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A Knowledge Management Approach for The University-Industry Collaboration in Open Innovation

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Abstract

In the knowledge-based society, universities have re-considered the traditional academic roles, and placed them in a broader context as part of its new role in promoting innovation. Based on existing models there has been developed a framework to analyze how universities support their implication and contribution to local economic development. The proposed approach refers to the university-industry collaboration (UIC) based on the knowledge transfer processes in order to increase their contributions, and influence the socio-economic development at the local level. The framework was represented as an ontology consist of five dimensions and 57 relevant items for potential UIC that were described in order to facilitate the decision-making process when establishing a particular type of contract or project. The main ideas debates in the article are related to the new role of the university in the knowledge-based society; knowledge and innovation transfer processes; the UIC ontology design and development.

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1. Introduction - the new role of the university in the knowledge based society

In the knowledge-based society, universities play an enhanced role in innovation as entrepreneur. They have re-considered their traditional academic roles of social reproduction and extension of certified knowledge, but placed them in a broader context as part of its new role in promoting innovation. Based on the tri-lateral networks and

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hybrid organizations model there has been developed a framework to analyze how universities developed their implication and contribution to local (regional) economic development (Etzkowitz and Leydesdorff, 2000a; Etzkowitz et al., 2000b; Tornatzky, et al., 2002) confirmed by (Meyer et al., 2014) (Figure 1). The Innovation U framework encompasses the boundary-spanning structures that reflect the universities relations with industry, local state, and government through programs development activities of state and local economic development organizations, industrial advisory boards, and councils with business community. These mechanisms are expected to contribute to economic development by producing locally captured (technological) outcomes. These outcomes can be structured in three university roles: education (smart people), research (new knowledge), and the knowledge transfer to society (entrepreneurship, knowledge, technology, expertise).

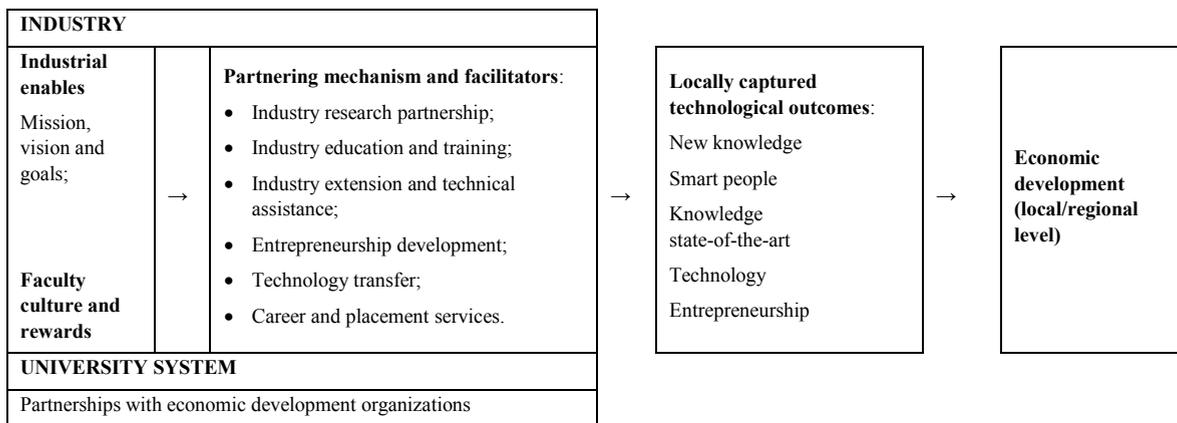


Fig. 1. Innovation U – Conceptual Framework.

The entrepreneurial outcome can be considered as a result of the university-industry-government relationship. According to (Ropke, 1998), the university itself can become entrepreneurial, the university members can become entrepreneurs, and the university interaction with the region can follow entrepreneurial patterns (Van Looy et al., 2011; Gibb et al., 2013).

In the last years, the literature has described the universities as knowledge transfer organizations (KTO) (Geuna and Muscio, 2009; Bodas-Freitas, 2013). The main subjects of knowledge transfer between universities and industrial organizations are related to research collaborations, intellectual property rights (most referring to patents) and start-ups, spin-offs companies establishment (Watanabe, 2009).

Many universities have stated to focus on establishing strong links with knowledge users by facilitating technology transfer through commercialization of academic knowledge (Etzkowitz et al., 2000b; Gulbrandsen and Sliperséter, 2007; Siegel et al., 2003; Siegel et al., 2008; Perkmann et al., 2013). According to the references, commercialization is considered a prime example for generating academic impact and benefits (financial and prestige) because it is an immediate, measurable market acceptance for academic research results (Markman et al., 2008). In order to support commercialization, many universities have established specialized structures, such as technology transfer offices, science parks and incubators (Clarysse et al., 2005; Siegel et al., 2003), and they have created internal rules and procedures to facilitate this activity (Thursby et al., 2001).

The governance of knowledge transfer process between universities and industry has been subject of different researches (Geuna and Muscio, 2009; Muscio et al., 2012; Perkmann et al., 2013; Schoen et al., 2014). The main idea debated is related to the need of a new knowledge transfer model, more efficient in the conditions of the new knowledge-based economy (universities has become knowledge transfer organizations and they are responsible for these processes and for monitoring, centralization). Nowadays, the knowledge transfer activities management is mainly allocated to technology transfer and is focused especially on assessing and protecting intellectual property and making it available to industry (Perkmann et al., 2013).

The typology of knowledge transfer mechanisms between universities and industry, together with the diverse particularities of each process (depending on the university specifics, dimension and research potential, human resources motivation, the specific economic conditions etc. together with the company particularities) have identified many difficulties (Watanabe, 2009; Bruneel, 2010; Ahrweiler et al., 2011; Perkmann et al., 2013). The top three difficulties are lack of skilled personnel, inadequate funds, and poor marketing (market and competition research, and missing of a coherent strategy related to the 4P of marketing – product/services, prices, placement, and promotion).

The university-industry collaboration has achieved a new dimension in the context of open innovation tendencies (Ponds et al., 2010; Chiaroni et al., 2011; Perkmann et al., 2011; D'Este et al., 2012; Leydesdorff, 2013). Since the beginning of the 21st century, innovation has evolved from being the artifact of an individual or internal process within firms to an interactive process between firms and/or in collaboration with knowledge-creating institutions (as universities are) at both the domestic and global levels. The open innovation model suggests that firms should combine external and internal ideas and technologies as effective pathways to market when advancing and commercializing technologies (Wynarczyk et al., 2013; Leydesdorff, 2013).

Based on relevant researches of Perkmann et al. (2013) and Leydesdorff (2013) there have been conclude that the collaboration between university and industrial partners/organizations in the open innovation context aims to support companies and universities to share their research and development resources (knowledge, ideas, expertise, patents etc.) in order to better develop and valorize the created products and services. An essential aspect of this new challenge of collaboration is that universities and their industrial partners have to share their innovation capacities (West and Bogers, 2013; Huff et al., 2013).

In accord with the above considerations, the present research will be focused on important issues of the knowledge/wisdom/innovation transfer processes for nurturing the university-industry collaboration simultaneously with the entrepreneurial education development in the universities environment. Forward, there will be described a proposed approach for the university-industry collaboration (UIC) based on the knowledge/wisdom transfer processes developed and gained by these two actors in order to increase their implication, contributions, and impact to social and economic development at the local/regional level. The approach framework will be represented as an ontology of potential types of collaborations, channels of knowledge/wisdom transfer opportunities and innovation transfer that were described in order to facilitate the decision making process when establishing a particular type of contract between an university and an enterprise. The main chapters of the article are: (1) Introduction - the new role of the university in the knowledge based society; (2) The knowledge transfer processes; (3) The ontology of university-industry collaboration (methodological aspects of the research and results); (4) Conclusions and future work.

2. The knowledge transfer processes (the university perspective)

From the purpose of the presented research, the university will be analyzed as a source for knowledge processes development (in accordance with its traditional and new mission); mainly there will be considered the knowledge transfer process that could be initiated and supported by universities.

For the knowledge transfer study, in Table 1 are briefly described the ten most mentioned activities between universities and external partners (Ropke, 1998; Tornatzky, et al., 2002; Perkmann et al., 2013; Schoen et al., 2014). The purpose of this inventory is to get an overview of the different type of activities that are carried out by a university in the field of knowledge transfer and that can be considered for the collaboration with potential industrial partners, too. Different departments of the university (in accord with its mission, vision, and goals) enroll these activities.

Each activity presented in Table 1 can be relevant for the entrepreneurial behavior of the universities researchers, and they have to be correlated with knowledge transfer intimate process that is developed through the learning process (Figure 2). The mechanism of knowledge transfer through education/learning presented in Figure 2 shows how researchers accumulate knowledge and wisdom through the learning process (get expertise). In addition, this mechanism could explain how young researchers can be developed through the education/learning process, supported by research teams and their sharing experiences. Knowledge externalization and socialization in the research group of specialists are important activities in human resources development process. These activities are

based on the knowledge transfer process inside and outside the research groups (open innovation could better support the knowledge creation process through the knowledge transfer processes).

In this context, the identification of knowledge transfer activities allowed the characterization of the mechanisms by translating into a scale of increasing mutual obligations or increasing cooperation and integration (Figure 3). Two main stages of cooperation are distinguished: the traditional knowledge transfer organization (the first stage, 1) and the virtual knowledge transfer organization (the last stage, 7). In our days, two or more universities cooperate on specific purposes and projects at the national or international level (e.g. in the European projects). This virtual knowledge transfer organization can cover the exploitation of a collective intellectual property portfolio or joint projects for specific research areas.

Table 1. List of the ten most mentioned knowledge transfer activities (adapted from (Ropke, 1998; Tornatzky, et al., 2002))

No.	University knowledge transfer activities	Description
1	Patents and licensing	This refers to the exploitation of intellectual property. Through its patents an higher education organization can protect its intellectual property and if a patent is guaranteed it can be commercialized through sales of the patent or the license.
2	Spin-off and enterprise creation	A spin-off company is a new company whose formation was dependent on the use of intellectual property that was created and/or developed at a Public Research Organization; spin-off is the entrepreneurial route to commercializing knowledge of public research, both intellectual property and non-intellectual property based.
3	University-industry networks	This describes the dynamic two-way interaction, university-industry in the collaborative networks.
4	International cooperation	This refers to the cooperation of the university with public and private organizations, beyond the national borders.
5	European affairs	It is related to the management, acquisition and monitoring of the European projects and the European funding.
6	Continuous professional development	This comprises the post-initial education programs aiming at improving the capability and realizing the full potential of professionals at work.
7	Alumni affairs	It is related to the alumni contacts management.
8	National subsidies	National government programs and policies intended to encourage certain types of research programs and other specified university activities.
9	Regional subsidies	Regional government programs and policies intended to encourage certain types of research programs and other specified university activities.
10	Grants	The government or other non-profit organizations to encourage (individual) development or growth in a particular area provide them.

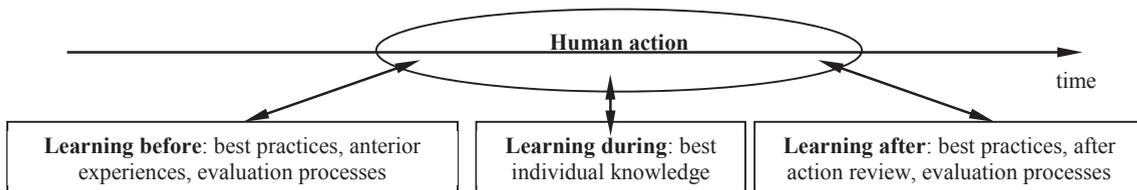


Fig. 2. The learning mechanism through the knowledge transfer process associated with human action (activities).

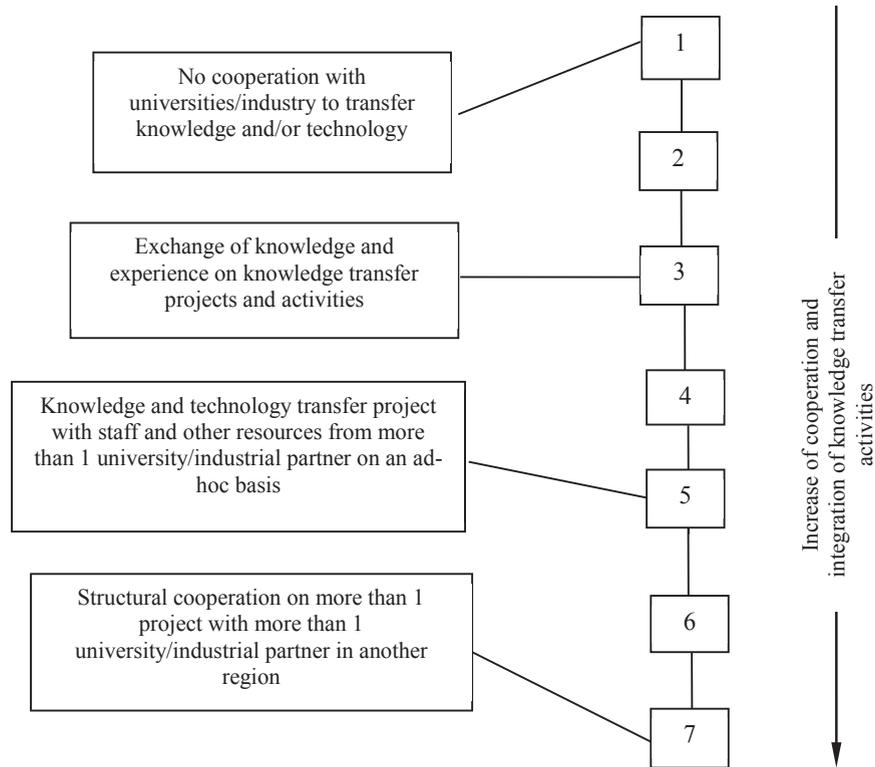


Fig. 3. Evolution of the integration and cooperation of knowledge transfer activities and mechanisms (adapted from (Ropke, 1998; Tornatzky, et al., 2002)).

Started from these items and based on the knowledge transfer activities described in Table 1 in the following it will be presented the proposed approach with the objective to identify the specific activities and mechanisms for the university-industry collaboration and the definition of the related ontology. This inventory (structured information and knowledge) was developed in order to support the decision-making process in choosing the right (effective and efficient) partnership and to mitigate risks.

3. The UIC ontology design and development

3.1. Arguments for the proposed approach

The development of the proposed new model has to be design within the historical context of the last year's dynamics in the knowledge management science and particular, in the field of knowledge transfer, in correlation with the new mission of universities. The following issues have been considered:

1. Universities have been transformed into knowledge organizations and they are drivers of innovation and business productivity, generating competitive advantages (Cohen and Noll, 2002; Nonaka and Takeuchi 1995);
2. The emergence of "new" technology driven industries, such as biotechnology, information and communication technology and nanotechnology, where scientific knowledge is particularly relevant (Geuna and Muscio, 2009);
3. The growing demand for a more skilled workforce, which resulted in an increase number of students and this could be essential for the knowledge economy (considered as a pull factor) (Geuna and Muscio, 2009);

4. Increased numbers of students completing secondary education and the increasing attraction of universities in terms of cultural capital (considered as a push factor) (Geuna and Muscio, 2009);
5. The increasing reliance on universities as policy instruments to drive local/regional development processes, and key actors in regional innovation systems, involving wider engagement of universities with their cities and communities, society and the economy and culture generally (Florida, 2002). In this context, universities could play an essential role in sustainable development strategies implementation and they could be examples in the case of social responsibilities practices in their local communities;
6. Pecuniary factors, as the government budget constraints that conduct to the reducing of financial support for university research in many countries (Geuna and Muscio, 2009).

In addition to these aspects, we assist to other two important phenomena that have affect the research and development activities nowadays, mainly in Europe:

- Ageing population that implies the reconsideration of some products (goods), processes (services processes, and product using process by considering the new anthropometry of user interface), and systems (as transport systems) in accordance with new customers requirements (limits);
- The migration phenomena that induce new dimension of the collaboration in a multicultural context (managing diversity and international human resources perspective are important approaches of research groups' management).

These preliminary considerations and perspectives have contributed to the research design approach of the UIC ontology. The main reason for this approach is to unify the different checklists or internal procedures available in universities for the analysis and evaluation process in the case of their collaboration with a potential industrial partner for the technical contract (consulting type) design and implementation (development). This will better support the decision making process in terms of early discover corrective measures for risks mitigation during the contract implementation. The created UIC ontology will allow integrative analyze the UIC process from the early stage of the contract initiation.

3.2. *The proposed approach for the university-industry collaboration (UIC)*

The proposed framework of the UIC was developed as an UIC ontology (finally as a Knowledge Application that could be easy exported in a Web platform). Ontology could be seen as taxonomy of concepts and their definitions supported by a logical theory. According to Huhns and Singh (1997), ontology is often captured in the form of a semantic network - a graph whose nodes are concepts or individual objects and whose arcs represent relationships or associations among the concepts. Denny in 2002 has suggested since that ontology is built in (more or less) the following manner: acquire domain knowledge; organize the ontology; check the work; commit to the ontology; Ontology building process has to be focused on what the ontology is required for (Gruber, 1993).

The developed research activities were:

- (a) Building the ontology with the purpose of generating a common reference language among researchers and future users that can overcome differences in culture, location, and fields of expertise in order to unify the practice of UIC;
- (b) Develop and implement a central knowledge application (KApp) that will allow easy risk identification and knowledge-sharing capabilities;
- (c) Implementing information technology enabled one-to-one or many-to-many communications capabilities to complement the face-to-face meetings between experts involved in UIC analysis a decision-making processes (that will be developed in a distributed manner, virtually).

The UIC ontology enables the decision-making process, knowledge sharing, and reuse. Initially, the ontology had two objectives:

- To ensure a common understanding of specific terms, concepts that are associated with a UIC process (during its lifetime) describing the following dimensions: *motivation factors, barriers, channels for the knowledge transfer, benefits and disadvantages* related to each aspect and each type of actor involved (public-private university; small or big companies etc.);
- To provide the structure of a complete knowledge map by consider the global framework Innovation – U (Figure 1) and the list of the 10 most mentioned knowledge transfer activities developed by universities (Table 1).

A secondary goal of the developed ontology was to enable explicit charting (mapping) of the mentioned dimensions to clearly define and locate each item and to develop a concise, extended database with all aspects related to a UIC. Table 2 described the adopted research methodology.

Table 2. The research methodology description (adapted from (Baban, 2013))

No.	Research activities	Description
1	Reference research on UIC	<ul style="list-style-type: none"> • Identification of the universities new role in the knowledge based society (Innovation U – Conceptual Framework definition and identification of the actors involved in UIC) • Description of the university as knowledge transfer organization • Description of entrepreneurship university concept • Inventory of the most listed knowledge transfer activities developed by universities • Literature review on academic engagement and knowledge commercialization
2	Reference research on open innovation	<ul style="list-style-type: none"> • Description of the concept approaches and methodologies of open innovation process with universities. • Identification of motivation factors, barriers, channels for the knowledge transfer, benefits and disadvantages of the university-industry collaboration in the open innovation context • Inventory of the gaps in UIC
3	UIC ontology development (theoretical researches)	<ul style="list-style-type: none"> • Definition of the ontology structure and the sub-Ontologies (top bottom approach) • Design and development of the items define for each sub-Ontology (bottom-top research) • Ontology building - adjustments and visualization of the research results • Test and validation (case study on existing UIC in our universities)
4	Marketing research on UIC in open innovation	Identifying the main dimensions of UIC in open innovation

3.3. The basic structure of UIC ontology

Using appropriate software application (MindManager, www.mindjet.com/mindmanager) the knowledge map, that describe the UIC ontology as a KApp, was first structure (the future software application allow the tree structure development) and build-up, including the description of each item in the related to each sub-Ontology: *motivation factors, barriers, channels for the knowledge transfer, benefits and disadvantages* (dimensions of the proposed framework). The UIC ontology design allows the analysis and optimization of the different UIC processes, activities or interdependences by considering different items depicted in the sub-Ontologies. Therefore, each item has been detailed, for its complete characterization using relevant, actual references and existing regulations, norms for research and development activities in Romania.

A bottom-up approach was applied in order to detail further levels of gather instances and documents for each ontology item. Together with the in-puts of experts and specialists from industry and academia there have been developed an effective UIC ontology that include 5 sub-Ontologies and in total 57 items that were described (and have to be analyze in a situation of potential collaboration and they have been explained from the university and industry perspectives). The synthesis of the preliminary research result is shown in Figure 4, presenting only the first and the second level of the ontology (second level was considered as sub-Ontologies in the proposed approach). The other levels were particular build and developed based on the existence knowledge available in the literature and by collecting information from UIC practice. Then for each final item of the knowledge map there was define a specific file (note) with a detail description (including relevant references, aspects according to some existing regulation, with some examples and case studies from particular UIC experiences depending of the university, industry and

collaboration type). These notes are definitions of database elements that were created simultaneously with the knowledge map.

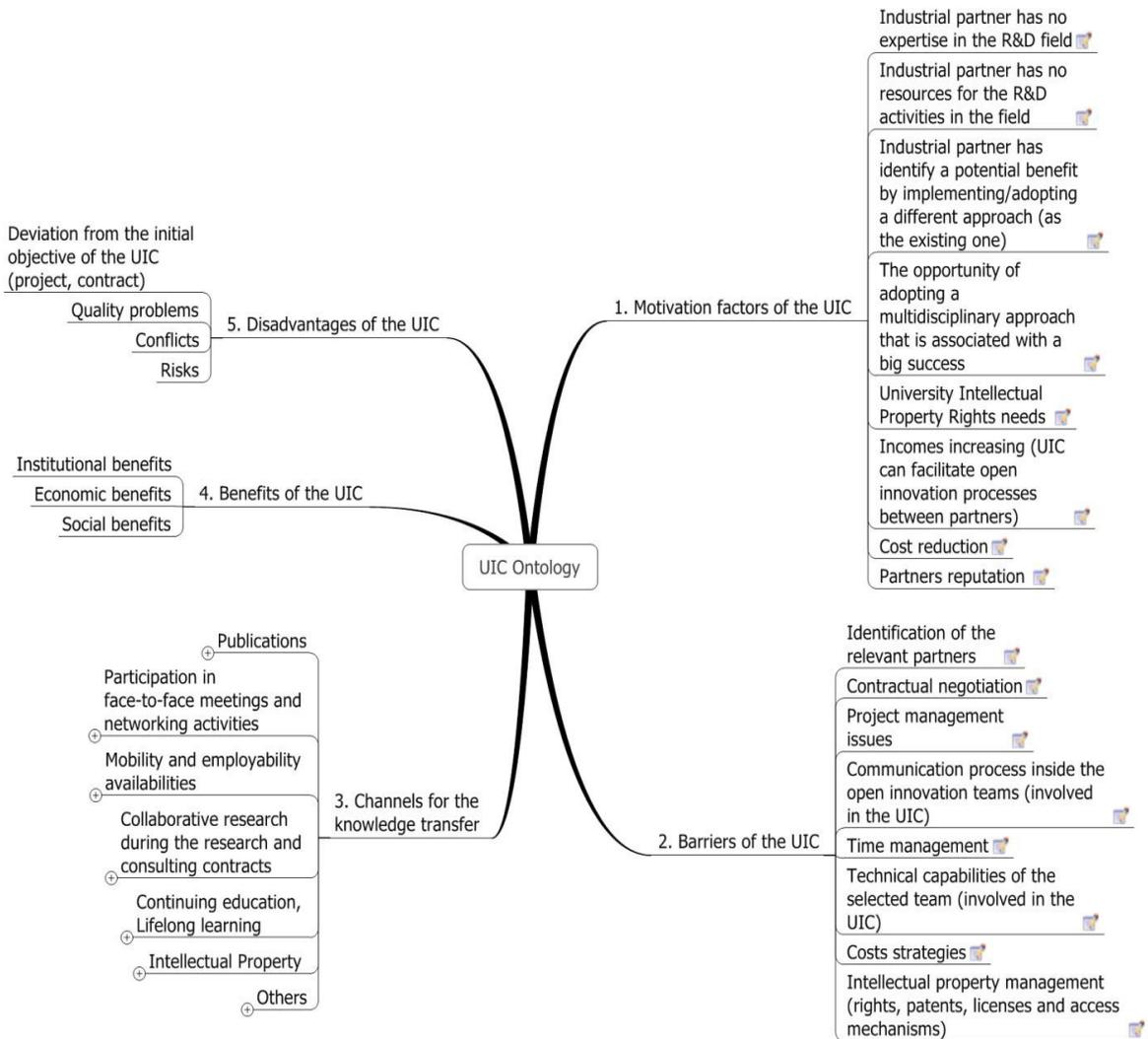


Fig. 4. Detail of the UIC ontology (the first and second level).

4. Conclusions and future work

The article aims to present an original, interdisciplinary approach of the collaboration between universities and industry. The approach proposed is based on studies conducted by consulting references in recent years, in order to identify the new role that has university in the knowledge society (and to anticipate its future role in the society based on responsibility). First, there were discussed elements that led to the development of a new conceptual model (Innovation U, Figure 1) by characterizing the university - industry relationship and by emphasizing the impact of this relationship on the local/regional economic development. In addition, there have been panned relevant aspects of the university as knowledge transfer organization (the most common ways of action are collaborating in research, intellectual property rights and the creation of new start-up companies, spin-off etc.). The high universities' concern

for this type of activity is driven by the need for academic marketing knowledge and thus getting immediate benefits in financial terms, boosting research and teaching activities, improving their prestige and recognition (results often associated with the knowledge transfer in learning or research processes).

The bibliographical research has identified as a driving factor of the university knowledge transfer:

- The academic staff entrepreneurial behavior (which can lead to the development of entrepreneurial universities),
- The ability to identify potential risks and obstacles associated with the transfer process,
- The ability to combine in an innovative manner, external ideas and technologies by facilitating open innovation (as a solution that can support technology transfer by commercialization of academic knowledge).

In this context, have been identified ten most mentioned knowledge transfer activities and there have been described the particularities of the process at the university level and at the individual level.

In the last part of the paper were presented aspects related to the creative processes that were the basis for the UIC ontology design and development. The ontology could be considered as a framework model (conceptual model) for managing knowledge transfer between universities and industry (in the particular case of Romania). The preliminary research results on the structure and minimal detailing of the 57 items included in the UIC ontology (developed by our experience gathered in different collaboration with industry), entitle us to consider the solution feasible.

In the future, the research will focus on the following directions:

- Defining all items description in the UIC ontology;
- Testing and validation of the UIC ontology in the case of some existing collaborations between our universities and industrial partners (in the context of open innovation);
- Marketing research development in order to characterize the university-industry collaboration dimensions, by considering the framework of the UIC ontology;
- Develop a web platform based on the UIC ontology as a tool for supporting universities-industry collaboration (measurement of the UIC performance).

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