidiaries", Ling Hu. Modern Economy, Vol. 3, pp. 424-428

[80] "The emergence of cooperation in tie strength models", Xu Bo and Yue Yunpeng. Chaos Solitons & Fractals, Vol. 91

[81] "Collaborative innovation network and knowledge transfer performance: A fsQCA approach", Xuemei Xie, Liangxiu Fang and Saixing Zeng. Journal of Business Research, Vol. 69, pp. 5210–5215

[82] "Knowledge transfer across dissimilar cultures", Wai Fong Boh, T. T. Nguyen and Yun Xu. Journal of Knowledge Management, Vol. 17, No. 1

and what they have to share. Lastly, culture produces the social environment that regulates in which ways knowledge transfer is being carried out[83].

Motivation encouraging practices influence the knowledge transaction and they can have an extrinsic or intrinsic nature. The first type is used to satisfy indirect needs, for example the monetary rewards which please a financial need. The intrinsic motivation techniques foster the commitment to the work making it more likeable and interesting to execute: *"if you want people motivated to do a good job, give them a good job to do"*[84]. These motivational practices should be created for succeed in the long term and they should be correlated with all the others arrangements for appraisal and compensation.

4.1.2 HOW TO MANAGE KNOWLEDGE DIFFUSION

Some of the variables affecting knowledge diffusion can be humanly controlled and managed, such as the connection between the organizations, the management aid-structures that have been established and the firms' cultures and absorptive capacities[85]. Knowledge diffusion, and the consequential organizational learning, are really fostered when the organizations deeply comprehend their associates' culture and also the overall environment in which they are operating. In the case that these factors are too unalike, severe problems may rise and they might be too challenging to overcome[86]. In order to better appreciate one another and also understand at the same level the actual knowledge that is being exchanged, the societies involved should develop a common organizational language, which will foster organizational learning by enabling a more effective communication and interpretation[87].

To regulate the different parties' actions, it is important to create a set of rules, standards, morals and values that stay at the base of the transaction and, having a shared identity makes it easier to do so[88]. Cooperating with more partners at the same time, such as in

[83] "Knowledge Transfer: A Basis for Competitive Advantage in Firms", Linda Argote and Paul Ingram. Organizational Behavior and Human Decision Processes, Vol. 82, No. 1, pp. 150–169

[84] "Human Resources Management and Knowledge Creation", Margit Osterloh. Organizational science, Vol. 3, No. 1, pp. 158-176

[85] "Research on competition diffusion of the multiple-advanced manufacturing mode in a cluster environment", C. G. Xue, J. J. Liu and H. W. Cao. The Journal of the Operational Research Society, Vol. 64, No. 6, pp. 864-872

[86] "Social Movement Organizational Collaboration: Networks of Learning and the Diffusion of Protest Tactics, 1960–1995", Dan J. Wang and Sarah A. Soule. American Journal of Sociology, Vol. 117, No. 6, pp. 1674-1722

[87] "Knowledge transfer in multinational corporations: Productive and counterproductive effects of language-sensitive recruitment", Vesa Peltokorpi and Eero Vaara. Journal of International Business Studies, Vol. 45, No. 5, pp. 600-622

[88] "The Emergence of a Shared Identity: An Agent-Based Computer Simulation of Idea Diffusion", David Rousseau and A. Maurits van der Veen. The Journal of Conflict Resolution, Vol. 49, No. 5, pp. 686-712

collaborative innovation networks, is beneficial for the advancement of a shared identity and for the improvement of organizational receptiveness, since the firms gain valuable experience facing related comparable circumstances recurrently[89].

The choice of the partner to start the transfer with can be a real challenge: usually, the more alike the organizational cultures are, the smoother the exchange will be, but in the case that they are too similar, the obtained results can be the opposite from the desired ones[90]. Indeed, it can actually be a restraint for innovation generation, because if there are no original incentives, new knowledge will not flourish and the innovation thinking of the firms will drop.

Generally, while organizations engage in partnerships, they start to learn innovative methods for accomplishing activities through mutual adaptations. Creative chaos fuels the communication between organizational units and the surrounding environment, providing challenging goals and breaking routines. This is extremely useful because, when transmitting knowledge from an organization to another, it may be needed to adjust it to each other's performances and behaviors and to generate reciprocal trust and transparency[91].

Trust is extremely important because transactions can lead to opportunistic behaviors, especially when the different parties have asymmetric powers, meaning that one side has more useful information than the other. These opportunistic behaviors are more encouraged if the value the knowledge to be exchanged raises. It is essential for the firms involved to trust each other in order to promote transparency which entails free communication and close interaction[92]. For these reasons, trustworthiness and a committed environment are crucial components that have to be present in order to begin the knowledge exchange. The trust level of a relationship is dependent on the amount of uncertainty when dealing with future events that cannot be organized or predicted, and to the level of ambiguity about the partner's responses to these episodes[93]. It is a difficult task to decide which level of trust has to be granted, because it should be very high when the

[89] "Social Movement Organizational Collaboration: Networks of Learning and the Diffusion of Protest Tactics, 1960–1995", Dan J. Wang and Sarah A. Soule. American Journal of Sociology, Vol. 117, No. 6, pp. 1674-1722

[90] "Network Structure and Innovation Ambiguity Effects on Diffusion in Dynamic Organizational Fields", Deborah E. Gibbons. The Academy of Management Journal, Vol. 47, No. 6, pp. 938-951

[91] "Transfer in Context: Replication and Adaptation in Knowledge Transfer Relationships", Charles Williams. Strategic Management Journal, Vol. 28, No. 9, pp. 867-889

[92] "Motivation, Knowledge Transfer, and Organizational Forms", Margit Osterloh and Bruno S. Frey. Organization Science, Vol. 11, No. 5, pp. 538-550

[93] "The Strength of Weak Ties You Can Trust: The Mediating Role of Trust in Effective Knowledge Transfer", Daniel Z. Levin, Rob Cross. Management Science, Vol. 50, No. 11, pp. 1477-1490

transaction is complex, but, at the same time, the risk and costs associated with trusting raise as well. Correspondingly, when the knowledge is tacit, there is a high demand for personal interaction, communication and guarantee about the partner's dependability[94]. Mutual faith is a powerful tool in order to drop the level of uncertainty and the transaction costs, because, if the partners really trust each other, less negotiations have to be carried out and the necessary level of management support will be reduced[95]. To conclude, knowledge transfer is not a one-way relationship: one firm's capacity to transmit valuable information is closely associated to its colleague's competence to institute a fair and unbiased environment in which all parties can act transparently[96]. For this reason, the firms' ability to create and assure relationship trust and commitment is a vital precondition for the achievement of the established goal.

However, it is unlikely that firms start transactions only relying on promises of just behavior and verbal interaction: usually, an improved reliable base, such as contractual stipulations, is required. Classically, contracts are used to reduce the organizations' tendency to engage in opportunistic behaviors, but the main issue is that they work well only when all the present and future conditions of the relationship are known when the contract is signed[97]. Unfortunately, especially in the case of a knowledge transaction, it is not possible that all the partied know for certain all the thinkable variables and for this reason it is difficult to stipulate meticulous contracts. Indeed, a major problem is that the firm which is acquiring the new knowledge cannot know its real value without essentially knowing it first[98].

A successful diffusion of knowledge is not only influenced by the organizational culture, but also on the managerial structures that are being used. For example, an important aid system is represented by the reward scheme[99]. Employees has to be rightfully rewarded, through salary increases, promotions, and so on, in order for them to engage in knowledge

[94] "Managing Tacit and Explicit Knowledge Transfer in IJVs: The Role of Relational Embeddedness and the Impact on Performance", Charles Dhanaraj, Marjorie A. Lyles, H. Kevin Steensma and Laszlo Tihanyi. Journal of International Business Studies, Vol. 35, No. 5, pp. 428-442

[95] "Partner misbehaviour in strategic alliances", T. K. Das and Noushi Rahman. Journal of General Management, Vol. 27, No. 1, pp. 43-70

[96] "Managing Knowledge in Organizations: An Integrative Framework and Review of Emerging Themes", Linda Argote, Bill McEvily and Ray Reagans. Management Science, Vol. 49, No. 4, pp. 571-582

[97] "Partner misbehaviour in strategic alliances", T. K. Das and Noushi Rahman. Journal of General Management, Vol. 27, No. 1, pp. 43-70

[98] "The Alignment of Contract Terms for Knowledge-Creating and Knowledge-Appropriating Relationship Portfolios", Jongkuk Lee. Journal of Marketing, Vol. 75, No. 4, pp. 110-127

[99] "Overcoming Cultural Barriers to Sharing Knowledge", Richard McDermott and Carla O'Dell. Journal of Knowledge Management, Vol. 5, No. 1, pp. 76-85

sharing. Moreover, firms need to pay attention to the needs of the single employees, because reward systems should not be standardized but adapted and customized to the different cases and positions[100].

Two very different approaches to knowledge management have developed over the years: the centralized one and its opposite.

Following the centralized approach, knowledge is refined by some appointed employees who will remove some features keeping only the most useful ones and creating in this way a pure concept of knowledge that everyone has to follow and put into use without any possible chance for adaptation. This model can be suitable for employees working in organizational units who have to share the same ways of doing things supported by a common point of view[101]. Of course it is very challenging to implement this model because it is hard that the same schema applies well for every situation and it may be perceived as constraining from the workers.

It is very rare that knowledge is standardized, but instead it should be possible to modify and adapt it to different situations. This is what a decentralized management system does: each unit or individual can adjust the knowledge to its local requirements in an autonomous way and it can also transfer it without having to follow an obligatory path[102]. This approach is extremely useful especially in firms which are composed by a lot of different units which have very diverse tasks and activities.

A decentralized management tool used to facilitate knowledge transfer within networks is information and communication technology (ICT), especially when the involved organizations are not geographically close to each other[103]. ICT expresses the important function of unified communications and the incorporation of telecommunications, processors, business software, middleware, cloud storage, and audio-visual techniques, which allow organizations to easily approach, gather, spread, and handle information.

[100] "Tacit knowledge sharing in organizational knowledge dynamics", Constantin Brătianu and Ivona Orzea. Journal of Knowledge Management Practice, Vol. 11, No. 2

[101] "Research on knowledge transfer in organizations: a morphology", J. Ajith Kumar and L. S. Ganesh. Journal of Knowledge Management, Vol. 13, No. 4, pp. 161-174

[102] "The Effects of the Degree of Decentralization and Networks on Knowledge Sharing in MNCs Based on 6 Empirical Cases", Helmut Kasper and Jürgen Mühlbacher. Journal of Knowledge Management, Vol. 3, No. 2, pp. 64-82

[103] "Knowledge Transfer in International Acquisitions" Henrik Bresman, Julian Birkinshaw and Robert Nobel. Journal of International Business Studies, Vol. 41, No. 1, pp. 5-20

With ICT firms are able to make the knowledge created by one party more reachable and ready to be utilized by others[104].

ICT is prevalently used in small world networks. These systems show an overall decentralized structure, but they have a certain degree of centralization due to the presence local clusters. This typical feature guarantees consistent accessibility, and reliable committed relationships among groups enable easy interaction within the system[105]. In this category of networks, ICT is able to efficiently manage and aid knowledge transfer because it develops connections between distinct organizations, and these interactions promote collaboration among all the members of the network. Moreover, in small world networks, the elevated level of local clustering and its characteristic high number of short paths between associates benefit the utilization of ICT, making routine announcements easier and speeding up their dispersion[106]. Even if knowledge management structures using ICT implement diverse machineries, equipment and practices, they share the same main goals: supporting informal communities, linking employees who are far from each other via corporate-wide Intranet and making the organization cultures easier to understand and accept[107]. These systems usually share a set of tools which present three main elements: cooperative settings in order to assist the informal communities and foster knowledge creation, Knowledge Bases to gather knowledge on the basis of a shared corporate conceptual system and an Enterprise Knowledge Portal, an easy-to-access interface that lets employee produce and transfer corporate knowledge and it creates one singular place where members of diverse units can find and share useful information[108].

In networks which present a decentralized structure, it would be appropriate to institute a correspondingly dispersed ICT system and especially a further decentralized knowledge management technique. Structuring the aid-management system in this manner would be the ideal choice because it would support when dealing with an inter-organizational environment, such as in a process of knowledge diffusion that frequently exceeds the

[104] "A Relational View of Information Seeking and Learning in Social Networks", Stephen P. Borgatti and Rob Cross. Management Science, Vol. 49, No. 4, pp. 432-445

[105] "The navigability of strong ties: Small worlds, tie strength, and network topology", Douglas R. White and Michael Houseman. Complexity, Vol. 8, No. 1, pp. 82–86

[106] "Broken Ties: The Impact of Organizational Restructuring on the Stability of Information-Processing Networks", Dowan Kwon, Wonseok Oh and Sangyong Jeon. Journal of Management Information Systems, Vol. 21, No. 1, pp. 201-231

[107] "New ICTs for Knowledge Management in Organizations", Pedro Soto-Acosta and Juan Gabriel Cegarra. Journal of Knowledge Management, Vol. 20, No. 3, pp. 417-422

[108] "Enterprise Knowledge Management Modeling and Distributed Knowledge Management Systems", Joseph Firestone. Journal of Knowledge Management, Vol. 13, No. 2, pp. 55-67

organizations' boundaries[109]. The main decentralized knowledge management technique is a peer-to-peer structure[110]. This system explains how the decisions of an individual, or of an entire organization, is influenced by the choices made by others coming from the same network and it can be applied in different manners. The most simple and fastest form is through word of mouth, meaning the exchange of opinions, beliefs and views among partners by face-to-face interactions. Another method that delivers the same peer purpose is through social learning, when individuals or firms emulate the behavior of others when they consider it is as the correct thing to do and particularly when the ones who are being copied are perceived as opinion leaders. Last but not least, network externalities are thought to have a similar peer effect, observing the consequences that the doings of someone have on the other associates of the network[111].

Establishing a decentralized knowledge management aid structure facilitates a large number of influential clusters of strongly associated organizations to make use of the peer-to-peer effect in an efficient way[112]. This peer system is not only accessible to strong ties: weak and intermediate links might use it less often, but it can deliver some benefits also for them, because the costs associated with the creation of a decentralized knowledge management system are a way less than the ones bore when establishing to a centralized structure[113]. Furthermore, peer-to-peer techniques typically decrease the difficulties also when exchanging knowledge at an individual level since the employees will disclose the gained benefits in a more cooperatively way[114].

4.2 TECHNOLOGY DIFFUSION

Technology transfer is a complicated, challenging, and time consuming procedure both when it occurs across different firms and also when it happens among singular unit functions within a single organization. It is strongly connected to and it might be treated

[109] "Centralized Versus Peer-to-Peer Knowledge Management Systems", Ronald Maier and Thomas Haedrich. Knowledge and Process Management, Vol. 13, No. 1, pp. 47-61
[110] "Performance Implications of Peer Monitoring", Misty L. Loughry and Henry L. Tosi. Organization Science, Vol. 19, No. 6, pp. 876-890
[111] "Multiple peer effects in the diffusion of innovations on social networks: A simulation study", Hang Xiong, Wang Puqing, and Georgiy V. Bobashev. Journal of Innovation and Entrepreneurship, Vol. 7, No. 2
[112] "Behavioral Externalities in Decentralized Organizations", Timothy W. Ruefli. Management Science, Vol. 17, No. 10, pp. 649-657
[113] "Distribution of Knowledge, Group Network Structure, and Group Performance", Diane L. Rulke and Joseph Galaskiewicz. Management Science, Vol. 46, No. 5, pp. 612-625
[114] "Model of Acceptance with Peer Support: A Social Network Perspective to Understand Employees' System Use", Tracy Ann Sykes, Viswanath Venkatesh and Sanjay Gosain. MIS Quarterly, Vol. 33, No. 2, pp. 371-393

as a subcategory of knowledge transfer and it can be viewed as the application of methodical doctrines to resolve concrete issues[115].

This process is defined as the transfer of know-how and its subsequent adaptation to local environments, through a successful distribution and absorption that can take place both within one country and across different ones[116].

When thinking about the desired results, there are two categories of technology transfer: one which involves the fabrication of new products and one which causes a more efficient manufacturing of already existing products[117]. When dealing with the transaction of technology involved in production procedures, it is not only necessary that the firms transfer technical know-how through machineries, blueprints, equipment and other materials, but also that they exchange knowledge of high competence engineering and technical employees[118].

The knowledge which is being transacted will make the receiver company able to produce a certain product or to offer a particular service. Differently from the simple selling of machinery, technology diffusion necessitates a continued and stable relationship between the two involved organizations to allow the receiver firm to manufacture the product with the chosen level of quality benchmarks and cost efficiency[119]. The final goal of technology transfer is not only to spread the mechanical know-how required to manufacture the product, but also the competence to control, develop and consequently produce independently the technology fundamental for the whole production system. Technology transfer is thus a learning process by which technological know-how is constantly gathered into the firms' knowledge bases and improves the production activities[120]. A technological diffusion with positive outcomes will ultimately allow a greater and richer accumulation of knowledge and competence to understand, learn and absorb technology into the production system.

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[115] "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics, Vol. 104, No. 4, pp. 495-513

[116] See note 115

[117] "Technology Transfer through Imports", Ram C. Acharya and Wolfgang Keller. The Canadian Journal of Economics / Revue canadienne d'Economique, Vol. 42, No. 4, pp. 1411-1448

[118] "Component-Based Technology Transfer in the Presence of Potential Imitators", Jiong Sun, Laurens G. Debo, Sunder Kekre and Jinhong Xie, Management Science, Vol. 56, No. 3, pp. 536-552

[119] "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics, Vol. 104, No. 4, pp. 495-513

[120] "Implementing New Manufacturing Technology: The Related Effects of Technology Characteristics and User Learning Activities", Lynda Aiman-Smith and Stephen G. Green. The Academy of Management Journal, Vol. 45, No. 2, pp. 421-430

The technology transfer process, allowing the exchange of physical machinery and tools, also entails the simultaneous diffusion of the cultural skills embedded in this equipment[121]. It occurs across different dimensions: within a single firm, from big-sized organizations to minor ones, from governments to corporations, between universities, from academic departments to firms, within and across national borders and both publicly disclosed and secretly[122]. When dealing with developing economies, the transfer of technology has to deliver three main resolutions: the investment of new production facilities which will develop new practices, the development of the already existing procedures and the creation of new knowledge[123].

There are two types of technology transfer: vertical and horizontal[124]. The first one deals with the movement of technology from basic research centers to applied research, development departments and subsequently to production: it is a managerial procedure in order to transfer technology from one stage of its life cycle to another. It usually concerns the transmission of a technology which is still not pre-commercialized or generic from its creator to a firm which can decide to either exploit it during the manufacturing of a new product or disclose it to the public and make its use accessible for the concrete resolution of a social issue (ex. nanotechnology) [125]. Horizontal technology transfer is the exchange of an already commercialized and typically mature technology from a company in a particular socio-economic environment to a firm in a different socio-economic setting, by means of intra-organization, cross-industry, or international networks (ex. technology licensing)[126]. Even if usually these kind of transfers involve a mature technology, it is possible to horizontally diffuse technology at any stage of its life cycle.

Organizations can approach technology transfer with three ranks of involvement. The first basic one is technology development which can happen passively due to the collaboration in researches. When involvement increases, there is technology acceptance, by which firms make sure that the desired technology is available to its potential receptors and that

[121] "Cultural differences, convergence, and crossvergence as explanations of knowledge transfer in international acquisitions", Riikka M. Sarala and Eero Vaara. Journal of International Business Studies, Vol. 41, No. 8, pp. 1365-1390

[122] See note 121

[123] "International technology transfer to developing countries: when is it immiserizing?", Dominique Redor and Mohamed Saadi. Revue d'économie politique, Vol. 121, No. 3, pp. 409-433

[124] "Differentiating between types of technology transfer: the Technology Building", Harm-Jan Steenhuis and Sirp J. de Boer. International Journal of Technology Transfer and Commercialisation, Vol. 1, No. 1 & 2

[125] "Vertical Technology Transfer via International Outsourcing", Kamal Saggi and Howard Pack. Journal of Development Economics, Vol. 65, No. 2, pp. 389-415

[126] "Patent Licensing, Technology Transfer, and Innovation", Mark Lemley and Robin Feldman. American Economic Review, Vol. 106, No. 5, pp. 188-192

these last ones are able to utilize it. The maximum level of commitment is technology application, when firms are fully able to exploit the transferred technology[127].

To understand its process of acceptance, adaptation and adoption, the technology adoption lifecycle is used, which divides the potential adopters in different groups characterized by various features. The fist cluster of people adopting a technology is composed by the innovators, promptly followed by the early adopters. Later on in the product lifecycle, technology will be implemented by laggards, which may use it only when it represents the last option remaining to carry out a particular activity[128].

4.2.1 VARIABLES AFFECTING TECHNOLOGY DIFFUSION

The variable affecting the technology transfer could be many, but in this section the main four are going to be explained principally from an organizational and communicational perception.

The first one is communication interactivity, which denotes a mutual trade of ideas, or, in this case, technology, in which all the contributors are operative and they can influence each other through this dynamic, two-way stream of information[129]. This variable is strongly connected to an individual's (or transfer channel) information-carrying ability which measures the level of task-pertinent data that this agent is able to effectively and correctly transfer[130]. One weak type of these transfer links is passive, such in the case as mass media channels, that can reach a great number of receivers and are not limited by geographical locations nor time constraints[131]. Their audience can be incremented using a small amount of costs. Among this category there are research papers, journal articles, video and audio tapes. One drawback is that there are scarce feedback returns, meaning that even if the message can reach a lot of people at the same time and at low cost, the sender does not know if the message is actually understood and if the receiver puts into use the technology. On the other hand, another type of transfer links is active: interactive technology diffusion channels are described as person-to-person media-rich

[127] "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics, Vol. 104, No. 4, pp. 495-513

[128] "Diffusion of Innovation and the Technology Adoption Curve: Where Are We? The Zimbabwean Experience", Cinderella Dube and Victor Gumbo. Business and Management Studies, Vol. 3, No. 3

[129] "The Technology Transfer Systems in Communities, Product Versus Processes", Enrique Villacis, Maria Lorena Rodriguez and Cynthia Ayarza. Procedia Engineering, Vol. 145, pp. 364-371

[130] "Information behavior in the technology transfer process", Grant Allard and Suzie Allard. Journal of Development Economics, Vol. 7, No. 1, pp. 125-156

[131] "Social structure and technology spillovers from foreign to domestic firms", Alex Eapen. Journal of International Business Studies. Vol. 43, No. 3, pp. 244-263

connections[132]. These structures, such as collaborative research and demonstrations, create a network of involvement between technology inventors and its consumers by boosting interactive communication with constant and accurate feedback[133]. Technology transfer, and its effective use, grows in a directly proportional way with respect to communication interaction between the parties involved in the transaction.

The second variable deals with equivocality, denoting the extent of concreteness of the technology that has to be exchanged[134]. Technology which present a highly level of equivocality is more complex to comprehend, hard to validate, and more unclear on what its possible functions could be.

The third variable is geographical and cultural distance[135]. Even if the first type of distance was considered a problem a few year ago, nowadays the situation is changed: thanks to ICT and especially since the advent of the Internet, organizations are able to share knowledge and technology even when they are dispersed in far geographical locations[136]. The variable that most affects the transfer is the cultural distance. Organizations can have big discrepancies regarding the environments in which they are operating in, values and morals, resource allocation, activities and how they are carrying them out, routines and practices, the preferred markets, organizational structure and all of these characteristics have to deal with the firms' cultural background[137]. These differences present substantial managerial challenges in order to engage in a successful technology transfer, adaptation and absorption. The geographical location does not directly influence the cultural proximity: technology creators can be physically far away from the consumers but culturally similar to them and this facilitates the transfer[138]. The more the cultures and values of the different parties are understood, the easier the technology transfer will be and the more likely its application will succeed.

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[132] "Social structure and technology spillovers from foreign to domestic firms", Alex Eapen. Journal of International Business Studies, Vol. 43, No. 3, pp. 244-263

[133] "Computer-based feedback and goal intervention: learning effects", Alfred Valdez. Educational Technology Research and Development, Vol. 60, No. 5, pp. 769-784

[134] "Know-How Transfer: The Role of Social, Economic/Competitive, and Firm Boundary Factors", Ariff Kachra and Roderick E. White. Strategic Management Journal, Vol. 29, No. 4, pp. 425-445

[135] "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics, Vol. 104, No. 4, pp. 495-513

[136] "Knowledge Transfer in International Acquisitions" Henrik Bresman, Julian Birkinshaw and Robert Nobel. Journal of International Business Studies, Vol. 41, No. 1, pp. 5-20

[137] "Cultural differences, convergence, and crossvergence as explanations of knowledge transfer in international acquisitions", Riikka M. Sarala and Eero Vaara. Journal of International Business Studies, Vol. 41, No. 8, pp. 1365-1390

[138] "Technology Transfer through Imports", Ram C. Acharya and Wolfgang Keller. The Canadian Journal of Economics / Revue canadienne d'Economique, Vol. 42, No. 4, pp. 1411-1448

At last, the fourth variable is motivation: it deals with the possible incentives that firms have to adapt new technology and the potential social recognition that will be generated[139]. Both creators and users of technology can be positive or hostile regarding technology transfer, asking themselves what they are going to gain after this time consuming practice and if it is worth it to even initiate it. Technology diffusion is more likely to have a positive outcome when the end situation is beneficial for all the parties involved[140]. Motivation can vary depending on the actual importance of the technology to be spread, on incentives that encourage the transfer, or simply on the personnel that will be responsible for this practice[141]. Usually, when incentives for transferring are high, motivation will raise as well, and rewards and social recognition will boost technology diffusion.

All these variables exert their influence at the same time and their combined effects can be summarized by putting them into a grid that forms four quadrants called "the technology transfer grid", as shown in Figure 1.

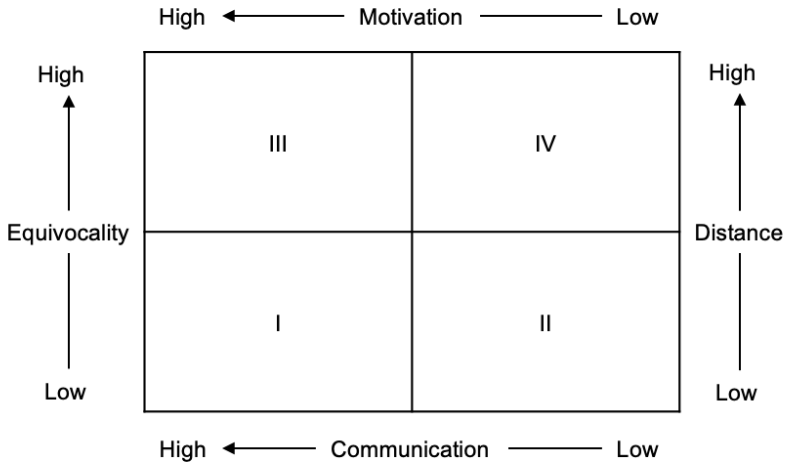

Figure 1: "the technology transfer grid"[142]

[139] "Motivation, Knowledge Transfer, and Organizational Forms", Margit Osterloh and Bruno S. Frey. Organization Science, Vol. 11, No. 5, pp. 538-550

[140] "Defining the Concepts of Technology and Technology Transfer: A Literature Analysis", Sazali Abdul Wahab and Suzana Idayu Wati Osman. International Business Research, Vol. 5, No. 1, pp. 61-71

[141] See note 141

[142] Adapted from: "Technology transfer in the IT industry: A Korean perspective", Tae Kyung Sung. Technological Forecasting and Social Change, Vol. 76, No. 5, pp. 700-708

The first cell presents the best case scenario for engaging in technology transfer. Communication is highly encouraged and interactive, motivation levels are high due to rewards and incentives, firms are culturally close and technology is easy to understand and put into practice[143].

Technology transfer and application is least common to happen in cell IV. An environment characterized by low communication and motivation, and high distance and equivocality is really hostile for a successful transfer because senders and receivers are not rightfully connected since they are culturally distant, there are no incentives to engage in interaction and technology itself is unclear. Technology can still be industrialized but it will not be transferred[144].

The other two cells present middle ground situations where two components are positive and two are negative influences and transfer success depends on the single case scenarios. Cell II presents a situation in which low communication and motivation are combined with low equivocality and cultural distance. The interaction among various members is usually passive and indirect, characterized also by little motivation for initiating the transfer process. Even if technology is easy to understand and firms are not limited from cultural barriers, it is not always sufficient to master a successful transaction[145].

In cell number three, communication and motivation are high, being positive influences for transfer, but also the levels of equivocality and cultural distance are high creating a counteracting effect. While there may be interactive relationships combined with right incentives, technologies are difficult to comprehend and firms are culturally distant[146].

Moreover, technology transfer is influenced by local technological progress: even if new technology is freely available and ready to be used, only those businesses that are currently using the same or a compatible technology can take advantage of it[147].

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[143] "Technology transfer in the IT industry: A Korean perspective", Tae Kyung Sung. Technological Forecasting and Social Change, Vol. 76, No. 5, pp. 700-708

[144] "Determining the Success or Failure of International Technology Transfer", E.L.C. van Egmond-de Wilde de Ligny and M. M. Kumaraswamy. Strategic Management Journal, Vol. 23, No. 3

[145] "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics. Vol. 104, No. 4, pp. 495-513

[146] "Cultural differences, convergence, and crossvergence as explanations of knowledge transfer in international acquisitions", Riikka M. Sarala and Eero Vaara. Journal of International Business Studies, Vol. 41, No. 8, pp. 1365-1390

[147] "Learning to learn, localized learning and technological progress", Joseph E. Stiglitz. Economic Policy and Technological Performance, Chapter 5, pp. 125-153

4.2.2 HOW TO MANAGE TECHNOLOGY DIFFUSION

Nowadays, many organizations institute an Office of Technology Transfer, and its main duty is to screen the environment searching for new potentially profitable technologies and formulate managerial plans on how to exploit them. These offices, since they deal with high levels of complexity and carry out difficult tasks, are often multidisciplinary, and their teams include economists, engineers, attorneys and lawyers[148].

The ways on how an available technology can be implemented in the production process are different: it could be possible to simply buy it from the producer, or a licensing agreement could be signed, or joint ventures and partnerships can be initiated in order to bare less risks, cut the costs and reallocate the distribution of resources and rewards[149].

The organizational management can be really helpful to establish a system in which the technology transfer, development and application are supported and facilitated.

Firstly, the managers should be able to increase the extent and efficiency of communication interactivity, in order to increment and improve the passive and the active transfer channels which are being used[150]. Both the organizations who are sending the technology and the ones which are receiving it have to unambiguously appoint and give an adequate level of authority to specific teams so that they can receive, manage, supervise and subsequently transfer the new technologies. Moreover, the firms should make all the employees aware of the crucial significance that the technology diffusion activities have, for example through organizational publications, highlighting role-model examples of the most successful cases[151]. These suggestions can be perceived as obvious but in reality their execution is challenging. For example, firms which receive new technologies often think that assigning the most talented employees on a merely "receiving task" is a waste of good capabilities[152]. This task is unfortunately underestimated by many organizations; indeed, the employees have to screen for new technologies, appraise their compatibility

[148] "Stabilizing the Boundary between US Politics and Science: The Role of the Office of Technology Transfer as a Boundary Organization", David H. Guston. Social Studies of Science, Vol. 29, No. 1, pp. 87-111

[149] "The El Outaya salt refinery project: A joint venture technology transfer case", Zhilin Yang, Arthur F. Madsen and Meihua Zhou. African journal of business management, Vol. 6, No. 11, pp. 8320-8326

[150] "Social structure and technology spillovers from foreign to domestic firms", Alex Eapen. Journal of International Business Studies, Vol. 43, No. 3, pp. 244-263

[151] "Commercializing Academic Research: Resource Effects on Performance of University Technology Transfer", Joshua B. Powers. The Journal of Higher Education, Vol. 74, No. 1, pp. 26-50

[152] "Change and persistence with failed technological innovation", David Maslach. Strategic Management Journal, Vol. 37, No. 4

with the existing ones, decide whether to proceed with the transfer and then manage their arrival, their adaptation and absorption[153].

The management team that deals with technology transfer should also make technologies easier to comprehend and more clear to interpret in order to decrease the equivocality aspect[154]. For example, to do this, firms can encourage on-site demonstrations so that technology will be more comprehensible to possible new consumers. Organizations are advised to clearly express both their researches expectations and also the instances in which certain technologies are usable; in this way, the teams involved in research and product development can get an improved understanding of which results are being expected from them before and after the transfer process[155]. Firms are also solicited to inspire and promote cooperative project works because they boost an easier and widespread distribution of essential information and beneficial outcomes[156]. Another useful managerial practice would be to set up educational and training programs from which employees can learn how to deal with new technology transfer both at the sending and the receiving firms[157].

In order to deal with the possible cultural distance, firms should start a process of expansion of the number, but most importantly of the diversity, of employees that operate in the technology transaction process[158]. In this way, it will be easier to understand different values and cultures that another organization may present, and also it will bring into the mix new points of view and ways of doing things. Also, the team that deals with technology transfer should be broad both in the number of components but also in the skills that each one can bring to the table, picking employees that have different educational and training backgrounds[159]. On-site visits can be useful to better understand the environment from which the technology comes or in which the technology will be sold

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153 "Change and persistence with failed technological innovation", David Maslach. Strategic Management Journal, Vol. 37, No. 4

154 "Know-How Transfer: The Role of Social, Economic/Competitive, and Firm Boundary Factors", Ariff Kachra and Roderick E. White. Strategic Management Journal, Vol. 29, No. 4, pp. 425-445

155 "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics, Vol. 104, No. 4, pp. 495-513

156 "Technology Transfer, Collaboration and Cooperation", Elisa Morgera, Elsa Tsioumani and Matthias Buck. From: Unraveling the Nagoya Protocol: A Commentary on the Nagoya Protocol on Access and Benefit-sharing to the Convention on Biological Diversity, pp. 314-321

157 "Educational Technology Diffusion in Organizations: A Call for Systemic Vision and Organizational Development", Guglielmo Trentin and Rosa Maria Bottino. Educational Technology, Vol. 52, No. 2, pp. 54-60

158 "Cultural differences, convergence, and crossvergence as explanations of knowledge transfer in international acquisitions", Riikka M. Sarala and Eero Vaara. Journal of International Business Studies, Vol. 41, No. 8, pp. 1365-1390

159 "International Technology Diffusion", Wolfgang Keller. Journal of Economic Literature, Vol. 42, No. 3, pp. 752-782

and they should be encouraged and financially supported[160]. Last but not least, organizations could launch workshops and seminars in order to lecture their workforce and to make them aware of the different organizational cultures that they will encounter during the transfer process[161].

In order to increment the employees' motivation to engage in technology transfer, a firm should offer the right incentives, such as monetary rewards and social recognition for the people who are able to deliver a successful exchange[162]. Credit might be given in the form of monetary benefits such as bonuses and increases in salaries, promotions, exceptional licensing and royalty agreements when using the relocated technology[163]. An employee can also be socially rewarded by being featured in newsletters, being nominated in public acknowledgments and in the certification of successful stories and by being asked to be a part of videos that explain how to undertake technology transfer activities[164]. Motivational incentives can also be attributed during some important situations such as having the possibility to team up for collaborative projects with famous and highly appreciated personnel, or with individuals from diverse cultures and backgrounds or being selected for exclusive training opportunities to increase know-how and expertise[165]. Also in this context, the implementation could present some challenges: for example, firms have to be careful to give the right incentives in order to foster technology transfer, without limiting other aspects of the individuals' responsibilities.

4.3 INNOVATION DIFFUSION

Innovation diffusion is the complex process by which an innovation is spread to all or some members in a network over a certain period of time[166].

There are five main factors involved in the diffusion process. The first one is represented by, of course, the innovation: an idea, technique, or physical item which is seen as new by

[160] "Know-How Transfer: The Role of Social, Economic/Competitive, and Firm Boundary Factors", Ariff Kachra and Roderick E. White. Strategic Management Journal, Vol. 29, No. 4, pp. 425-445

[161] See note 160

[162] "Managerial Incentives for Technology Transfer", Derek J. Clark and Anita Michalsen. Economics of Innovation and New Technology, Vol. 19, No. 7

[163] See note 162

[164] "Multinational Firms and Technology Transfer", Amy Jocelyn Glass and Kamal Saggi. The Scandinavian Journal of Economics, Vol. 104, No. 4, pp. 495-513

[165] "Social Contagion and Information Technology Diffusion: The Adoption of Electronic Medical Records in U.S. Hospitals" Corey M. Angst, Ritu Agarwal, V. Sambamurthy and Ken Kelley. Management Science, Vol. 56, No. 8, pp. 1219-1241

[166] "Strategic Intrafirm Innovation Adoption and Diffusion", Richard A. Jensen. Southern Economic Journal, Vol. 68, No. 1, pp. 120-132

external viewers. The ones who are interested in and who will make an effort to use the innovation are the adopters, and they can be individuals, or entire organizations, universities, hospitals, governments or even countries[167]. Innovations are transferred mainly through communication channels, that spread information between the actors. The fourth element deals with time, because this transfer process usually occurs over a long period of time: innovations are seldom accepted immediately[168]. The last element is represented by the type of network in which the innovation is being exchanged, the type of relationships inside the social system, the government legislations, and so on[169].

A typical innovation diffusion path is a process which counts five main stages of decision making[170]. In the first phase, a potential adopter encounters for the first time to an innovation but he/she does not have any useful information about it and he/she is not interested in learn more[171]. With time, he/she will be persuaded into knowing more details about it and ultimately he/she will think at the benefits that the innovation will bring and will decide if adoption is the right choice[172]. If the outcome of this decision is positive, the individual will implement the innovation and may search even further information about it to ease its adoption. On the last step, he/she will confirm if the innovation will still be used[173].

In free choice conditions, individuals will interact for the most part with people to which they feel they are more alike, regarding attributes, values, education level, and so on[174]. Communication among them is typically facilitated since they share a similar background and, correspondingly, also innovation diffusion results easier. However, for innovation to be successful, there should be some difference between the members involved in the transfer, so that they can both learn from each other, acquire new ideas and let their knowledge base grow[175].

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[167] "Multiplant Firms and Innovation Adoption and Diffusion", Richard A. Jensen. Southern Economic Journal, Vol. 70, No. 3, pp. 661-671

[168] See note 167

[169] "Network Structure and Innovation Ambiguity Effects on Diffusion in Dynamic Organizational Fields", Deborah E. Gibbons. The Academy of Management Journal, Vol. 47, No. 6, pp. 938-951

[170] "Diffusion of Innovations", Rogers Everett. Simon and Schuster 5th Edition, pp. 26-28

[171] "Strategic Intrafirm Innovation Adoption and Diffusion", Richard A. Jensen. Southern Economic Journal, Vol. 68, No. 1, pp. 120-132

[172] "Innovation Diffusion in Heterogeneous Populations: Contagion, Social Influence, and Social Learning", H. Peyton Young. American Economic Review, Vol. 99, No. 5, pp. 1899-1924

[173] See note 172

[174] "The Importance of Relationship Timing for Diffusion", James Moody, Social Forces, Vol. 81, No. 1, pp. 25-56

[175] "Agent Heterogeneity in Adoption of Anaerobic Digestion Technology: Integrating Economic, Diffusion, and Behavioral Innovation Theories", Clark P. Bishop, C. Richard Shumway and Philip R. Wandschneider. Land Economics, Vol. 86, No. 3, pp. 585-608

An innovation is characterized by its rate of adoption, meaning the rate at which the various members of the network will implement it, and it is usually defined as the time span needed for its adoption by a specific percentage of the actors[176].

Different actors will engage in innovation implementation at different times and the will subdivide as follows: innovators are the first ones to adopt, which bare the maximum risk and usually have a good financial background which can protect them in case of failure; then there are the early adopters, which are the main opinion leaders and make cautious choices of implementation in order to preserve their important communication position; early majority adopters will follow, and they usually wait longer than the previous categories so that the failure risk is significantly lower; the fourth group is called late majority, and they will adopt the innovation only after the majority of society did it before them; last but not least, laggards typically present an aversion to things that change the status quo and will adopt an innovation only if necessary[177].

Innovations do not always succeed after their market debut. For an innovation to be considered as failed, it is not necessary that no one had adopted it, but it is sufficient that it does not come close to the 100% adoption rate[178]. This can happen because the innovativeness is weak, it could be prevailed by better competitors, or it could not have been rightfully spread and made known across the network members[179]. Innovations that succeed in some networks might fail in others because they do not apply to everyone. Anyways, innovation diffusion and the adoption rate are very hard to measure because it is not possible to know with absolute certainty what are the real cause of the implementation process[180].

Consequences of innovation diffusion can be both positive and negative[181]. Pro-innovation bias researches state that all innovations are considered to be positive and they all must be implemented[182]. Unfortunately, this is not always the case: indeed, it can

[176] "Multiplant Firms and Innovation Adoption and Diffusion", Richard A. Jensen. Southern Economic Journal, Vol. 70, No. 3, pp. 661-671

[177] "Diffusion of Innovations", Rogers Everett. Simon and Schuster 5th Edition, pp. 57-62

[178] "Fast and Expensive: the Diffusion of a Disappointing Innovation", Henrich R. Greve. Strategic Management Journal, Vol. 32, No. 9, pp. 949-968

[179] "Actualizing Innovation Effort: The Impact of Market Knowledge Diffusion in a Dynamic System of Competition", Detelina Marinova. Journal of Marketing, Vol. 68, No. 3, pp. 1-20

[180] "Innovation, Diffusion, and Trade: Theory and Measurement", Ana Maria Santacreu. SSRN Electronic Journal, Vol 3, No. 4, pp. 45-51

[181] "Innovation Diffusion Theory", Tahir Ahmad Wani and Syed Wajid Ali. Journal of General Management Research, Vol. 3, No. 2, pp. 101–118.

[182] "Policy Diffusion and the Pro-innovation Bias", Andrew Karch, Sean C. Nicholson-Crotty, Neal D. Woods and Ann O'M. Bowman. Political Research Quarterly, Vol. 69, No. 1, pp. 83-95

happen that, due to innovation diffusion, some cultural customs and philosophies can be overwhelmed by another society, and this phenomenon can inflict substantial costs on large groups of people. Also, in many circumstances, information-flow is one-sided: from the innovation creator to its receiver. Of course the innovator, which has to sell its invention, has to be persuasive and may seek to make the others implement the innovation even if it is not completely beneficial for them, controlling the exchange and the information which is disclosed[183].

4.3.1 VARIABLES AFFECTING INNOVATION DIFFUSION

Innovation transfer and diffusion varies depending on its level of brought benefits perceived by the possible future adopters, its possibility to make comparisons with the already existing techniques and tools, its level of comprehensibility and easiness to be learnt, its testability, meaning the possibility to be tested before being fully adopted, and its likelihood to be reinvented, used for another scope adding on the initial desired one[184]. These characteristics are jointly estimated at the same time: just because an innovation is easy to learn, it does not mean that it will bring a big advantage and so it may not be interesting to adopt[185].

Generally, an innovation will be transferred more or less quickly correspondingly to its rate of adoption. The diffusion rate depends also on the characteristics of the single adopters[186]. Personality traits of the CEO or of the different levels managers can strongly influence the probability of innovation implementation in a firm.

Also the motivation of these people contribute on the transfer rate and they are tied to particular situations more than individuals[187]: someone might perform well and make the right choices only on determinate environments, so for example, adopt innovations only when it seems less risky. Motivation through the right incentives can be the right push to initiate the adjustment required to absorb an innovation. These rewards, other than the monetary ones, can also be recognition and social prestige[188]. Diffusion depends also on

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[183] "Technology Adoption and the Emergence of Regional Asymmetries", Emanuele Giovannetti. The Journal of Industrial Economics, Vol. 48, No. 1, pp. 71-102

[184] "Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers' Theory", Ismail Sahin. The Online Journal of Educational Technology, Vol. 5, No. 2

[185] See note 184

[186] "Innovation, Diffusion, and Trade: Theory and Measurement", Ana Maria Santacreu. SSRN Electronic Journal, Vol 3, No. 4, pp. 45-51

[187] "Entrepreneurship and Innovation", Erik Stam. From: Micro-foundations for Innovation Policy, pp. 135-172

[188] "Testing Diffusion of Innovations Theory with data: Financial incentives, early adopters, and distributed solar energy in Australia", Genevieve Simpson and Julian Clifton. Energy Research & Social Science, Vol. 29, pp. 12-22

the financial possibility, since these initial alterations can be costly at first and on the authority that a person has, his/her persuasion power on the others[189]. Opinion leaders, the individuals which are implementing an innovation on its first life cycle stages, have the ability to engage greatly the rest of the population generating high consent rates in the audience[190]. For their purpose, opinion leaders require optimal communication skills to disclose all the significant information gained through their first exclusive experience. These category of people is really useful on a social context: indeed, it is able to scan the environment looking for potential innovations and it try them out to see if they satisfy their and the rest of the public needs[191].

Other variables regard the characteristics of firms. In organizations, the situation is even more complex because these entities have to function as a whole but are ultimately composed by individual people, which present different attitudes toward innovation[192]. Also in this context the previous variables of motivation, compatibility and triability are determinant. Firms, maybe after looking at their competitors moves, can be pressured towards innovation to try to obtain better outcomes and this force usually starts right from the individual workers[193]. Innovation that require less organizational changes are more likely to be implemented and the same goes when an innovation is starting to get largely adopted within the environment in which a specific firm is operating. A lack of communication within the organization can lead to a delayed innovations adoption[194]. Employees may be reluctant to accept an innovation due to rightful apprehension of being relocated or fired. Management often fight against the change because of inertia, unwillingness to desert already learned ways of doing things, and hesitancy to fund the needed investments[195]. Also the already existent machineries and equipment may represent a barrier to innovation adoption because, even if they are sunk costs, they may feel like a waste of money if they have to be replaced[196].

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[189] "Testing Diffusion of Innovations Theory with data: Financial incentives, early adopters, and distributed solar energy in Australia", Genevieve Simpson and Julian Clifton. Energy Research & Social Science, Vol. 29, pp. 12-22

[190] "Accelerating the Diffusion of Innovations Using Opinion Leaders", Thomas W. Valente and Rebecca L. Davis. The Annals of the American Academy of Political and Social Science, Vol. 566, pp. 55-67

[191] See note 190

[192] "Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers' Theory", Ismail Sahin. The Online Journal of Educational Technology, Vol. 5, No. 2

[193] See note 193

[194] "Diffusion of Innovations: Communication Evolution and Influences", Jatin Srivastava and Jennifer J. Moreland. The Communication Review, Vol. 15, No. 4

[195] "Barriers to Innovation Diffusion in Industrial Networks: A Systematic Combining Approach", J. P. Huhtala, Pekka Mattila, Antti Sihvonen and Henrikki Tikkanen. Advances in Business Marketing and Purchasing, Vol. 21, pp. 61-76

[196] See note 195

More variables come from the external environment. Indeed, not every geographical location allows firms to implement the desired type of innovation because some environments can be hostile to change[197]. Different cultures may see innovations with a different eye and while some may be open to think in different ways, others can be more risk-averse and reluctant to bring variations in their settings[198]. Finally, also the political context affects innovation transfer: some innovations are purposely spread, for example through governmental legislations, and usually this kind obtain a fast rate of diffusion[199].

4.3.2 HOW TO MANAGE INNOVATION DIFFUSION

As stated in the previous section, innovation diffusion is mainly an influence process and not everyone is able to convince the audience at the same manner.

Opinion leaders are the people designated to spread positive (or negative) information regarding an upcoming innovation[200]. They have the highest decision power especially during the trial stage, when they can suggest modifications to the inventor and, of course, they will exert their influence on the later adopters[201]. This category of people usually has a wide access to media, where they can advertise and push the innovation on the population, they benefit from advantageous contacts, they have a great social experience, a higher exposure and they profit from a better socioeconomic position[202]. Even though a lot of people within a network can have persuasive powers, one can be considered an opinion leader only in the case when its influence behavior is generated by an early adoption of the innovation and not by a simple trade of beliefs and information[203]. A society can be thought as composed by different subsystems which correspond to diverse levels of hierarchy: a relationships network unrolls within each group and opinion leaders of each level have the strongest influence on members from the same level as them or from lower levels. The various relationships are tighter when they are built within social

[197] "Geographical Clusters and Innovation Diffusion", Rui Baptista. Technological Forecasting and Social Change, Vol. 66, No. 1, pp. 31-46

[198] "Integrating Models of Diffusion of Innovations: A Conceptual Framework", Barbara Wejnert. Annual Review of Sociology, Vol. 28, pp. 297-326

[199] "Innovation diffusion in global contexts: determinants of post-adoption digital transformation of European companies", Kevin Zhu, Shutao Dong, Sean Xin Xu and Kenneth L. Kraemer. European Journal of Information Systems, Vol. 15, pp. 601–616

[200] "Accelerating the Diffusion of Innovations Using Opinion Leaders", Thomas W. Valente and Rebecca L. Davis. The Annals of the American Academy of Political and Social Science, Vol. 566, pp. 55-67

[201] "Opinion Leaders' Role in Innovation Diffusion: A Simulation Study", Peter S. van Eck, Wander Jager and Peter S. H. Leeflang. The Journal of Product Innovation Management, Vol. 28, No. 2, pp. 187-203

[202] See note 201

[203] "Exploring the Characteristics of Innovation Adoption in Social Networks: Structure, Homophily, and Strategy", Yongli Li, Chong Wu, Peng Luo and Wei Zhang. Entropy, Vol.15, pp. 2662-2678

networks rather than during a random interaction because of the higher motivation to cluster[204]. In networks, the different individuals are represented by nodes, and the strength of the influence applied, and the subsequent transfer of innovations, is effected by a specific node, a cluster of them, or by the network system as a whole[205]. The levels at the bottom of this pyramid usually present the highest number of actors and they tend to reached only by broadcast communication. However, direct and honest word of mouth from opinion leaders is way more persuasive than mass media advertisement[206]. For these reasons a firm or individual that creates innovations has to choose really carefully who will be its opinion leaders that will divulge their creations.

One managerial technique useful for the spread of an innovation, and related to the opinion leader concept, is the peer effect[207]. This phenomenon explains how the influencing power can really be exerted. The easiest way to initiate in peer-effect is through word of mouth, simply exchanging beliefs, opinions, ideas and information and engaging in a face-to-face interaction. Social learning, instead, deals with the imitation of opinion leaders' behaviors that are considered fair and just. This is not only limited to physical actions but also to the formulation of attitudes and rational thoughts[208]. Another mechanism of peer effect is by network externalities, which deal with the effects that someone's actions cause on the other members of the system[209]. Last but not least, a further method is the bandwagon effect. Individuals will accept innovations not just because opinion leaders publicized them, but because they want to conform to the majority of the population. Thus, when an innovation become popular, they will adopt it to feel part of the community[210].

In an organizational context, an innovation can be chosen to be implemented by a collective decision, when it is adopted with a general agreement, or by an authority choice, when a group of people, that usually retain an elevated level of decisional power, opt for

[204] "Network Structure and Innovation Ambiguity Effects on Diffusion in Dynamic Organizational Fields", Deborah E. Gibbons. Academy of Management Journal, Vol. 47, No. 6, pp. 938–951

[205] "Diffusion of Innovations on Random Networks: Understanding the Chasm", Marc Lelarge. ENS-Inria, Vol.1, pp. 178-185

[206] "Peer effects in the diffusion of innovations: Theory and simulation", Hang Xiong, Diane Payne and Stephen Kinsella. Journal of Behavioral and Experimental Economics, Vol. 63, pp. 1-13

[207] "Identification of peer effects through social networks", Yann Bramoullé, Habiba Djebbari and Bernard Fortin. Journal of econometrics, Vol. 150, No. 1, pp. 41-55

[208] "Innovation Diffusion in Heterogeneous Populations: Contagion, Social Influence, and Social Learning", H. Peyton Young. American Economic Review, Vol. 99, No. 5, pp. 1899–1924

[209] "Peer effects in the diffusion of innovations: Theory and simulation", Hang Xiong, Diane Payne and Stephen Kinsella. Journal of Behavioral and Experimental Economics, Vol. 63, pp. 1-13

[210] "Exploring the Characteristics of Innovation Adoption in Social Networks: Structure, Homophily, and Strategy", Yongli Li, Chong Wu, Peng Luo and Wei Zhang. Entropy, Vol.15, pp. 2662-2678

its adoption[211]. It is important to find the right balance between these two extreme positions because an innovation imposed by an individual on the rest of the workforce might not be accepted well and actually be fought against and rejected, causing costs losses and time wasting conflicts[212].

[211] "Towards a Comprehensive Understanding of the Innovation-Decision Process a Relational Model of Adopter Choice", Arun Vishwanath and Hao Chen. Strategic Management Journal, Vol. 67, No. 3, pp. 10-32

[212] "Fast and Expensive: the Diffusion of a Disappointing Innovation", Henrich R. Greve. Strategic Management Journal, Vol. 32, No. 9, pp. 949-968

CHAPTER 5
DISCUSSION OF THEORETICAL FINDINGS, GAPS AND SUGGESTIONS FOR FUTURE RESEARCH

In the following section, the main similarities and discrepancies between the different diffusion processes will be highlighted; then, gaps in the current literature will be pointed out and suggestions for further research will be recommended.

These transfer practices share various elements and are strongly correlated.

It can be considered that technology and innovation diffusion are subcategories of knowledge transfer. Indeed, every one of these processes involves a diffusion of basic knowledge: an organization needs knowledge abilities when approaching to a new technology, to understand how to adapt it, use it and maintain it; but knowledge it is also required when dealing with the implementation of an innovation. These aspects are even more correlated, since an innovation can be represented by a new technology or simply by new practical know-hows. Thus, it is not clear which is the main process that triggers the others. What can be evicted is that the variables that affect these processes are very similar, and also the management tactics implemented to facilitate the transfers are comparable.

The process with which organizations get in touch with new available information is nearly identical for the three elements: it starts with an awareness phase, when the firms identify the new knowledge, technology or innovation, then there is the acquisition stage, when organizations, if they have the right resources, acquire these new pieces of information, or machineries and so on. It is followed by a transformation process, in which the acquired material is adapted to be more profitable in the own local conditions, an association one, where firms recognize the benefits which the new implementations brought, and an application phase, in which companies achieve successful accomplishments using the newly acquired materials. Lastly, there can be a feedback process where firms transfer back their experiences to the initial sender/seller to make the exchange reciprocally useful.

In order to implement a successful transfer, communication between members has to be at the heart of the transaction. Organizations have to understand each other and be willing

to collaborate, cultural distance has to be on a medium range because if it is too high, it will prevent the diffusion to happen due to elevated misunderstandings; if it is too low, no new information will be produced and transferred. Firms' specific culture has to be flexible and adaptive to change: indeed, knowledge, technology and innovation transfer will cause alterations of the practices that a company is implementing before the transfer takes place. Motivation is a crucial factor that determines how successful the transfer will be: people are usually reluctant to change, because it is easier to follow routines and already experimented effective ways of doing things, so, the right incentive has to be given in order for them to engage in new and different activities.

The use of a peer structure is another common aspect: diffusion is facilitated when more and more people use the new knowledge, technology or innovation. Imitating others, especially opinion leaders, that on the earliest stages understand the potential of the new element and start using it, is less risky because the trial period has already been covered by someone else.

One difference that can be evicted is that firms usually already know when it is time to change their technology because the mechanic components can be outdated and may not perform very well. So technology transfer it is mainly driven by an actual need. Innovation diffusion, instead, can be seen as a persuasion attempt process: in many cases, organizations do not think they need, and don't fully understand the potential of an innovation until they have actually implemented it. It is usually wanted by a limited number of people who has an elevated decisional power and who is able to predetermine the benefits that the innovation will bring.

Maybe because these transfer processes are so connected, and sometimes even the boundaries where a knowledge diffusion ends and an innovation one starts, or a technology transfer begins (and vice versa), there are not as many papers on the last two components as there are on knowledge. Since knowledge is the core element that links all the diffusion practices together, the majority of the literature is concentrated on that aspect of the transfer, and many results for technology and innovation diffusion had to be extrapolated from these articles dealing primarily with knowledge. Also, between 2000 and 2017, there are not so many articles published especially about technology diffusion, but they almost all go back to the 1990s or even earlier.

A suggestion for further research will then be to study how the transfer of technology changed in the last decades, because it is possible that some practices evolved during all this time. Also for innovation, a more specific and recent examination would be welcomed.

Furthermore, not so many papers connected these three transfer processes highlighting the differences among them: it would be interesting to see an analysis on that more in detailed.

CONCLUSIONS

The purpose of this thesis was to examine the intricate processes knowledge, technology and innovation diffusion.

It started off giving a definition of the main terms that will be re-encountered many times during the essay.

Knowledge can be perceived as a public good, non-excludable and non-rival, following the Neoclassical theory. From this point of view, spillovers are frequent, facilitating the diffusion, that cannot be controlled because anyone can use the knowledge created at zero costs, generating moral hazard and free-rider problems. From a Neo-Schumpeterian perspective, knowledge is a latent public good, which has to be possible to be sent and ready to be understood and used for the transfer to be successful.

Technology is seen as the use of theoretical knowledge in practical activities. It is something used in order to achieve pre-determined goals, solve problems and carry out tasks that involve specific skills and assets to be exploited. Technology is composed by two indissoluble main components: the physical one and the informational one.

Absorptive capacities are a concept common to both knowledge and technology: they cannot be used by an external party if the recipient does not have an already existent and inherent knowledge and technology base.

The word innovation comprehends methods, concepts, products and services which are completely new. An innovation is defined by its human component, degree of novelty, relative advantage, comparability, complexity, trial-ability and observability. Innovations can be of incremental or radical nature.

Diffusion is the process with which these three elements are spread within one firm or different organization. Its most valuable component is communication, followed by some other variables such as the social system, uncertainty, adoption level and time.

Networks are cooperative groups of firms which work together to pursue a shared goal, and which can obtain diverse competences by the other partners. Collaborative innovation networks typically present five main features: a dispersed and interdependent involvement, no simple chain of command, agreement to cooperate and share data and trust. These networks are beneficial since they can allow the reaching of the ideal allocation of resources, cutting costs and stopping the inefficient double-inventing. The

most common and important types of networks are small worlds and scale free. The first ones, characterized by information reliability, are really efficient in the transfer processes fostering organizational learning, the clustering coefficient is high and the path length is short. In the second type of networks, usually the most efficient, there are hubs, which produce high densities, ultimately helping diffusion.

Knowledge transfer occurs when different organizations exchange knowledge with the purpose of enlarging their skills and resources, developing new capabilities and promoting innovation. It is a self-duplicating process since the firm who is sharing its knowledge does not lose it after the transfer. A very important requirement is that firms truly comprehend and respect each other's culture and values, making it easier to set rules and standards to follow. Cultures should not be too similar in order not to limit innovation. Knowledge diffusion is subject to opportunistic behaviors, particularly when the value of the knowledge is elevated: trust is a key element, that can decrease the level of uncertainty and the transaction costs. Information and communication technology can increase knowledge transfer, making knowledge easier to access and be used. A decentralized management structure, through ICT, can connect different companies, promote cooperation, simplify routine interactions and speed up their communication. A successful system used to foster knowledge diffusion is the peer-to-peer one, which can be implemented through word of mouth, social learning and network externalities.

Technology transfer is a complex and challenging learning process that lets firms exchange their know-how and its consequent adaptation to local situations. The is for the receiver organization to obtain the abilities necessary to control, develop and consequently produce independently the technology. It can be divided into vertical and horizontal. Organizations can approach technology transfer with three ranks of involvement: technology development, acceptance and application. At first technology is adopted by innovators, then early adopters and lastly by laggards. Technology diffusion is affected by five main variables: such as communication, equivocality, cultural distance, motivation and local technological progress. To deal with the challenges of technology diffusion, firms usually develop an Office of Technology Transfer, which has to screen the environment searching for new potentially profitable technologies. Organizations have to establish an environment in which the technology transfer, development and application are supported and facilitated, increasing communication interactivity and awareness, in order to make technologies easier to comprehend. To do this, firms could offer on-site

demonstrations, promote cooperative works and set up educational and training programs. Moreover, the right incentives should be given, such as monetary rewards, promotions and social recognition.

Innovation diffusion has five main protagonists: the innovation itself, the adopters, communication channels, time, and the type of network in which the innovation is being exchanged. A standardized innovation transfer follows five decision making steps: knowledge, persuasion, decision, implementation and confirmation. Communication is crucial once again, and it is usually facilitated when firms share a similar culture. Also for innovation diffusion, people will be divided into innovators, early adopters, early majority adopters, late majority and laggards. A successful transfer depends on the innovativeness level, innovation's triability and comprehensibility, personality traits of the adopters and motivation. The use of opinion leaders and peer pressure, also exerted through the bandwagon effect, could be a useful management technique in order to promote successful innovations on a large audience.

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