Knowledge Transfer Assessment in a Co-innovation Network

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Abstract. Frequently, the innovation processes require knowledge in several domains that enterprises do not usually hold. In order to address this problem, the issue of the knowledge transfer in collaborative environments started to attract attention. In this context, the characterization and assessment of the knowledge transfer among members within a network is an important element for the wide adoption of the networked organizations paradigm. However, models for understanding the knowledge transfer in a collaborative environment are lacking. Starting with some discussion about the nature of knowledge production and transfer, this paper introduces an approach for analysing the level of maturity in terms of knowledge transfer in a collaborative network. Finally, based on experimental results from a Portuguese collaborative network, the Brisa case study, the benefits, challenges and difficulties found are presented and discussed.

Keywords: Knowledge Transfer, Collaborative Networks, Case Study.

1. Introduction

Nowadays, enterprises in global markets have to achieve high levels of performance and competitiveness to stay “alive" [1]. In order to be competitive, enterprises must develop capabilities that will enable them to respond quickly to market needs. According to several authors, one of the most relevant sources of competitive advantage is the innovation capacity [2]. However, the innovation capacity requires access to new knowledge that enterprises do not usually hold. As a result, the enterprises can improve their knowledge either from their own assets, making sometimes high investments, or from the knowledge that may be mobilized through other enterprises based on a collaborative process.

However, despite the collaboration among enterprises has been considered unusual and indeed suspicious by many SME managers until a few years ago, nowadays it is commonly assumed that the participation in a collaborative process is a common trend for many enterprises. Literature in the field has pointed out that the participation in a collaborative process brings benefits to the involved entities. On the basis of these expectations are, amongst others, the following factors: sharing of risks and resources,

joining of complementary skills and capacities, access to new / wider markets and new knowledge, etc [3].

In fact, there is an intuitive assumption that, when an enterprise is a member of a long-term networked structure, the existence of a collaborative environment enables the increase of knowledge production as well as the transfer of knowledge, and thus the enterprises may operate more effectively in pursuit of their goals.
However, in spite of this assumption, it has been difficult to prove its relevance due to the lack of models that support mechanisms that explain the production and transfer of knowledge in collaborative environment. Furthermore, the absence of indicators related to knowledge transfer – clearly showing the amount of knowledge transferred and the impact of this knowledge at a member level, for instance, in terms of capacity for generating new ideas, processes and products, organizational improvement through the combination of the existent resources, and diversity of cultures and experiences of other enterprises – might be an additional obstacle for a wider acceptance of this paradigm.

This paper discusses the nature of knowledge transfer as a contribution to a future identification of a set of indicators that are suitable for collaborative networks. This work aims at contributing to answer the following main questions:

- How is knowledge transferred from one network member to another?
- What are the factors that facilitate or constrain knowledge transfer in collaborative environment?

2. Knowledge Production and Transfer in Collaborative Networks

Upon reviewing the international literature, we find many studies highlighting the societal importance of innovation and knowledge within modern economies. CASTELL's [4]. "Network Society" or SOETE's [5]. "Knowledge Economy" are highly regarded concepts, but we could mention other interesting works from Toffler [6], Bell [7], or Giddens [8].

Knowledge always played an important role in the economy. But only over the last few years has its relative importance been recognised, just as that importance is growing. However, the stock of knowledge upon which economic activity is based today is definitely much larger than in previous eras. In the emergent economy and society, the accumulation of knowledge becomes the main motivational strength towards growth and development [9], [10], [13].

Actually, the last decades have shown a generalised concern about the study on how companies create knowledge and, particularly, on how they operate this transference. Knowledge is recognised as a principal source of economic rent, and the effective management of organizational knowledge has increasingly been linked to competitive advantage and is considered critical to the success of the business firm. One of the distinctive features of the knowledge-based economy is the recognition that the diffusion of knowledge is just as significant as its production, leading to increased attention to "*knowledge distribution networks*" and "*national systems of innovation*". These are the agents and structures which support the advance and use of knowledge in the economy and the linkages between them.

In this line of thought, Gibbons et al. [11] introduce a distinction between *Mode 1* knowledge production, which has always existed, and *Mode 2* knowledge production, a new mode that is emerging alongside it and which is becoming more and more relevant. While knowledge production used to be located primarily at scientific institutions (universities, government institutes and industrial research labs) and structured by scientific disciplines, its new locations, practices and principles are becoming much more heterogeneous. *Mode 2* knowledge is produced in different organizations, resulting in a *heterogeneous* practice. The potential sites for knowledge production include not only the traditional universities, institutes and industrial labs, but also research centres, government agencies, think-tanks, and high-tech spin-offs. *Mode 2* refers to a production of knowledge which is not exclusively reserved for qualified academic research but focuses on the different actors integrated in a contextualised problem-solving oriented process. The importance of knowledge is then assessed by its social value and interest to stakeholders engaged in the process of production.

Five main features of *Mode 2* summarise how it differs from *Mode 1*. First, *Mode 2* knowledge is generated in a *context of application*; *Mode 1* knowledge can also result in practical applications, but these are always separated from the actual knowledge production in space and time. A second characteristic of *Mode 2* is *transdisciplinarity*, which refers to the mobilisation of a range of theoretical perspectives and practical methodologies to solve problems. Transdisciplinarity goes further than interdisciplinarity in the sense that the interaction of scientific disciplines is much more dynamic. Theoretical consensus cannot easily be reduced to specific scientific parts. Thirdly, *Mode 2* knowledge is produced in a diverse variety of organisations, resulting in a very *heterogeneous* practice. The potential sites for knowledge generation include not only the traditional universities, institutes and industrial labs, but also research centres, government agencies, think-tanks, high-tech spin-off companies and consultancies. These sites are linked through networks of communication, and research is conducted in dynamic interaction. The fourth feature is *reflexivity*. It means that researchers become more aware of the societal consequences of their work ('social accountability'). Sensitivity to the impact of the research is built in from the start. Novel forms of *quality control* constitute the fifth characteristic of the new production of knowledge. Traditional discipline-based peer review systems are replaced by additional criteria of economic, political, social or cultural nature.

In *Mode 2*, research is carried out in the context of application in which there is a continuing dialogue between interested parties – including producers and users of knowledge – from the beginning. Thus, the concept of knowledge transfer has to be reconsidered. It cannot be understood as a simple transmission of knowledge from the university to the receiver. The participants may include business people, venture capital, industry, research centres and many others in addition to the university. In short, all need to become actively engaged in the process of knowledge production and its transfer.

Figure 1 illustrates the two modes (I, II) of knowledge production and its transfer taking as environment the collaborative networks.

The purpose of the next section is to define a knowledge transfer model to be used in the context of collaborative networks.

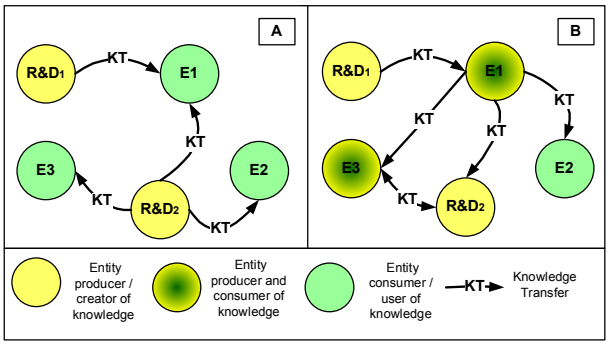

Fig. 1 – Production of knowledge environment 1A) Mode I and 2B) Mode II

3. A Model to Assess the Knowledge Transfer

In order to analyse and understand the processes and mechanisms of knowledge transfer in a systematic way, it is necessary to develop a model that deals with the complexity inherent to this kind of phenomena. As starting point, the aims of the proposed model are: To understand the running of an active collaborative network; to create a common reference framework; to serve as a basis for "what-if" analyses; and to motivate changes in the operation process of the network.

Based on the literature [11,12], and taking into account the context of collaborative networks, as a first approach, the model proposed includes the following perspectives:

- **Transfer mechanisms** – This perspective focuses on the identification and characterisation of distinct ways of "physical" interrelationship that support the process of knowledge transfer between enterprises within a network, such as internal publications, external publications, reports, patents, exchange of resources between organizations, log of good practices (lessons learned), repository of information (infrastructure dedicated), e-mail, videoconferencing, infrastructure to support collaborative processes (e.g. workgroup tool), telephone / mobile phone, informal meetings, and periodic meetings.
- **Competences Management** - This perspective addresses the principles, policies, and governance rules that may facilitate or constrain the processes of creating the competence and searching for competences by the members of the network. Therefore, general issues such as definition of accessibility levels (e.g. public, internal to network members or private), definition of policies in terms of competence dissemination among members of the network, definition of principles to assure the transparency and traceability of the competences in the network, definition of a competence taxonomy (e.g. market , ICT , management, manufacturing), levels of importance (e.g. central or marginal), time aspects (e.g. historical or current), and definition of rules in terms of Intellectual Property rights (IPR) (e.g. confidential or non-confidential) are considered here.

- **Nature of the relationships** - The nature of the relationships determines the way collaborative space enables or facilitates the flow of knowledge among enterprises. Thus, this perspective focuses on the identification and characterisation of the various types of relationships that enterprises may have with other enterprises within the network: the relationships with new enterprises created from existing enterprises that belong to the network (e.g. spin-offs and start-ups) and also the relationships between the network as a whole and external entities (e.g. suppliers, customers, end-users, competitors, external institutions, and potential new partners).

Figure 2 illustrates the proposed model for the analysis of knowledge transfer in the context of network organizations.

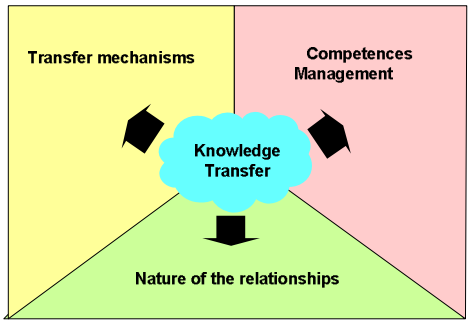

Fig. 2 – Knowledge transfer model

4. Knowledge Transfer Assessment Using the Proposed Model

Methodology

The research is based on one case study pointed to the largest Portuguese motorway[1] is based on two main projects developed by Brisa, namely E_TOLL – *Electronic Tolling System*, a self-service toll lane where it is possible to pay by bank card or cash, and ALPR – *Advanced License Plat Recognition*, an enforcement system based on the automatic license plate recognition for situations where the vehicle is not equipped with an on-board-unit (OBU) or the OBU fails to electronically identify the vehicle.

Brisa identified E_TOLL and ALPR as the projects that contribute the most to the return on investments. It means that they were relevant in terms of innovation and created value to the company. These were the criteria for choosing E_TOLL and ALPR as pilot projects. On a first stage, companies and other institutions (technology centres, universities) involved in the projects were contacted and invited to cooperate

[1]The present results are based on research work developed under the ongoing project – CoRe - Competências de I&D para a Criação de Valor na Rede Brisa, FCT/UNL, BRISA, ISEL/IPL, 2011-2012.

with our research. Empirical data stems from two main sources: in-depth interviews (the basic tool for qualitative research on social systems) conducted with key participants belonging to the network, and a brief survey (for quantitative data) applied to participants by using a social network analysis. The involvement of various partners in the network is critical in order to foster a spirit of openness and cooperation in this fundamental process.

Brisa Case Study

The Brisa company currently operates, on a concession basis, a network of eleven motorways, with a total length of around 1096 km, constituting the main Portuguese road links. Given its importance and dimension, Brisa owns several companies specialising in motoring services aimed at improving the quality of the service provided to customers and increasing its own operating efficiency. The Brisa co-innovation network is a long-term collaborative network (a VBE) that has more than 30 members from several domains and business activities (e.g. research institutions, universities, associations, governmental entities, start-ups, business angels, and suppliers).

Knowledge transfer mechanisms

This section aims to discuss a main question: "*how is knowledge transferred from one enterprise/partner to another*?" considering the preliminary data related to the knowledge transfer mechanisms resulting from a survey applied (table I) to Brisa network partners.

Table 1 — Mean (based on a scale of 1- low to 10- high) for each type of transfer mechanisms identified

Transfer mechanisms	*Mean*
Internal publications	3.8
External publications	2.9
Reports	3.8
Patents	2.6
Exchange of resources between organizations	6.1
Log of good practices (lessons learned)	5.1
Repository of information (infrastructure dedicated)	4.0
E-mail	7.0
Videoconferencing	1.3
Infrastructure to support collaborative processes (e.g. workgroup tool)	1.3
Telephone / mobile phone	6.5
Informal meetings	6.9
Periodic meetings	6.5
Other	4.5

From the results, one can observe that the mechanisms most used by the Brisa network are the e-mail followed by the informal meetings, formal periodic meetings, telephone and exchange of human resources between organisations. The exchange of human resources in particular, when coming from industry and integrating research groups, was mentioned as a valuable collaboration strategy. On the other hand, the

least used mechanisms are the video conference and other specialised infrastructures to support the collaborative processes (e.g. workgroup tool).

According to the results, the knowledge exchange among the enterprise members of the studied network is not based on much too sophisticated technologies. As argued by the manager of one enterprise partner, the Brisa network could improve the sharing of knowledge by using technologies specifically oriented for collaborative networks. In general, the interviewed partners were unanimous about the idea of an existing open network in terms of knowledge sharing, although some of them referred that the knowledge transfer process could be enriched by the use of advanced tools.

Competences Management

This section addresses the competences identified within E-TOLL and ALPR projects based on the information gathered through questionnaires.

From the sub-areas mentioned by the partners, a set of categories were created in order to structure a range of competences (from C1 to C25), making up this collaborative network within the projects under study. The resulting map shows that the partners hold a broad number of competences ranging from computer vision (C1), integration of systems (C5), software development (C14), Remote Monitoring (C18) and Electronic Toll Collection (ETC) systems (C20) to Plastic Injection (Industrial Design, (C8) and Development of Moulds (C9).

The following figure shows the competences used by each partner in the collaborative projects.

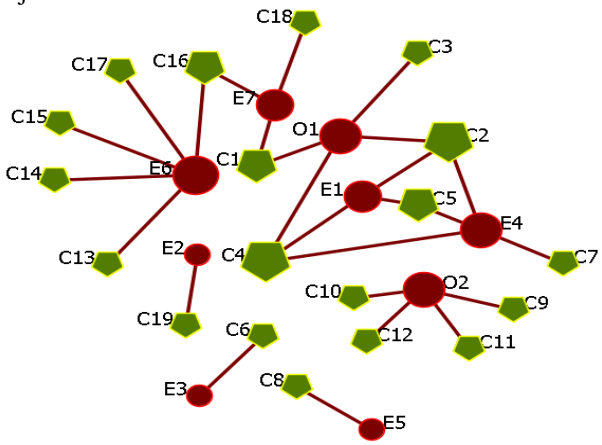

Fig. 3a – Competences used by each partner in the collaborative projects.

The adoption of a graphical visualisation of competences provides a tool to analyse in detail the 'sub-structures' that may be present in a collaborative network.

In Figure 3a, the node size of the enterprises/organizations represents the sum of competences used in collaborative projects (E_TOLL – *Electronic Tolling System,* and ALPR – *Advanced License Plat Recognition*), and the node size of the competences represents the level of abundance of each competence in the network during the execution of collaborative projects.

Hence, during the execution phase of the projects, for instance, the most versatile enterprise is E6, as it is the one with the greatest number of distinct competences,

followed by E4 and O1. On the contrary, E5 and E3 are the institutions that individually contribute with only one specific competence to the project. On the other hand, according to the competences perspective, it is possible to confirm that competences C2 and C4 are the most common in this network. Additionally, there are some partners that are the only ones to hold unique competences, which give them a powerful position inside the network.

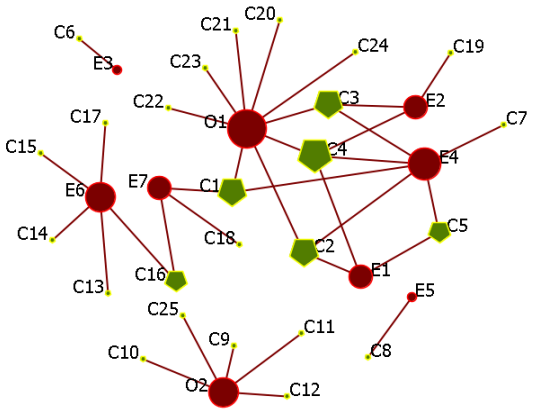

Fig. 3b – Competences held by each partner in the end of the collaborative projects.

The node size of the enterprises/organization in Figure 3b represents the sum of competences used in the projects and the new competences achieved resulting from the collaborative project. The node size of the competences represents the level of abundance of each competence in the network at the end of the projects. Therefore, at a macro level, by looking at competence nodes it is possible to identify the emergence of new competences, such as: C21, C22, C23, C24 and C25. In addition, at a member level, it is also possible to identify the dissemination of competences among members of the network, for instance enterprise E2 owns two new competences: C3 and C4.
One can observe that almost all organisations and companies held more competences after being involved in the projects, for instance: the E2 increased the number of competencies, as depicted in figure 3a. The gains of organizations and companies are visible by comparing the two scenarios (figure 3a and 3b). When considering the *Mode 2* knowledge production features, another interesting result is related to the competences held by universities (O1 and O2) in the sense that production and knowledge transfer involves all partners and universities receive competences from companies and *vice-versa*. It is a positive sum game. The collaborative work seems to be a privileged way of combining competences and integrate specific knowledge from different sources. Knowledge results from a great variety of organizations and institutions, and is heterogeneous in terms of the skills and experience people bring to it.

Nature of the relationships
In order to analyse the nature of the relationships, as illustrated in Figure 4a, 4b, on a scale from 1 to 10, the following aspects were assessed:
- Frequency of contacts – measuring the number of business contacts between

network members over time.

- Intensity of contacts – measuring the strength of business contacts in terms of lifespan (time) over time.

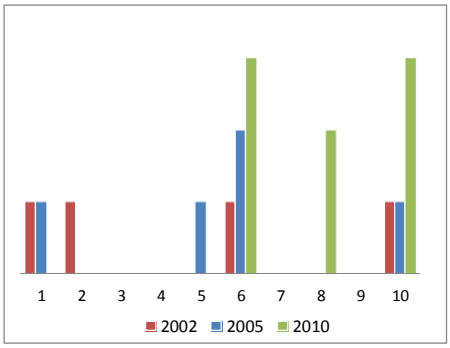

Fig. 4a – Frequency of business contacts over time (1- low and 10- high frequency)

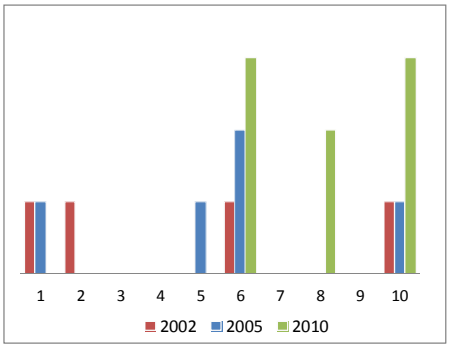

Fig. 4b – Intensity of business contacts over time (1 – spot and 10 - long-term)

Upon analysing these charts, we identify the existence of an increase in terms of both the frequency of contacts and the intensity of contacts over time among different members of the network.

Considering this, those two variables can be viewed as a measure of the involvement capacity of network members; also, in a co-innovation network, the collaborative processes are mainly based on knowledge transfer, and thus it is possible to infer that the knowledge transferred between partners has increased over time.

Furthermore, since in a co-innovation network the pattern of linkages (knowledge transfer) between network members determines the configuration of the network structure, the position of enterprises within the network might be relevant to understand the role of each enterprise in the process of knowledge transfer. Based on this approach, a useful tool to analyse the knowledge transfer in detail can be obtained by applying several concepts from the Social Network Analysis area and relating these to mechanisms / processes of knowledge transfer.

However, the development of indicators related to knowledge transfer based on concepts from Social Network Analysis, to clearly show the amount of knowledge transferred and the impact of this knowledge at a member level, requires further research and development.

5. Conclusions

Summing up, it is referred by partners that knowledge transfer mechanisms could be improved by the use of more sophisticated technologies. Furthermore, the interview narratives point out that it will be important to promote useful tools to manage knowledge sharing among member partners. On the other hand, the results show increasing frequency of contacts as well as its intensity over time. Additionally, the network incorporates an extended list of competences that are shared within the work projects. One important aspect in terms of competence transfer is the mobility of

people among partners. Participating partners valued the exchange of people as strategy to improve competences. As argued by the CEO of BIT (Brisa Innovation and Technology), this mobility is a relevant added value in terms of knowledge and competence transfer.

Reaching a better characterisation of the nature of knowledge production and transfer in co-innovation networks is an important element for a better understanding of the behavioural aspects and also for improving the sustainability of this organizational form.

The development of a set of indicators to capture and measure the knowledge transfer can be a useful instrument to the manager of this network, as a way to support the promotion of collaborative behaviours, and for a member to extract the advantages of belonging to a network. However, the development of practical indicators to analyse the knowledge transfer requires further work.

Acknowledgments

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