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A Proposed Model for Measuring Performance of the University-Industry Collaboration in Open Innovation

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The paper aims to present a scientific approach to the creation, testing and validation of a model for performance measurement for university-industry collaboration (UIC). The main idea of the design process is to capitalize on existing success factors, facilitators and opportunities (motivation factors, knowledge transfer channels and identified benefits) and to diminish or avoid potential threats and barriers that might interfere with such collaborations. The main purpose of the applied methodology is to identify solutions and measures to overcome the disadvantages, conflicts or risk issues and to facilitate the open innovation of industrial companies and universities. The methodology adopted was differentiated by two perspectives: (1) a business model reflecting the university perspective along with an inventory of key performance indicators (KPIs); (2) a performance measurement model (including performance criteria and indicators) and an associated methodology (assimilated to an audit) that could help companies increase collaboration with universities in the context of open innovation. In addition, in order to operationalize the proposed model (facilitating practical implementation), an Excel tool has been created to help identifying potential sources of innovation. The main contributions of the research concern the expansion of UICs knowledge to enhance open innovation and to define an effective performance measurement model and instrument (tested and validated by a case study) for companies.

Keywords: university, industry, collaboration, knowledge management, performance model

Introduction

Starting with the researches of Etzkowitz and Leydesdorff in 2000, universities' roles have been reconsidered from the innovation promotion perspec-

tive. Researchers retain the traditional academic roles of social reproduction and extension of certified knowledge, but placed them in the broader context of a knowledge-based society. Based on tri-lateral networks and a hybrid organizations model, the Triple Helix framework of Etzkowitz and Leydesdorff underline how universities can develop their implication and contribution to local (regional) economic wealth. In this context, third mission's activities of universities are related to generation and application of knowledge outside the academic environment. This is currently a topic of growing importance in the agendas of both research and education policymakers, as well as of university administrators. Academic and scientific communities have recognized that 'universities are the fuel that propels knowledge-based economies' (Comacchio, Bonesso, & Pizzi, 2012; Perkmann & Walsh, 2009).

In the last decade, university third mission has been reconsidered in the new economic context by refining academic strategy (Laredo, 2007; Trencher, Yarime, McCormick, Doll, & Kraines, 2014; Etzkowitz & Leydesdorff, 2014). Furthermore, universities worldwide have intensified their effort in creating visible and strong achievements for their communities and society, and have thus actively participated in economic development, in addition to their own regular research and teaching achievements (Lai, 2011; Perkmann & Walsh, 2009).

This new emergent mission focused on economic development through several types of implications, such as collaborations or networks with business or industrial partners, which have been proved to be effective and efficient ways of nurture that generate mutual economic benefits (Etzkowitz & Leydesdorff, 2014). Furthermore, research and development interactions between universities and partners from the real economy 'represent the type of link by which the main influence of science on economy is carried out' (Morandi, 2011). Relevant researches have underlined a direct positive dependency between collaborating with a university and the innovation capacity of an economic entity (such as enterprises, companies or even public bodies) (Spithoven & Knockaert, 2012). University-industry collaborations (UICs) have a positive impact on universities knowledge processes development, too (Kinyata, 2014).

Despite the overall recognized role universities play as knowledge providers in order to support technological innovation (Thune, 2007; Vuola and Hameri, 2006; Ng, Lee, Foo, & Gan, 2012) and despite the positive dynamics of UICs, some challenges have been identified and they need special attention in order not to lead to conflicts among the involved actors. There are still interests' differences between universities and economic entities. These could be transferred into differences in their motivations and expectations in terms of collaboration outcomes:

- Universities are most interested in creating knowledge that is public and accessible through publications and patents (Ahrweiler, Pyka, & Gilbert, 2011; Zukauskaite, 2012);
- Industrial entities' main objective is to generate profit by taking ownership of the economic value of new knowledge in order to achieve a high level of competitiveness (and this should be done in a short period);
- Universities focus on long-term research based on academic objectives, whereas firms face a changing environment, which requires them to focus on shorter-term research (Lee, 2011).

The main research questions that this article addresses are related to the Romanian context of UICs development:

- How can the performance of UICs be measured and evaluated?
- Which are the particularities of UICs performance measurement by universities and enterprises?
- In both cases, which could be the relevant key KPIs that could be considered?

The paper aims to present a model for measuring the performance of UICs. The core idea of the model design is to valorise existing success factors and opportunities, and to diminish or avoid the potential threats and barriers that could interfere with collaboration. The performance-measuring model is based on the created ontology of UIC in open innovation as developed in a reference review and creative common work of a research group of experts in the context of a Romanian research and development project. The main ideas of the article refer to: (1) description of the adopted methodology and the research context; (2) description of the designed UICs ontology and the process of its testing and validation; (3) description of the performance measurement approach for UICs from the industry perspective; (4) case study for testing and validation of the theoretical researches (a pilot research).

The main innovative practical contribution of the research refers to the usefulness of the performance measurement model and tool (preliminary tested and validated), which have been proved as valuable in enabling the strategic alliance management between universities and industrial partners.

Literature Review

Universities as Active Actors of Open Innovation Processes

In the actual context of the education market dynamics, universities are more and more involved in open innovation practices in order to achieve

their third mission. Their capabilities of building networks in research, development and innovation projects, but also their capacities to support knowledge management processes with external partners, support their initiatives in successful open innovation processes. Chesbrough (2003) recognized that universities have moved from a so-called closed innovation system to an open innovation one. Other studies have debated the university ways of implications in open innovation processes, by showing process models associated with knowledge flow between both actors (Laredo, 2003; Geuna & Muscio, 2009; Draghici, Foldvary-Schramko, & Baban, 2015).

While the term 'open' may include a number of factors as legal, economic etc., the process of supporting and encouraging networking (for innovation and creativity increasing) refers to public-private partnerships as university-industry cooperation or collaboration. Researchers and practitioners from the academia have considered this innovation context as a key element for European universities (referring to their research units). In addition, it has been underlined the fact that universities 'play a leading global role in terms of top-level scientific out-put, but lag behind in the ability of converting this strength into wealth-generating innovation' (Maassen & Stensaker, 2011).

Opinions on UICs Performance Measurement

Measuring the performances of UICs was the subject of different studies from different perspective:

- The Perkmann, Neely, and Wals (2011) have underlined the motivation and benefits of firms when building alliances with universities. The subject has been present in their previous work (Perkmann & Walsh, 2009). Based on the analysis, a success map with metrics has been designed by considering relevant components of input, of processes, of output and of impact (outcomes). The proposed model included appropriate metrics for each of the component. Authors recognized the difficulties of the model application and that researchers should investigate the challenges encountered by firms in setting up and managing performance management systems;
- Other authors have used the bibliometric approach to measure UICs performance, to demonstrate universities performance in the field (Ankrah, 2007), but this assessment model is of most interest for universities;
- Other group of researches have developed a model based on the Balanced Scorecard for measuring the results of UICs (Flores, Al-Ashaab, & Magyar, 2009; Al-Ashaab, Flores, Doultsinou, & Magyar, 2011). This was a consequence of the idea of introducing key performance indi-

cators (KPIs) for the performance measurement in the case of UICs (Lee, Lee, & Kang, 2005).

Despite the different approaches of UICs performance measurement presented in the literature, there is still a gap of knowledge. The main limits of the actual researches are related to their practical exploitation and the difficulties that may occur when a specific model should be implemented in a company engaged in open innovation processes with universities. Our research approach is focused on fulfilling this gap and overcoming these disadvantages.

Brief Description of the Research Context

The context of the proposed methodology development and implementation has been defined by the national project entitled 'Knowledge Management-Based Research Concerning Industry-University Collaboration in an Open Innovation Context' (contract no. 337/2014, project code PN-II-PT-PCCA-2013-4-0616, acronym: UNIinOI). The project partnership consists of three Romanian public universities (University of Oradea, Politehnica University of Timisoara, and the Technical University of Cluj-Napoca) and a small Romanian company (EMSIL TECHTRANS Ltd.), which agreed to collaborate in order to implement an approved working plan. The project objective was to develop a procedure for nurturing an open innovation environment between universities and industrial partners, as well as to design a performance measurement model of UICs that can support industrial partners (this perspective was of main interest).

Methodological Aspects

The adopted research approach aims at designing the performance measurement model of UICs, in particular from the perspective of the Romanian industry that needs to intensify the open innovation processes, and consists of four phases. They were inspired by the LEAD framework (Learn, Energize, Apply and Diffuse as represented in Table 1) adapted from Flores et al. (2009) and Al-Ashaab et al. (2011), and which has been proved to be a feasible approach for collaborative projects of universities with industry (the case of CEMEX – Cranfield University research project).

Each phase of the methodological approach are described in Table 2.

The definition of the UICs ontology (in phase two, ENERGISE) has been done following the next steps: (a) identification and selection of the dimensions and items to be considered; (b) documentation and debate on the items definition and their adaptation to the UICs Romanian specificity; (c) the ontology building and visualization. This stage was completed with the test and validation of the designed UICs ontology. In addition, some

Table 1 LEAD Methodology Applied in the Case of UNIinOI Project

Phase 1 (2014): Learn	Literature review on UNICs, university third mission, UNICs from the university and industry perception, facts and challenges. *Results:* Background theory and best practices of UNICs.
Phase 2 (2015): Energise	Synthesis on key aspects of UIcs: motivation factors, barriers, channels for knowledge transfer, benefits and disatvantages. Buiding and visualisation of the ontology. Conducting a diagnosis for UICs in the case of three Romanian universities (public). *Results:* UICs ontology definition.
Phase 3 (2016–2017): Apply (exploite)	Definition of the UNICs business model (applied for the Romanian universities). Performance measurement model design for the UNICs, applying in industry. Designing the associated methodology for the performance measurement model (procedure of practical exploitation). *Results:* UNIinOI_BSc model and methodology; test and and validation.
Phase 4 (2014–2017): Diffuse	Dissemination of the research results on UICs (international conferences and journal).

considerations on the business model development related to Romanian universities were included in order to better fundament phase three (APPLY) of the LEAD framework.

In the phase three of the proposed approach, six evaluation criteria were considered; for each of them, key performance indicators (KPIs) were associated. Based on these, working procedures and the UNIinOI_BSc model for the performance measurement model were designed. For the purpose of the model's preliminary testing and validation, an UNIinOI_BSc tool was designed (an Excel software application) that allow score calculations for each KPIs and the graphical representation of the assessment results.

After considering the research results gained by the project team in the following chapters of the article, we will present the main findings that were convergent to the design of the performance measurement model of UICs.

The University-Industry Collaborations Ontology Designed, Testing, and Validation

The Design Phase

In order to define a coherent performance measurement model of UICs, the created conditions and the environmental context of the collaborative and creative work between universities and industrial partners were investigated. The UICs ontology definition is based on this preliminary investigation.

The established framework consists of five dimensions described by 30 relevant items, which have been defined for suitable ontology exploitation (transformed and assimilated with an evaluation model of the universities capacity to collaborate with industrial or business partners). The main is-

sues for the characterization of ontology dimensions were inspired mainly by the previous work of Ankrah (2007). Furthermore, the early research results of the UNIinOI project's team, were considered in defining the ontology, while analysing the knowledge transfer processes in the context of UICs (Draghici et al., 2015; Draghici, Baban, Ivascu, & Gaureanu, 2016; Ivascu, Cirjaliu, & Draghici, 2016).

The integration of relevant research results from the literature and their adaptation to the concrete situation of UICs in Romania were conducted within the definition of UICs ontology dimensions together with their representation as a hieratical structure (Table 1).

Based on Ankrah (2007), Van de Vrande, de Jong, Vanhaverbeke, and De Rochemont (2009), Padilla-Melendez and Garrido-Moreno (2012), Draghici et al. (2015), Draghici et al. (2016) and Ivascu et al. (2016), the following items were considered for the first dimension 'motivation factors:'

1. Industrial partner has no expertise in the research field;
2. Industrial partner has no resources for research activities in the field;
3. Industrial partner has identified a potential benefit by implementing or adopting a different approach;
4. The opportunity of adopting a multidisciplinary approach is associated with big success;
5. University intellectual property rights needs industrial valorisation;
6. Incomes increasing through the facilitation of open innovation processes in UICs;
7. Industrial partner can get considerable cost reduction related to research and development;
8. Both partners reputation assure successful results of UICs.

For the 'barriers' dimension of UICs there the previous researches of Van der Meer (2009), Bruneel, d'Este, and Salter (2010), Howells, Ramlogan, and Cheng (2012), Draghici et al. (2015), Draghici et al. (2016) and Ivascu et al. (2016) were considered. In this case, the main items of characterization were:

1. Weaknesses in relevant partners' identification, selection and recruiting;
2. Weakness in contractual negotiation;
3. Weaknesses in issues regarding the project management in UICs;
4. Weaknesses regarding the communication process between partners of the UICs for open innovation processes development;
5. Weaknesses in time management;

6. Technical capabilities weaknesses of the selected teams involved in the UIC;
7. Weaknesses of the cost management strategy;
8. Weaknesses regarding intellectual property management associated with the innovation transfer between partners involved in the UIC.

Another dimension of ontology are the 'channels of the knowledge transfer' and it was defined by considering the research results of Van der Meer (2009), Alexander and Martin (2013), Draghici et al. (2015), Draghici et al. (2016) and Ivascu et al. (2016). The items of characterization in this case are:

1. Publications of all types;
2. Face-to-face meetings and networking activities between partners involved in UIC;
3. Mobility and employability availabilities;
4. Collaborative research during the UIC's contract development;
5. Activities of continuing education or lifelong learning supported in by UIC;
6. Intellectual property products;
7. Other dissemination activities and products share between UIC partners and using different environments (off-line, on-line).

The dimension 'benefits' of UICs has been described using the findings of Ankrah (2007), Draghici et al. (2015), Draghici et al. (2016) and Ivascu et al. (2016). The characterization items refers to the following aspects:

1. Institutional or organizational benefits of both actors involved in UIC;
2. Economic benefits (improvement of economic indicators);
3. Social benefits.

For the 'disadvantages' dimension of the ontology, the research results of Ankrah (2007), Draghici et al. (2015), Draghici et al. (2016) and Ivascu et al. (2016) were considered, and the items of characterization were:

1. Deviations from the initial objective of the collaboration or project or contract (more often delays generated by unpredictable situations or aspects that may occur);
2. Quality problems (UIC do not meet industrial requirements);
3. Conflicts or misunderstandings that may occur between UICs' partners;
4. Appearances and development of risks that were not estimated or were badly managed.

The creative work developed in a collaborative manner by the specialists from the three Romania universities and partners in the UNIinOI project have led to the UICs ontology configuration. Based on partner experiences and expertise in UICs, the ontology was used as a basis for the definition of the evaluation approach regarding the actual state of involvement by Romanian universities in collaborative projects or contracts with actors from the business environment (particularly with industrial actors). In order to achieve this task, several face-to-face and virtual sessions were developed between partners from December 2014 until December 2015. The UICs ontology versions' visualization were done using the facilities of the MindManager software tool (www.mindjet.com). This has been a useful tool to support the collaborative design sessions between partners, as well as for the graphical modelling (Table 2).

The UICs Ontology Test and Validation

The designed UICs ontology dimensions and items were used for the implementation of a survey scenario in order to test and validate the preliminary research results. The ontology items were transformed into questions that defined a proposed questionnaire in order to characterize the main dimensions of the UICs. The designed questionnaire allowed the collection of responses related to each dimension and item; the respondents' opinions or perceptions (answers) were evaluated based on the Likert scale with 5 points (1, totally disagree/unimportant, . . . 5, totally agree/very important).

The dimensions considered for the analysis, together with their items for characterization, were codified as shown in Table 1. In addition, a mathematical model was established for the related scores calculation: scores related to the D1, D2, D3, D4 and D5 dimensions and for the total score (T). In the case of dimension D3 'channels for knowledge transfer,' an open question was included that was not considered for the mathematical approach. Finally, the developed model for the evaluation of the UICs consisted of five dimensions and 29 related items.

Answers of the applied survey were collected through face-to-face meetings with Romanian researchers (managers from different levels of the research domain and research staff were subjects of the survey) who belonged to three research communities within three Romanian public universities involved in the UNIinOI project. The collected responses were processed (using Excel software facilities) by the responsible person of each university and the global research results determined the UICs foot print (radar graphic).

The testing and validation approach of the designed ontology benefited from the support of the research communities from the following Romanian universities: Politehnica University of Timisoara (UPT), University of Oradea

Table 2 The UICs Ontology General Overview

Motivational factors	Industrial partner has no expertise in the R&D field. Industrial partner has no resources for the R&D activities in the field. Industrial partner has to identify a potential benefit by implementing/adopting a different approach. The opportunity of adopting a multidisciplinary approach that conduct to a successful solution. University intellectual property rights needs. Incomes increasing (facilitates open innovation processes between partners). Cost reduction. Partners reputation.
Barriers	Identification of relevant partners. Contractual negotiation. Project management issues. Communication process for open innovation between partners involved in the collaboration. Time management. Technical capabilities of the selected teams (involved in the collaboration). Cost strategies. Intellectual property management (rights, patents, licences and access mechanisms).
Channels for the knowledge transfer	Publications. Participation in face-to-face meetings and networking activities. Mobility and employability availabilities. Collaborative research developed during research and consulting contract. Continuing education and lifelong learning. Intellectual property.
Benefits	Institutional benefits. Economic benefits. Social benefits.
Disadvantages	Deviation from the initial objective of the collaboration (project, contract). Quality problems. Conflicts. Risks.

(UO) and Technical University of Cluj-Napoca (UTCluj). The research sample consisted of researchers from those three universities and the questionnaires were collected from September 2015 until November 2015, using face-to-face meetings. Table 2 presents the research results gained after the fill-up questionnaires were processed, for each university. In Table 3 the UICs foot print graphs are presented for each university involved in the research together with the ideal profile (maximum score achieved for each considered dimensions).

The research results (Table 2) shown similar opinions and attitudes of the respondents from each university related to UICs. The Total/university (3.55, 3.68, and 3.59) scores demonstrate that existing collaborations are developed with difficulties in the field of knowledge and innovation trans-

Table 3 The Mathematical Model Adopted for the UICs Foot Print Determination

Code	Dimension	Score/item/dimensions' score	
D1	Motivation factors	$X_1 = (1x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5)/5,\ i = 1,\ldots,8$ $D1 = (\sum X_i)/8,\ i = 1,\ldots,8$ $X_1 \ldots X_8$ – absolute value of the score by each item $x_1 \ldots x_5$ – number of responses related to the Likert scale points	(1) (2)
D2	Barriers	$X_1 = (1x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5)/5,\ i = 1,\ldots,8$ $D2 = (\sum X_i)/8,\ i = 1,\ldots,8$ $X_1 \ldots X_8$ – absolute value of the score by each item $x_1 \ldots x_5$ – number of responses related to the Likert scale points	(3) (4)
D3	Channels for the knowledge transfer	$X_1 = (1x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5)/5,\ i = 1,\ldots,6$ $D3 = (\sum X_i)/6,\ i = 1,\ldots,6$ $X_1 \ldots X_6$ – absolute value of the score by each item (X_7 was transformed into an open question) $x_1 \ldots x_5$ – number of responses related to the Likert scale points	(5) (6)
D4	Benefits	$X_1 = (1x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5)/5,\ i = 1,\ldots,3$ $D4 = (\sum X_i)/3,\ i = 1,\ldots,3$ $X_1 \ldots X_3$ – absolute value of the score by each item $x_1 \ldots x_5$ – number of responses related to the Likert scale points	(7) (8)
D5	Disadvantages	$X_1 = (1x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5)/5,\ i = 1,\ldots,4$ $D5 = (\sum X_i)/4,\ i = 1,\ldots,4$ $X_1 \ldots X_4$ – absolute value of the score by each item $x_1 \ldots x_5$ – number of responses related to the Likert scale points	(9) (10)
T	Total score	T = (D1 + D2 + D3 + D4 + D5)/5	(11)

Table 4 Research Results on Testing and Validation of UICs Ontology

UPT (212 subjects)	UO (154 subjects)	UTCluj (232 subjects)
D1 = 3.784788	D1 = 3.857955	D1 = 3.745151
D2 = 3.898585	D2 = 4.112825	D2 = 3.967134
D3 = 3.242138	D3 = 3.494589	D3 = 3.41822
D4 = 3.281447	D4 = 3.500000	D4 = 3.346264
D5 = 3.542453	D5 = 3.435065	D5 = 3.479526
T_{UPT} = 3.55	T_{UO} = 3.68	T_{UTCluj} = 3.59
Global score: T_{global} = 3.61 (of max. 5)		

fer. The research has identified that Romanian universities do not have a coherent business model (definition, implementation in relation with their strategy and the national, regional strategy for research and development) for their collaboration with industrial actors and this is a top management problem. According to the answers given by the university researchers, it was observed that they understand well the D2 'barriers' dimension of the UICs (the scores calculated for D2 are near the value 4, in the case of all investigated universities). According to the average profile determined

for the three universities, low scores were observed for the 'channels for the knowledge management transfer' (D3 = 3.38) and the 'benefits' (D4 = 3.38) dimensions, and the general causes could be similar to those presented above (missing a business model and a coherent strategy for UICs). In the project context, additional conclusions were elaborated per each university in order to explain the lower scores value for some dimensions (in rapport with the maximum score 5, which reflects a perfect collaboration of the university with industrial partners).

The Performance Measurement Model

Debate on the University Business Model for Intensifying UICs

In general, the success of the university system has been built on the trust the community has in universities mostly because of the high quality didactical and scientific processes that they deliver; reputation has always spurred competition between institutions. Both quality and trust grew in large part due to universities' historic independence from business and government in relation to teaching and research (Mitchell, 2015).

The literature is weak in presenting how universities should design their business model, but some trends are being debated around the ideas of Entrepreneurship University, university focusing on sustainability, on-line university, and smart or smarter university.

On the other hand, the university business model design could be similar to the case of a company, but the actual trends of the concept have to be considered. By synthesizing the business model literature, Brad and Brad (2016) have formulated a new representation of the business model, one that is linked to a business strategy and offers quantitative measures of its value. The proposed model by Brad & Brad (2016) considers two type of values, which can be adapted to universities also:

- The one for customers, as students, business partners and communities in the universities case (the reason for going on the market as high prestige organizations), and
- The one for shareholders, assimilated with different national agencies or policy makers in the case of the Romanian higher education system (which determines and motivates the academic business running).

'Both types of value are strongly linked to a business vision, which at its turn is linked both to a differentiation strategy and a development strategy. In the proposed innovative business model, key resources are mainly responsible for customer value creation, whereas key processes are mainly responsible for shareholders value creation. Key processes are strongly influenced by key resources, and the development strategy is influenced by a differentiation strategy' (Brad & Brad, 2016).

Because Romanian universities do not have a well established business model that facilitates and strongly supports UICs, preliminary researches were focused on discovering the key areas that are used to support UICs (more efficient and effective), by considering the values described above. From the results of several cross-case analysis (done during focus group meetings with researchers of the three Romanian universities), it was concluded that a business model for effective collaboration should consider six key areas (Draghici et al., 2016):

- A well-established research structure (in the university) that supports efficiently the administrative activities related to the research projects. Romanian university research centers and transfer of innovation centers do not have financial autonomy;
- Providing high quality project management, particularly with regard to objective setting, progress monitoring and effective communication;
- Understanding (maintain contact) the specifics of the UICs' economic and social environment. The administrative staff of universities supporting the research project development should identify trends and specifics of the activity (e. g. by using alumni) together with priorities and requirements in order to satisfy industry specific requirements;
- Develop new partnerships and nurture the existing ones by valorising funding opportunities. Factors such as trust, commitment and continuity of high experienced human resources have been shown to be of maximum importance for the collaboration success;
- Nurture the organizational culture that recognized the power of research and its benefits for the industry. This could be a veritable 'weapon' for the continuous development of human resources, which could positively impact the university reputation;
- Establish a coherent strategy of research activity dissemination (with high impact) and support marketing activities associated with this.

Partially these key areas are well-defined and functioning properly in Romanian universities. In addition, KPIs of the UICs are defined in order to assess the university research performance, each year. Their definition is based on legal provisions regarding the minimum standards for professors and associate professors positions, as well as the quality standards regarding the development of the study programs. These KPIs can be summarized as following:

1. KPI related to research and innovation projects, consultancy or technical services provision: (a) No. of industrial partners per year; (b) Length of industrial partnership/relationship; (c) No. of UIC projects

per year; (d) Total value of the UICs projects per year; (e) Total investments in infrastructure development and maintenance; (f) No. of new product/services created by UICs; (g) No. of new processes created by UICs; (h) No of university researchers involved in UICs; (i) No. of PhD students from industry; (j) Technology transfer mechanism supported each year (total grant given by industry);

2. KPI related to education: (a) No. of new created facilities for education per year; (b) Total value of the industry investment for students' education (facilities for education); (c) No. of students' internships supported by the industry; (d) No. of students' placements (on-the-job training); (e) No. of students' examinations regarding their scholastic achievement; (f) No. of invited seminars, demonstrations developed by industrials representatives; (g) No. of best/talent students rewards; (h) Total value of the grants supporting best/talent students (rewards);
3. KPI for university prestige: (a) No. of papers (only papers having common authors from university and industry or having mention to a company name in the acknowledgement); (b) No. of patents, invention disclosures, value of copyright licenses (only those having common authors from university and industry); (c) No. of patents, invention disclosures, value of copyright licenses (only those having common authors from university and industry); (d) No. of new spin-off companies created annually; (e) Value of revenue generated by the spin-off; (f) Value of external investment raised; (g) Prizes given to the university by industry, professional organizations, network of industrial partners etc.; (h) No. of UIC common events (conferences, seminars, workshop, job shop etc.) having industrial partners as sponsors.

The annual report of the Romanian universities assessment regarding their research activity, including UICs aspects are published on their web pages. For example, in the case of the Politehnica University of Timisoara (UPT), the research report can be found at http://www.upt.ro/Informatii_research-yearbooks_170_en.html.

In the case of the Romanian universities, it is a regular practice to assess their research performance and this is not only for financial reasons, but also to demonstrate their prestige and their market position and success.

The Performance Measurement Model Design (the Industry Perspective)

In the following pages, the industry perspective regarding UICs will be considered. The aim of industrial companies is to generate innovative solutions of products/services, processes or systems and thus to positively af-

fect their business performance and sustainability (Al-Ashaab et al., 2011). Companies' business models have to allow the acceleration of their internal innovation processes through the intensification of all knowledge circulation processes (e.g. acquisition, transfer, sharing and dissemination in UICs) (Lee at al., 2005). Furthermore, companies expect to enrich their Intellectual Capital when intensifying open innovations (Michelino, Cammarano, A., Lamberti, & Caputo, 2014).

By adopting and applying a LEAD framework, the design process of the model for the effectiveness of the UICs has been supported as an extended collaborative Balanced Scorecard model (having the acronym UNIinOI_BSc). The proposed model includes six evaluation criteria; for each of them key performance indicators (KPIs) were associated, as shown in Table 3. The designed working procedures and the UNIinOI_BSc model have allowed the design and visualization of the taxonomies (or knowledge maps done using MindManager software tool) associated with each criterion and the corresponding KPIs, as suggested by previous research of Al-Ashaab et al. (2011).

Considering the proposed UNIinOI_BSc model, an associated methodology of practical exploitation similar was created with an audit procedure for UICs that can be easily adopted by an industrial company. The main steps of the proposed audit consists of:

1. Data collection (internal proofs and information from the industrial company);
2. KPIs calculation. During this methodological step, the relevant criteria or audit perspective for the company will be established (sometimes not all the defined KPIs are needed for the audit or some of them have to be re-defined), together with the representative employees that will be involved in the audit process (from each company areas);
3. The UICs footprint representation that intends to calculate the scores related to each KPI, it will calculate the average score related to each considered criteria and then UICs footprint representation;
4. The determination of the UICs level of maturity and elaboration of the audit conclusions (including debates on the results gained).

The whole approach is aided by a developed UNIinOI_BSc tool (based on Excel software) that allows not only the score calculations for each KPIs as an average of the scores given by different employees from different companies area and the average per each criteria, but also the graphical representation of the UICs footprint (as a radar graph). In addition, a total score of the UICs is established by calculating the average score obtained by each six criteria.

Table 5 Key Performance Indicators Used in the UNIinOI_BSc Model

Competitiveness	KPI_C1	annual budget of R&D activities of UICs
	KPI_C2	no. of new products, services, process as results of UICs
Sustainability of the business (short term)	KPI_S1	no. of UICs projects with positive environmental or social impact
	KPI_S2	no. of universities included in collaborative projects of open innovation dedicated to product lifecycle sustainable development improvement
	KPI_S3	no. of open innovation projects with universities for the development of models, methods and/or normative for sustainable development
	KPI_S4	no. of conferences or workshops for knowledge transfer in open innovation, events organized in collaboration with universities
Innovation processes	KPI_I1	no. of intangible assets per year (patents and licenses, trademarks etc.)
Strategic partnership	KPI_SP1	no. of partnerships with collaborative strategic projects in open innovation with universities
	KPI_SP2	no. of collaborative projects in open innovation with universities per year
	KPI_SP3	no. of financed international project proposals that were developed with universities in open innovation (e.g. Horizon 2020)
	KPI_SP4	no. of scientific articles (in journals and/or proceedings) published in common by industrial and university's researchers
Internal business processes	KPI_IBP1	no. of best practices developed and adopted per year, in each organization process as a consequence of UICs
	KPI_IBP2	no. of improvements done during the key products' lifecycle because of UICs
	KPI_IBP3	no. of new methodologies, methods and tools developed for the improvement of any organizational process through UICs projects

Continued on the next page

KPIs are evaluated based on the company's internal information (concrete information about different aspects of UICs), as in the case of criteria 1 to 5 and 6b. For the 6a criteria (description in Table 3), the collected opinions from the employees were processed using a Likert scale of 5 points (1 – very low perception, opinion,... 5 – very high perception, opinion). The considered employees group involved in the audit needed to have high representativeness (they know and/or they are usually involved in UICs).

The use of the UNIinOI_BSc Excel tool assumes the following actions to do (their description is taken from the created tool):

1. On the tab identified as 'UICs Summary,' to identify the name of the assess company;
2. On the tab identified as 'UICs Summary,' to identify the date that this assessment was completed;

Table 5 *Continued from the previous page*

Knowledge management	KPI_KM1	understanding the tasks and duties of open innovation with universities
	KPIKM2	understanding information in open innovation
	KPI_KM3	the use of data, information and knowledge based on open innovation with universities
	KPI_KM4	systematic management tasks in the field of knowledge for open innovation with universities
	KPI_KM5	individual capacity for knowledge accumulation in open innovation with universities
	KPI_KM6	sharing individual knowledge, which is essential in open innovation collaboration with universities
	KPI_KM7	sharing knowledge with other teams involved in open innovation with universities
	KPI_KM8	the degree of knowledge utilization in open innovation with universities
	KPI_KM9	the culture of knowledge use in open innovation with universities
	KPI_KM10	the capability of tasks internalization related to knowledge in open innovation with universities
	KPI_KM11	training opportunities for the implication in open innovation with universities
	KPI_KM12	the level of organizational learning for open innovation with universities
Intellectual Capital	KPI_IC1	no. of joint training courses developed with universities
	KPI_IC2	no. of joint know-how acquisition processes developed with universities
	KPI_IC3	no. of joint documented best practices per year developed with universities
	KPI_IC4	no. of joint laboratories developed with universities
	KPI_IC5	no. of joint databases developed with universities
	KPI_IC6	no. of joint workshops developed with universities

3. On each of the remaining tabs within this file, to simply read the explanations related to the questions. Then to collect the related information from the company or to do a survey (collect employees opinions). Finally, to provide a numerical answer in the box adjacent to each question.

The graphical representation of each evaluated KPIs is based on the following defined colour codes:

- For the allocated score 1 (in the case of a specific KPIs), the corresponding Excel box is coloured in RED, which means that the corresponding practice in the company is 'Not Developed;'
- For the allocated score 3, the corresponding Excel box is coloured in

YELLOW, which means that the corresponding practice in the company is 'Under Development;'
- For the allocated score 5, the corresponding Excel box is coloured in GREEN, which means that the corresponding practice in the company is 'Developed and Executed.'

When user input has a valid score value of either a 1, 3, or 5, the box containing the score will automatically turn into the corresponding colour in order to equalize the score value, as mentioned previously. In addition, the colour code for the global score calculation (UICs footprint) and interpretation are:

- Score between 560 (100%) to 411 (73.39%), the Excel box will turn into GREEN, which means 'UICs are developed and executed;'
- Score between 401 (71.61%) to 262 (46.79%), the Excel box will turn into YELLOW, which means 'UICs are under development;'
- Score between 261 (46.61%) to 112 (20%), the Excel box will turn into RED, and the conclusions is that 'UICs are not developed.'

The UNIinOI_BSc Excel tool has been defined based on the collected opinions, practical experiences of responsible general managers and research-development (R&D) staff who have experience in common projects with universities. The refinement of the designed tool has been done following considerable repetitive tests. The colour code represented for the KPIs indicators evaluation and the assessment ragnes for the global score of the company represents the resulting effects of the UICs on a company's general performance.

The Methodological Framework Test: The Case of an Automotive Industry Company

In the following section, the assessment or audit results of an automotive company (of big size) will be presented using the UNIinOI_BSc model and its associated methodology (including the created Excel tool). The company has a long and relatively intensive collaboration with universities in its geographical area (the case study was located in the West Region of Romania, Timisoara city). The production and R&D managers supported the assessment process. The UICs audit was developed based on several interviews and information collections done during a five-day period when researchers visited the company. Each criteria was assessed in accordance with the established and refined KPIs. In the case of poor existing data for some KPIs calculation, in the field allocated for their scores in the UNIinOI_BSc tool, a score was filled by the production and the R&D managers opinions. The results of the audit are shown in Table 4.

Table 6 Calculation Results' Summary from UICs Audit: Case Study of an Automotive Company

Criteria/Perspectives	Target values (100%)	Category scores
1. Competitiveness	45	45
2. Business sustainability	50	50
3. Innovation process	105	71
4. Strategic partnership	125	71
5. Internal business processes	75	43
6. KM and IC	55	35
Total Assessment Score	455	315

As it can be seen form the research results, the automotive company reaches the target value for competitiveness criteria (maximum score gained), but its UICs are underdeveloped in the case of the other criteria in the model. Based on these results, the company's management has discovered a lack of UICs and, consequently, they have elaborated measures in order to correct the situation. The results discovered an unused resource of innovation through UICs. Through this case study, the UNIinOI_BSc model and the design tool have been tested, refined and validated.

Discussions and Conclusions

This paper addresses how performance of UICs could be measured considering the universities perspective on one side, and the industry perspective on the other side. The research problem formulation and solving took into consideration the specifics of the Romanian education market and the research-development and innovation environment related to higher education.

The proposed approach inspired itself by similar research results achieved at the international level, and it was motivated by the increasing requirements for collaboration with business or industrial partners of Romanian universities.

The paper has presented the research approach in order to establish a UICs performance measurements model for the assessment of the collaborative research impact. The study has underlined two perspectives of assessment:

- University, based on the designed UICs ontology, a questionnaire and a methodology were proposed for the assessment of their collaboration (through projects or contracts) with industrial partners. The calculations results of the considered dimensions evaluation, together with the UICs footprint (both considered as valuable results of the university audit related to its third mission), have proved that the designed

ontology can be considered mature and valuable for practical use. In addition, based on the analysis results of the three Romanian universities, strengths and weaknesses have been provided in the field of their research and development strategies and most of their actual collaborations with industrial partners (also, gaps in the national policy and regulations in the field have been identified by further analysis and debates);

- Industry (or companies' perspective), for which the UNIinOI_BSc model and tool have been developed, tested, and validated. This second perspective has offered a more contested area of research due to the lack of existing literature.

The proposed UNIinOI_BSc model for the UICs performance measurement reflects an output-based approach, which is of real interest for companies' policies, with considerable emphasis on open innovation outcomes and competitiveness. The proposed UNIinOI_BSc methodology and the created Excel tool enable precise information to managers for their companies' maturity levels in UICs, as well as to identify potential sources and ways to allow and support open innovation.

Our approach was developed using the LEAD framework, adapted to the specific context of the UNIinOI Romanian project. This framework supported the definition of a coherent and logical research scenario that allows consistent preliminary results, as the described UICs ontology and its testing and validation. Furthermore, the outcome of this systematic approach is the methodological renewal of UICs performance measurement in the case of universities (a better positioning of this process remains in the context of university's third mission development) and the definition of the UICs audit in the case of industrial companies, which could discover new sources for intensifying open and collaborative innovation process.

The benefits of the applied methodology come out especially from the industry perspective through the case study but, as there is only one single company in the scope of the research, the generalization is challenging. The presented case study for the exploitation of the performance measurement model (in the case of the automotive company) represents a pilot test and, as such, we considered that the testing and validation processes should continue (for companies of different industries and of different sizes). This is a limit of our research, but a motivation for future researches, as well.

In conclusion, the presented research on UICs audits both from the perspective of universities and from industrial partners showed not only the actual state of UICs specifics in Romania, but also the gaps of understanding and realization of such collaborations in order to nurture open innovation and future collaborative innovation processes. Furthermore, we estimate

that the university third mission is mature in the case of Romanian universities and their industrial partners, and that the university role should be refined and renewed continuously. It has already been estimated that a fourth mission will be dedicated to a higher education role and implication in building a sustainable development society.

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