UNIVERSITY – INDUSTRY INTERACTION ON KNOWLEDGE MANAGEMENT THROUGH OPEN INNOVATION SYSTEMS

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Abstract: This theoretical paper discusses knowledge management in an open innovation systems context on a basis of university – industry collaboration. Knowledge management is necessary to ensure the inbound and outbound flows of knowledge that define open innovation, and to ensure that the knowledge, provided by the open innovation process ,can be used for successful collaboration between universities and industry. The importance of knowledge is emphasized in the literature on open innovation, but most modern literature takes only a narrow point of view on the problem and is not related to knowledge management through inter-institutional collaboration. The paper discusses the General framework conditions for efficient university-industry collaboration and in this context, it outlines the Systematic procedure of open innovation implementation. The main outlined knowledge flows in networking shows a combination of a positive and neutral effect on the effectiveness of innovation at the level of business units, which means that open innovation within the network is generally beneficial for a multidisciplinary organization as well as Incoming innovations across organizational boundaries are beneficial for the innovation activity of a business unit, in contrast to outgoing innovations that have a neutral effect on it. The ability of organization to recognize the value of new external information, absorb and apply it for commercial purposes is crucial for its innovative potential. The creation of knowledge and the ability to master can be created without a special R&D unit in university - joint research and development can be fruitful, and trade areas can provide the opportunity for training and joint acquisition of new knowledge.

Keywords: Knowledge management, open innovation, university – industry collaboration.

1. Introduction

Expert H. W. Chesbrough [1] introduced the concept of open innovation in 2003 in his book *Open Innovation: A New Imperative for Creating and Profiting from Technology*. Open innovation refers to external knowledge, entering an organization (incoming open innovation), and internal knowledge, flowing from an organization (outgoing open innovation), that an organization can use when introducing new products and introducing its own innovations on the market [1–3].

Despite the existence of various forms of open innovation approaches, we know little about how organizations introduce innovations in external cooperation, benefit from their innovations [4, 5], as well as with whom and for what reasons they collaborate with external partners. In particular, this is applicable in the context of sustainable development innovations [6], citing the need to rethink and redesign products, processes and services to meet the sustainable development requirements that are demanded by various groups, such as customers, universities, non-governmental organizations and governments [7].

The objective of this paper is to present knowledge management novelty in open innovation as encompassing depiction of the university – industry interaction phenomenon.

Since cooperation between scientists and industry plays a significant role in stimulating innovation processes, a step-by-step structure for introducing open innovation in academia is reviewed, as well as an investigation into linking open innovation and university-industry collaboration are discussed.

In recent years, many organizations have collaborated with knowledge centers, such as universities. On the one hand, companies have limited access to all necessary competencies, skills, equipment, capital, etc. On the other hand, it is important for universities, that their scientific results commercialization that financial support for research precedes research projects and their reputation improved. This is why collaboration between industry and universities can be a good approach to combine knowledge and ideas, as well as decide how to use and develop new concepts. Innovation is also key to creating new products and solutions.

Organizations therefore, they have to integrate the innovation process into their daily business and in the long run strategy. To properly use external resources, the innovation process and cooperation in new product development is becoming more open, leading to a new concept, called open innovation.

2. Materials and methods

In recent decades, cooperation between universities and industry has been studied from different perspectives. For example, J. A. Pertuze and others [8] described and analyzed the results of a three-year study in 25 multinational companies with focus to identify best practices for the university industry collaboration from an industry perspective. Another European study of universities' activity to develop cooperation with industry [9] has also been achieved to understand how this type of collaboration can be managed from the university point of view. In addition, some authors [10] investigated six case studies in UK for a better understanding of university-industry management cooperation. At the same time, some authors have focused on describing the concepts of open innovation and their motives [1, 11], and more recently – identifying competent business strategies [12].

There are many concepts in literature that emphasize the most essential aspects of co-creation and a number of existing methods for involving users, such as: Virtual community, Crowdsourcing, User Co-Creation, Collective Intelligence, Open Innovations, User-Driven Innovations, Lead User and others.

However, less effort was dedicated to the introduction of Open Innovation in organizations and the study of the university – industry collaboration in the context of open innovation.

This theoretical paper analyses and systemizes the main context of knowledge management through Open Innovations systems and distinguishes the main principles on the chosen research topic for efficient university – industry collaboration. Scientific methodological systemization and inductive approach are envisaged.

3. Results

3. 1. The Open Innovation paradigm

The paradigm of open innovation is underscored by the fact that firms can improve their performance by opening up their business models and reducing their R&D costs by effectively incorporating external knowledge. In other words, companies can gain value through knowledge that exists outside their organization. The transition from a closed to an open innovation model necessitated the adoption of a more open approach to innovation within the framework of the traditional academic view of business strategy. The adoption of this innovative approach is further emphasized by the need to strengthen ties and cooperation between participants in the innovation process.

cess. Free will and collaboration are key features of open source software, which is recognized in the literature as a role model for open innovation, and is a fast-growing method of technology development. In addition, innovation communities provide an excellent opportunity to improve companies' innovation, as they have become an important source for identifying user needs and concerns.

P. Haapalainen [3] provides an interesting review about open innovation literature. He states that open innovation "comes in many forms and tastes, which adds to the richness of the concept, but hinders theory development". Openness of innovation, financial issues of knowledge transfer, different knowledge processes, inbound and outbound knowledge flows as well as the effectiveness of the open innovation process are discussed in the review. L. Dahlander and D. M. Gann [13] further presents that open innovation consists of two parts: first, is the way from closed to open innovation, and second are various open innovation practices.

Scientists [13, 14] also provide a broad literature review while they explore the openness of innovation. They conclude that internal capabilities and external relations are complementing rather than substituting each other. Based on inbound and outbound knowledge flows and the pecuniary/non-pecuniary nature of innovation, they introduce four categories of openness:

1) acquiring;
2) sourcing;
3) selling;
4) revealing.

Acquiring and sourcing are related to inbound open innovation, and the former requires processes like licensing or buying, while the latter is more about "taking and using". In the case of outbound open innovation, a company can sometimes sell knowledge to others, but in other cases may simply reveal it to others.

Other scientists [15] also presented a process model for integrating knowledge into open innovation. This model consists of five states: determining the stages of the innovation process, determining the corresponding knowledge about innovations, choosing the appropriate integration mechanism, creating effective management mechanisms and balancing incentives and means of control.

3. 2. Accelerators for Open innovation development

In this context, the Open Innovation (OI) approach is the inflow and outflow of knowledge that accelerates innovation development and enhances the commercialization of innovation [16]. Effective OI requires a flexible and dynamic collaborative organizational structure [17]. More importantly, OI can positively impact business performance by expanding opportunities for innovation, sharing risks and resources, reducing product development time, improving employee participation and increasing access to new knowledge, technologies and markets [18].

The classic concept of an innovative funnel, proposed by expert H. Chesbrough [1] and shown in **Fig. 1**, divides the OI process into three main stages: (i) research projects/studies; (ii) development; and (iii) commercialization.

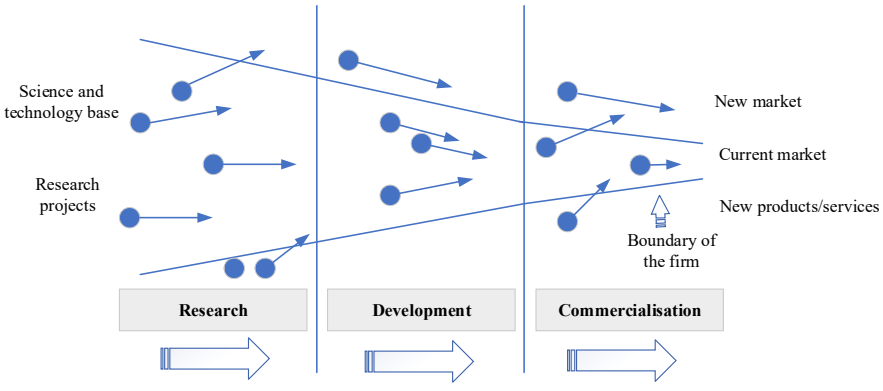

Fig. 1. Open Innovation funnel
Source: Adapted from [1]

At the research stage, firms are looking for ideas, concepts, partnerships and projects from technological and scientific sources. This model emphasizes the fact that external capabilities need to be better explored, which allows for the development of innovation through research on technology and resources [17]. New opportunities, partnerships and projects may arise at the development stage.

However, in essence, the development stage is a filter for projects, selected in the previous stage, which can be addressed to current or new markets and can lead to licensing agreements, joint projects to develop products and services, technology transfer initiatives and the creation of new organizations' capital. Finally, in the commercialization phase, external industry channels are explored to create value for an organization.

3. 3. General framework for university-industry interaction

In the context of collaboration between universities and industry, the process of transferring knowledge from the university to industry, two forms can occur: formal and informal. A formal translation leads to tangible and visible results. Its results include patents, research, license agreement, etc. Although the focus is on formal transfer of knowledge, informal transfer may be beneficial to both parties. Informal transference leads to intangible results. Its influence includes conferences, seminars, social networks, joint research projects, consultations, and skilled employees [19].

While the effectiveness of collaboration between universities and industry discussed in the literature [14, 12], there is a common lack of accurate indicators for measuring and quantifying research performance collaboration. Since measuring intangible knowledge is difficult, the focus is on those aspects of knowledge that are more explicit and easily measurable. Measurement of an approach can be proposed based on quantitative indicators and codified features, such as: number of patents and inventions, made by firms, universities or both, number of solved technical problems, the emergence of subsidiaries, etc. Assessment of benefits and the number of successes also depends on who performs the assessment.

There are often different points of view in the industry, which can reduce the reliability of estimates. Thus, different results can be obtained by different measurement methodologies, especially if evaluation is carried out by different people within an organization.

The proposed structure (**Fig. 2**) is a step-by-step basis for the implementation of joint projects, which begins with the selection of partners, based on key assessment factors. The process of university-industry collaboration continues with steps that actualize cooperation between universities and industry. If these steps work well, the structure will result to mutual results.

The company, as well as the university, should carefully choose a partner, based on some specified criteria. In particular, as noted in case studies and interviews, seven factors seem more important for an adequate choice of partner: mutual understanding, cultural compatibility, additional competencies, shared experience, past collaborating partners, skilled staff and clear agendas.

These are common steps, shown in **Fig. 3**, that can be changed, adjusted or even deleted, depending on the context of the university and the industry collaboration profile, however the main consequential steps remain unmixed.

In recent years, many universities have decided to adopt a philosophy of open innovation, gradually to improve the generation of ideas and the development of unique products and services. However, open innovation still needs to be defined more clearly, as well as its advantages and disadvantages, to encourage more organizations to use this new innovation process. In fact, an organization must know why this wants to use open innovation, what it wants to achieve through this, and how its organizational structure changes with open innovation. In addition, a roadmap is necessary for its implementation.

3. 4. Linking open innovation and university-industry collaboration

While the literature of open innovation has traditionally focused on the knowledge and ideas, flowing from each other, universities can also be a useful source for the transfer of knowledge and technology, not limited to transferring intellectual property defined partnerships between universities and industry in seven classes that:

– Research partnership: conducting joint research and development between organizations;

– Research services: contract research, consulting, university research funding firms;

– Transfer of human resources: differentiated needs by industry, training industry employees, internships and industry training;

– Academic Entrepreneurship: Development and Commercial Exploitation University technological inventions through the company;

– Commercialization of property rights: transfer of university-oriented intellectual property patents and industry licensing;

– Informal interaction: social relations, networks, conferences, etc.;

– Scientific publications: collaborative publications such as magazine articles.

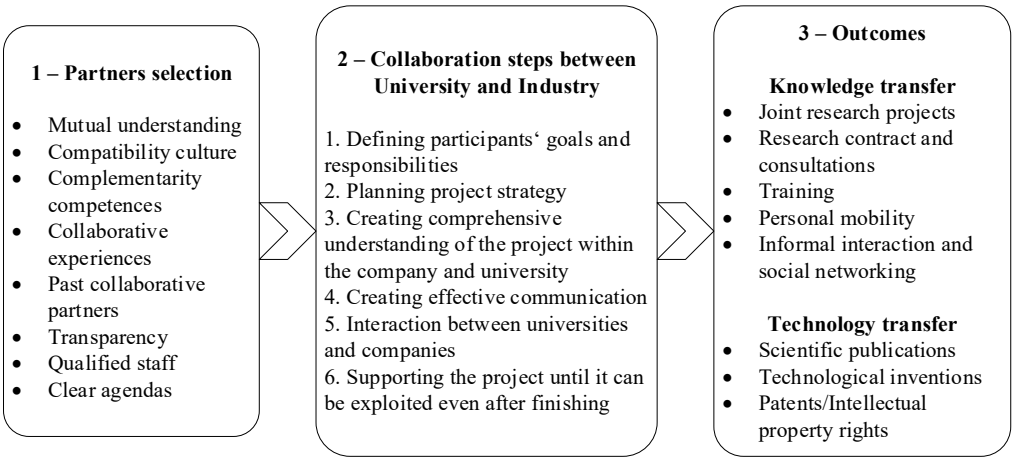

Fig. 2. General framework for university-industry collaboration
Source: Adopted from [12]

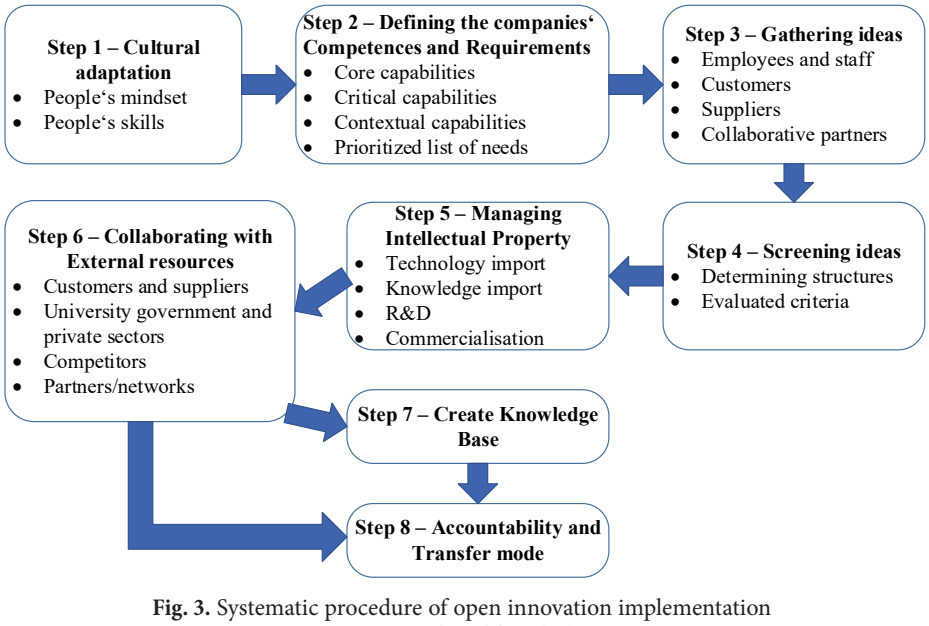

Fig. 3. Systematic procedure of open innovation implementation
Source: Adapted from [12]

In research partnerships, there may be different levels of interaction between industry and scientists' research services. While academic entrepreneurship and the transfer of human resources are interconnected to an average level of involvement in relationships, the commercialization of property rights requires less relationship intensity. Scientific publication and informal interaction, as appropriate, can accompany all forms. In high relations, individuals and teams from academia and industry work together on specific projects to achieve common results.

3. 5. Prototypes of open innovation systems

Looking at the interaction between the direction of the flow of knowledge and the cost of open innovation, scientists [13] classified innovation into four categories: the search, acquisition, sale, and identification of open innovation, as shown in **Fig. 4**.

The first type is the search for open innovation, which means that an organization uses external sources of innovation without monetary compensation. If existing knowledge is free and accessible, an organization can use it to initiate internal technological innovation.

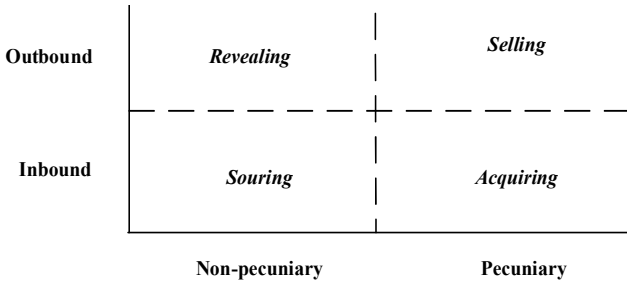

Fig. 4. The prototype of open innovation categories
Source: Adapted from [13]

The second way is to identify open innovation, when an organization reveals its internal resources to the external environment, without receiving a quick financial reward. In particular, organizations do not seek to directly benefit from the disclosure of internal resources.

The third type is the acquisition of open innovation, when an organization acquires valuable external resources along with cash. Firms can drive domestic innovation by acquiring a valuable technology.

The last way is to sell open innovation, which means an organization sells or licenses its internal resources to other firms. Firms can make full use of their internal resources by selling or licensing intellectual property. This will close the gap between inventions and commercialization.

Acquisitions and deliveries are unattainable, and sales and disclosure of information are impractical in terms of the direction of the knowledge flow. This typology of open innovation provides a good conceptual framework for empirical research on open innovation [20].

Theoretically, there are different ways to combine different types of open innovation. Two or three types of open innovation can be combined. Deeper scientific analysis shows that an organization can combine various types of open innovation in almost any way.

Within the open innovation paradigm, each type of open innovation has its advantages and disadvantages. Although previous studies examined in detail both the advantages and disadvantages of open innovation (**Table 1**), this paper shows that a combination of different open innovations is useful in overcoming the disadvantages of open innovation. If the advantages of one type can be used to compensate for the disadvantages of another, an organization can combine these types of open innovation. To overcome the weaknesses of open innovation, an organization can take advantage of this type of open innovation and overcome other types of weaknesses.

Table 1
Strengths and weaknesses of different open innovations

Category	Type	Advantages	Disadvantages
Souring	Inbound innovation	Acquiring external resources for free	Identifying and interesting cost, Some potential limitations
Acquiring	Inbound innovation	Acquiring precious resources	Acquiring cost, Apportion a part of revenue
Selling	Outbound innovation	Capture huge profits	Give up the opportunity for NPD, Share value of internal resource
Revealing	Outbound innovation	Cultivate users, Create opportunities for collaboration	No financial reward

Table 1 summarizes the advantages and disadvantages of the four types of open innovation. Both souring and acquiring can be considered as incoming innovations. In open sources of innovation, a firm can receive external resources free of charge, but it needs to spend time identifying valuable external resources and integrating these resources into new product development (NPD). Moreover, there are many potential limitations to open innovation. In general, open source software is an important external resource for developing new products. However, some intellectual property agreements may require companies to disclose modified source codes. The high cost of acquiring external resources can prevent an organization from introducing open innovation.

3. 6. Knowledge management flows

In fact, the results show that the innovation efficiency of an industry unit improves as a result of intranet outbound innovations, but does not improve due to intranet inbound innovations. In other words, the transfer of innovation-related knowledge between enterprises is beneficial for the provider business unit, but indifferent to the recipient business unit [21]. The combination of a positive and neutral effect on the effectiveness of innovation at the level of business units means that open innovation within the network is generally beneficial for a multidisciplinary organization, but does not exclude situations, in which the innovation of a particular business unit is detrimental to the well-being of the entire multidisciplinary organization [20, 22]. Similar considerations apply to exchanges of business units with their external networks. Incoming innovations across organizational boundaries are beneficial for the innovation activity of a business unit, in contrast to outgoing innovations that have a neutral effect on it.

As it is stated in **Fig. 5**, these results, obtained at the level of business units, show that open innovation is thus favorable for multidisciplinary organizations and networking structures. The fact that outgoing innovations are not beneficial for suppliers' business units does not mean that sales and disclosure of innovations cannot be beneficial for multidisciplinary networking organizations as a whole, even in cases where the interests of specific industry units can be detrimental.

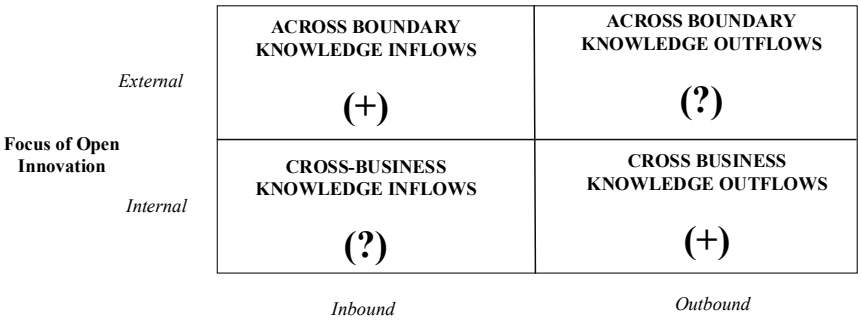

Fig. 5. Open innovation and knowledge flows in networking structures
Source: Adopted from [20]

4. Discussion

However, there are several areas of optional failure of an innovation system. Scientists point out three such failures and argue that stakeholders from various organizations can work together and strengthen each other. The first mistake is related to the degree of interaction: either insufficient interaction between subjects, or too strong interaction, which can lead to the formation of a habit. The second problem mentioned is the absence of inadequacy of actors (often in areas, such as user orientation and user knowledge), as a result of which the chain of innovations is broken. The last problem area concerns a path of dependency and blocking. Organizations, as a rule, remain within the framework of existing working paradigms, which prevents them from thinking outside the box and going beyond a new framework.

One of the new approaches that supports innovation by engaging diverse stakeholders is the Universities eco-innovations systems approach. Universities eco-innovations systems help to solve the problems of mass implementation of ICT solutions as a means of developing society by attracting citizens. This leads users/consumers/citizens to an innovative system. At this type of university-industry, ICT innovations are created and tested in a collaborative, multi-contextual, empirical real-world environment. A person is in the center of attention as a citizen, user, consumer or employee and is considered a valuable source of innovation.

According to scientists [23], the ability of an organization to recognize the value of new external information, absorb it and apply it for commercial purposes is crucial for its innovative potential. The authors designate this ability as the organization's ability to master and suggest that this is closely related to the level of prior knowledge of an organization. The development of capacity building organizations (which increases innovative efficiency) depends on history or the path, and the lack of investment in knowledge in the early stages can adversely affect the future development of technical capabilities in this area. The absorption capacity is associated with R&D, the industry's ability to determine technological capabilities, acceptability (imitation quality or reproducibility) and the interdependence of competitors through its absorption capacity and is associated with R&D expenses.

However, the creation of knowledge and the ability to master can be created without a special R&D unit in university. In some cases, joint research and development can be fruitful (depending on the type of knowledge being created), and trade areas can provide the opportunity for training and joint acquisition of new knowledge. When different communities and stakeholder boundaries intersect or overlap during the course of a project, trade zones may appear. These trading areas can allow previously excellent knowledge to flow in both directions between interested parties or communities. The stronger and richer the trade zone, the easier it is to learn how to travel from one community to another and to get new knowledge to interested parties.

Regarding the problems, associated with the regional integration of the university and industry, the analyzed studies' results pointed out [10, 12, 24, 25] such aspects as administrative bureaucracy, technological uncertainty, distrust, time constraints (such as the slow response time of research institutions), overly complex technology transfer processes and practical difficulties in developing agreements on intellectual property rights and patents.

Moreover, the critical aspect, which most industries calls, concerns what they consider to be incomplete and inadequate staff training for Open innovations' technical and business skills. Researchers noticed that specialists who graduated from local universities are often not ready to work in the Open Innovations model, which requires additional training on specific methods, tools, systems and methods that are commonly used among networks of more advanced industries.

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