A PERFORMANCE INDICATORS OF UNIVERSITY-INDUSTRY COLLABORATION

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Abstract

Universities’ responses to external stakeholder influences in the increasingly competitive globalizing world of higher education are reflected in frequent changes to their business models over the last years. University business models evolved through a series of transitions to the content, structure and governance of universities’ activities. Numerous different business models have been developed: Research University, Entrepreneurial University, Developmental University, Innovative University, Global University, Virtual University, e-University, Digital University, Open University, Corporate University, University 2.0, University 3.0, University 4.0, Agile University, Creative University, Smart University, University of the future, etc. Choice of a particular business model is predominantly influenced by a university’s business strategy and its digital transformation strategy. Strategic mission, vision, goals and actions, as well as areas of transformation are of particular significance.

However, it should be also said that the future of universities relies on how successfully they interact with their numerous and diverse external stakeholders. In the “clients” category of external stakeholders, industry partners hold the second place by significance, just after students. University-Industry links from the perspective of intensity of their interaction in building relationship and doing work are usually based on the C3 (Cooperation-Coordination-Collaboration) framework, where the lowest form of interaction is cooperation, followed by coordination, and collaboration as the most advanced one. Modelling a successful interaction with the industry represents a topic of widespread interest owing to substantial innovation and economic growth it had produced. To foster university-industry interaction, and hence the knowledge and technology transfer between these two parties, academics, companies, and especially politicians, are paying attention to science and technology policies more than ever. Definition and use of proper indicators for measuring university-industry collaboration are of particular significance.

Based on the systematic literature review of results of relevant academic research of university-industry collaboration types and possible indicators, the aim of the paper is to define different types of interaction between universities and companies (enterprises) and to describe the indicators for evaluating the collaboration activities. Three groups of indicators have been identified: input, output and impact indicators. With respect to the fact that input indicators measure only the intent of interaction and not the outcome of it, they are discussed in more broad terms in this paper. Significant attention was devoted to results of interaction between universities and industry, i.e., output and impact indicators, which are more suited for evaluating the efficiency of their collaboration. The findings of the paper indicate the importance of diverse indicators and their usage to measure the inputs, outputs and impact of university-industry collaboration. In such way, both sides in the interaction may evaluate it and take necessary action in the endeavour of its continuous improvement.

Keywords: university-industry, collaboration, performance, indicators.

1 INTRODUCTION

University business models evolved through a series of transitions to the content, structure and governance of universities’ activities. Analysis of models present in the last decade suggests that they are largely different, that they undergo permanent innovative changes, and generally incorporate digital technologies at a growing pace. In other words, universities’ business models are changing at a greater pace and extent than ever before [1]. Elements with particular relevance to business models of universities’ operating in dynamic and complex environments include [2]: university stakeholders and management of relations with stakeholders; intangible individual and corporate resources and capabilities; university’s value propositions; cost structures; university revenue streams; distribution channels used for delivering value; and ways in which the university responds to challenges arising from its own organizational complexity.
Complexity of above-mentioned elements in a volatile business environment and globalized higher education market proves and necessitates the need for continuous innovation of universities’ business models. One of the key reasons for business model innovation is digital transformation, which in turn affects universities’ processes and activities through changes to one of its most significant constituents. There are three ways to accomplish a successful innovation of a business model: through innovations in industry models, revenue models and organization models [3].

Industry, as a category of stakeholders, has a significant influence on the development of a innovative business model. The interaction between the university and the industry is of strategic significance to their separate, as well as their common interests. Universities form various relations with the industry, ranging in terms of objectives and scopes. Interaction can be more or less intensive, and may focus on teaching/training and research [4]. In addition to that, interaction may be formal or informal [4], among individuals, or among organizations. It is also very important to differentiate short-term and long-term interaction among partners [5]. Each of the mentioned types of interaction dictates a great number of activities that are most frequently structured in accordance with the degree to which the participants are linked. Different researchers have presented different typologies or taxonomies of the interaction in their papers, and therefore, it is a challenge to synthesize them and present them uniquely.

Performance measurement is of exceptional significance to effectiveness and efficiency of any process. Adequacy of input is a prerequisite of a successful university-industry collaboration process, and as such and be considered a key success factor. Without suitable inputs, it is unlikely that objections of collaboration will ever be achieved. Therefore, development of input indicators and systemic monitoring and assessment of their values is required for an objective valuation of realistic expectations of a university-industry collaboration. Results of this interaction can be divided into direct and indirect outcomes, while the two are mostly referred to as outputs and impacts. Development of a set of indicators for outputs and impacts is a starting point for evaluation of results and efficient management of the entire process. The greatest challenge in evaluation is to realistically determine the impact as a direct result of collaboration, since it can be influenced by other factors as well.

This paper consists of four sections. After the introductory considerations on the concept and elements of business models, the first chapter continues with a description of industry partners, as one of the most significant categories of stakeholders in the development of activities in innovative university business models. The second chapter is a brief overview of the methodology used in the research. The third chapter is made up of three segments. The first is devoted to university-industry interaction types and an overview of activities within each type. In the second segment of this chapter the importance and the challenges of the evaluation are discussed, while the last segment is devoted to the indicators of university-industry collaboration, with emphasis on output and impact indicators. The final chapter contains conclusions.

2 METHODOLOGY

The theoretical research was executed as a systematic literature review, with the intention to provide an overview of existing knowledge on the subject issue. The authors opted for a method proposed by D. Tranfield et al. [6], who emphasize core principles that apply to systematic literature review in the field of management and organizations. Those principles allow the design of a replicable investigation and minimize any bias caused by the subjective assessment of different researchers [6]. The iterative review process propose three principal stages: planning the review; conducting a review; and reporting and dissemination.

(1) Planning the review phase was focused on developing a framework for conducting the literature review. This phase also encompassed identification of the research goals and the research questions; formulation of the research strategy; determination of criteria for inclusion/exclusion of sources, along with criteria for source evaluation; and formulation of the strategy for extraction and synthesis of extracted data.

The goal of the systematic literature review was to explore present empirical findings on the topic of university-industry interaction types and to describe the possible indicators for evaluating the collaboration activities. The search was performed within the academic databases of the EBSCOhost, Springer Link and Wiley InterScience. Primary sources were collected and evaluated. The search for secondary sources, which involved examination of sources referenced in the primary sources, was conducted simultaneously.
The following step was to define criteria for inclusion/exclusion of sources:

- **Criteria for inclusion:**
  - Types of sources: Scientific articles published in academic journals and proceedings of the scientific conferences, written in English, which contain the defined search strings – "university-industry", "collaboration" or "cooperation", and "performance". They were searched in article titles and abstracts.

- **Criteria for exclusion**
  - Papers without empirical research related to selected key words, i.e., papers based solely on authors’ opinions, book reviews or any kind of non-scientific articles, papers not available.

The final step of this phase was to define the strategy for data extraction, and the strategy or synthesizing extracted data. The extraction process involved repeated reading of relevant papers and identification of data significant to answering the set research questions. Data synthesis strategy was related to connecting and comparing identified topics concepts and categories.

(2) **Conducting a review** involved execution of particular activities, in accordance to the framework developed in the planning phase. The activities included: search for the primary sources; selection of primary sources in accordance with inclusion/exclusion criteria; evaluation of sources; data extraction and data synthesis.

The phase started with querying identified academic electronic databases using the defined set of key words. The total number of results for each electronic database is presented in Table 1.

<table>
<thead>
<tr>
<th>Academic database</th>
<th>“university-industry”</th>
<th>“university-industry” + “collaboration”</th>
<th>“university-industry” + “performance”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Title</td>
<td>Abstr</td>
<td>Title</td>
</tr>
<tr>
<td>Business Source Premier</td>
<td>158</td>
<td>264</td>
<td>29</td>
</tr>
<tr>
<td>Springer Link</td>
<td>113</td>
<td>-</td>
<td>29</td>
</tr>
<tr>
<td>Wiley Online Library</td>
<td>20</td>
<td>105</td>
<td>5</td>
</tr>
</tbody>
</table>

The first step of analyzing the results was focused on analyzing paper titles and abstracts. Papers with titles and abstracts relevant to the defined research question were recorded in an Excel spreadsheet, with descriptions of their relevant data. The second step involved analyzing the Excel spreadsheet created in the previous step, with the aim to determine duplicate entries. After they have been eliminated, a detailed analysis of remaining papers was executed.

The process of detailed analysis involved repeated reading of complete papers, with application of quality assessment criteria. 43 papers were eliminated during quality evaluation, while 12 relevant papers remained. The process of text coding was carried out on these papers, as to link similar topics into concepts, and identify key categories for data synthesis.

(3) **Reporting and dissemination** the results of the literature review involved formulation of answers to the specified research questions. An overview of obtained results is given in the following chapter.

### 3 RESEARCH RESULTS

Analysis of interaction between universities and the industry, i.e. identification, definition a classification of such interactions, was based on the C3 (Cooperation-Coordination-Collaboration) Framework. From the perspective of intensity of interaction in building relationship and doing work, the lowest form of interaction is cooperation, followed by coordination, and collaboration as the most advanced one [7]. In order to develop a successful university-industry interaction, both partner sides have to go thru a lengthy process starting with cooperation, in its various organizational forms, thru coordination and teamwork, to collaboration [6].
3.1 University-Industry Interactions Types

University-industry interactions take many forms, which authors classify in different ways. However, they are mostly divided into two groups [8], [9]:

A. Teaching and training

- Active participation of industry in curriculum development,
- Offer of lifelong learning courses by universities, and specialised customised programmes for industry,
- Training industry employees through course enrolment,
- Personnel exchanges - participation of experts from industry at universities as part-time or visiting professors, or lecturers,
- Postgraduate training in company (e.g. joint supervision of PhDs),
- Projects with the participation of students by writing theses or seminar papers;
- Graduating students; internship in companies; student volunteers’ internship;
- In-kind support from industry (equipment donations, student scholarships, teaching grants etc.),
- Industry provision of on-the-job training opportunities and part-time work opportunities,
- Education of top talents and employees sent by companies, etc.

B. Research

- Tangible industrial support to the university (research contracts, research grants, direct funding of research institutes or university departments, equipment donations, opportunity to use industry research facilities, etc.),
- Exchange of knowledge (industry projects with the participation of students by writing theses or seminar papers; hiring of research-oriented students; knowledge sharing through scientific publications; participation in conferences, seminars, or round tables; student volunteers’ internship, industrial consulting by university staff; bilateral staff exchange, joint research etc.
- Technology transfer (patent sale or licensing, joint ventures for the commercialisation of joint research, creation of spin-of firms),
- Starting up executed through founding by companies and others in the University campuses: business incubators, centres of excellence, technology networks and platforms, convergence laboratories and technology centres and parks).

Factors with a significant effect on the interaction involve: motivation, social networks, organizational culture, communication, project management and knowledge management. In contrast, factors with lower frequency include: trust, funding, size, geographical location, evaluating potential partners’ technological capabilities, absorptive capacity, information and communication technologies (ICTs), etc. [9].

3.2 The Evaluation of University-Industry Collaboration

The use of the channels of interaction as performance indicators can be considered quite common when it comes to the evaluation of university-industry collaboration. However, in the interaction between universities and companies, not only is the interaction itself important, but also the outcomes of this interaction. J.A. Pertuzé et al. [19] goes even further with the claim that not the outcome of the collaboration is important but the impact "how the new knowledge derived from collaboration with a university can contribute to a company’s performance". Outcomes are the results of collaboration, which create an opportunity for a company, but the real significance of research outcomes to a business can be measured by the impact on the firm’s productivity or competitiveness. Therefore, it is much more important to focus on the “impact of the collaboration on company’s products, processes or people” [19]. The situation is no different when it comes to interests of other parties in the interaction–universities and government. Figure 1 illustrates the input-impact process.
On top of transformation of university-industry collaboration from informal ad-hoc activities to larger-scale initiatives, the stakeholders recognize that there is a need for more systematic measurement and evaluation both to assess initiatives a posteriori, but even more importantly to monitor on-going initiatives. Moving from predominantly reactive measurement and assessment of results to realtime performance measurement should enable adjustment and improvement “on the go”. Recognizing this need, Perkmann et al. [18] proposed a performance management framework for measuring success in university-business alliances. The essence of this approach is reflected in the design of a ‘success map’ that represents the precise process as well as the ingredients by which positive outcomes are achieved within university-business alliances. Similar to Kaplan’s and Norton’s strategy maps, these maps clearly indicate causalities of traceable activities of a specific process. The success map (Figure 2) allows one to differentiate between input and output factors, hence providing a guide for designing both leading and lagging indicators for the performance management framework. These characteristics of success maps can be considered crucial for going beyond mere post-hoc performance measurement that allows evaluation when it is already too late to intervene. Having leading indicators allows users to accompany live initiatives and hence intervene when things go wrong.

In another novel development, J. Spaapen et al. [19] develop a concept of ‘productive interactions’ as an ex-ante indicator for the potential impact of university-industry interactions. Productive interactions indicate ways in which researchers communicate with their environment, and may include direct (personal) interactions, indirect interactions and financial interactions. The basic idea behind this concept is the necessity of interaction between researchers and their stakeholders, as to attain the desired social impact of research. Accounting for these interactions will therefore provide a leading indicator for the potential impact a project or programme may develop in the future.

One of the key issues of each performance measurement system is what should be measured? Performance measures provide a way of assessing the progress over time of specific activities, by quantifying key aspects of these activities. As no single measure can represent all aspects of an activity, a set of measures is usually required for a performance measurement system. A measurement system typically comprises several metrics, standards against which performance can be measured (norms), measurement techniques, frequency and timing of measurement and reporting, and a reporting format [14]. Finally, a meaningful measurement system needs to address the various dimensions of the processes it intends to control.
3.3 Types of University-Industry Collaboration Performance Indicators

Performance measurement indicators can be divided into categories that correspond to the phases of the university-industry collaboration process: inputs, (in-process) activities, outputs and impacts. The input indicators are foremost suitable for evaluating the intent of a desired output, but do not guarantee it [15]. Output and impact indicators deal with results of the collaboration, but it is important to make the distinction that the outputs are the outcomes which are the direct results of the cooperation. The impact refers to direct or indirect effects that collaboration has on the different parties [12].

Perkmann et al. [18] distinguishes three major input factors – resources, researchers’ capabilities and researchers’ motivation. Although not mentioned by Perkmann et al. [18] the number of researchers involved in collaboration with enterprises can also be considered as an input (as far as the increase of this number also allows assuming the increase in the amount of university-industry interaction).

R&D expenditures and finances given to universities are important input indicators for any type of R&D activity. While sharing R&D costs offers benefits to alliances generally, university–industry alliances can usually gain additional leverage via public funding. The contributions from government granting agencies, businesses, individuals and foundations can be input indicators of university research. The most direct indicator of university-industry cooperation is the level of industry sponsorship and financing of university research [15].

Bibliographic metrics can be used to measure researchers’ capabilities. The problem with estimating the researchers’ capabilities by the number of publications and citations is that the aim of university-industry cooperation is often not a publication. Industry is interested in applied research, and from the industry side, the publications are not necessary. When defining the indicators concerning the measurement of researchers’ capabilities, the aim of the cooperation should be taken into account. Depending on that, all outcomes achieved in the past can be considered (e.g. reports, patents etc.).

Although it might not easy be to evaluate researcher motivation directly, the researcher also wants to focus on interesting projects and the impact of the career model is as important to him or her as for other professionals [16]. For encouraging scientists to do cooperation with enterprises, the stimulation system and career model in university are also important.

The number of in-process activities is indicating the intensity of the collaboration. Frequent interaction between the partners facilitates the transmission of know-how and tacit knowledge as opposed to the formal exchange of codified research results. From research it appears that the more there are different meetings for educational or contact making purposes, the stronger the linkage between university and the business also is [13]. Workshops, seminars and meetings, where the participants are from both university and industry, can be considered as measures of university-industry interaction.

3.3.1 University-Industry Collaboration Output Indicators

As already mentioned, outputs from university–industry collaboration are usually considered as the direct outcomes of this interaction. According to Perkmann et al. [18] there are several metrics available to operationalize outputs from university–industry collaboration. Patent applications or patents granted can be used as measures of the technological output of university–industry projects. However, patents are only one among several mechanisms used by companies. Also, some university–industry alliances are based on explicit ‘open science’ rules that stipulate that all knowledge generated should flow into the public domain with no restrictions.

The number of joint publications of university and industry scientists is a very explicit indicator of university-industry collaboration [15], [21]. Langford and Tijssen use joint research publications which are co-produced by R&D staff from private sector organizations and universities for evaluating university-industry research cooperation. The joint research publications focus on longer-term perspectives while applied research with a short- or medium-term commercialization focus are usually not disseminated in the peer-reviewed literature, but as reports, patents or other form, which often are also confidential. In Table 1, some possible output indicators of university-industry collaboration are defined for different types of collaboration.
Table 2. Output indicators of university-industry collaboration by the types of collaboration.

<table>
<thead>
<tr>
<th>Type of collaboration</th>
<th>Output indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum development and delivery</td>
<td>Number of programmes /curricula developed in interaction with industry; number of courses with guest lectures from industry and attendees in these courses; joint supervision and number of master and/or doctoral theses; number of graduates.</td>
</tr>
<tr>
<td>Lifelong learning</td>
<td>Number of courses held; number of attendees and graduates at these courses; number of researcher exchanges between university and industry; number of other scientific and research training schemes for industry.</td>
</tr>
<tr>
<td>Student mobility</td>
<td>Number of student trainees in industry; number of student placements in industry; number of PhD student exchanges (with industry); number of industry funded postgraduate positions/scholarships.</td>
</tr>
<tr>
<td>Academic mobility</td>
<td>Number of researcher exchanges between university and industry; postdoctoral or doctoral positions offered within alliance.</td>
</tr>
<tr>
<td>Commercialization of R&amp;D results</td>
<td>Patent applications; number of patents granted; number of plant variety rights; number and value of copyright licenses; provision of training in research commercialization; number of spin-offs formed; market value of spin-offs; value of revenue generated by the spin-offs; number of staff working on commercialization activity in dedicated and support roles.</td>
</tr>
<tr>
<td>Collaboration in R&amp;D</td>
<td>Number of consultancy contracts; number and value of contract research projects; number and value of collaborative research projects; number of joint publications; number of joint inventions; number of (new) products/processes successfully created in collaborative research (e.g. as reported in the final report), number of invention disclosures.</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>Number of joint ventures; number of entrepreneurship courses to students and researchers in university; number of attendees at entrepreneurship courses.</td>
</tr>
<tr>
<td>Governance</td>
<td>Number of business actors on the board of university; number of academics on the boards of firms.</td>
</tr>
</tbody>
</table>

3.3.2 University-Industry Collaboration Impact Indicators

The impact of the university-industry collaboration (UIC) can be considered as its’ long-term outcome and in general can be distinguished as economic or social impact. To measure the impact of university-industry collaboration outputs, the indicators should show if the collaboration achieved its aim and what have been the consequences of the collaboration for the partners [19]. At the macro level the impact should be measured in the areas of well-being (e.g. health and quality of life, working life, living environment); economic; knowledge, education and culture; and environment [17]. The economic impact of UIC on a general can be measured using indicators such as: GDP per capita, productivity, turnover growth, export growth or employment growth. More specific impact indicators are, for example, license revenues and success of spin-off companies [15]. The impact of R&D collaboration, commercialization of R&D and academic mobility can be measured in new products, new or updated curriculums and processes derived not directly in the cooperation, but due to the cooperation. The most important impact of UIC is definitely the increase in the income of enterprises and also university. In the case of universities the growth of industry’s funding indicates a directly increased cooperation between universities and industry. The commercialization of R&D also encompasses the formation of spin-offs and therefore the survival and growth of spin-offs can be considered as an impact indicator. In the same way, the impact of entrepreneurship is the growth of joint ventures. The impact of governance, but also other types of cooperation, should be the cultural development of universities and industry, which can be evaluated by increased cooperation between universities and companies. The medium and long term impacts can be measured by indicators which would allow the evaluation of increased knowledge intensity in industry, overall productivity of economy development of high growth enterprises, employment, and national prosperity. The success of UIC in the field of education can also be estimated by the rate of recent graduates’ hiring and their employment in the field of their studies. In Table 3, some impact indicators of UIC are defined.
Table 3. Impact indicators of university-industry collaboration

<table>
<thead>
<tr>
<th>Type of impact indicator</th>
<th>Impact indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic impact indicators</td>
<td>Organizational level: productivity of the company, competitiveness of the company, competitiveness of the university, number of new university/industry alliances, knowledge intensity of production, income based on patents and other outcomes of previous UIC activities. General level: GDP per capita, total factor productivity; productivity renewal indicator; number and share of high growth enterprises; renewal rate of enterprises; share of inward FDI per GDP; knowledge intensity of production; success of spin-off companies; productivity growth; turnover growth, export growth, the increase in exports created by new inventions; net increase of jobs, employment growth; recruitment of graduates, rate of recent graduates’ hiring and their employment in the field of their studies.</td>
</tr>
<tr>
<td>Social impact indicators</td>
<td>Health and quality of life, working life, living environment, attitude towards education, social return on investment, level of the environmental pollution, level of energy efficiency, quality of new study programs, number of awards for scientific achievements.</td>
</tr>
</tbody>
</table>

4 CONCLUSIONS

While companies are increasingly intensifying their collaboration with universities, there is a lack of tools to evaluate such interactions. A performance measurement system for university–industry collaboration should distinguish between different process stages, including inputs, in-process activities, outputs and impacts. The identification of the specific measures for each of these stages is a real challenge, especially if we want to determine both prospective and retrospective measures and subjective and objective measures. In this paper we discuss specific indicators for measuring and assessing the outputs and the impact of university-industry collaboration. Through these indicators we provide managers with a multi-dimensional tool for reliable evaluation of the university–industry collaboration.

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