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Framework for Measuring Innovation Performance in Higher Education Institutions

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Abstract: Current approaches to measuring innovation in higher education (HE) provide a very limited picture about the real scope of the innovation activities of higher education institutions (HEI) as they address only some dimensions of HEI innovativeness, which negatively affects the ability of the HEI to manage its innovative efforts. The purpose of this paper is to present a way forward on how to measure HEI innovation performance that will go further than the usual indices. It describes a five-perspective framework with dedicated, comprehensive metrics for the measurement of HEI innovation performance. To test the concept and the possibility of empirical application two consecutive surveys have been conducted. Survey of innovation performance was conducted in order to collect hard data on HEI innovation performance and 14 persons in charge of completing the innovation performance questionnaire were interviewed in order to better understand the availability and reliability of the requested data.

Keywords: higher education institutions; innovation performance; measuring innovation

1 INTRODUCTION

The significance of higher education institutions (HEI) to national socio-economic development is widely recognized by governments and the private sector, especially in terms of knowledge production and the provision of highly skilled professionals. HEIs in modern economies have challenging tasks: to provide high quality services that meet the needs of the economy, and to perform its social function; these services have to satisfy a variety of stakeholders and facilitate positive developments in the society [1] as universities are beginning to be held responsible for the regeneration and transformation of the regions [2]. Increasingly privatized HE markets demand highly competitive capabilities, which often puts HEIs under pressure to improve their efficiency, minimize costs, and maximize results in all areas of their operation. However, the mechanisms of the free, unregulated market do not fully apply to HE [3], since various agencies are charged with regulating, planning and supervising different aspects in HE.

Innovation is recognized as a crucial factor of competitiveness in the economy and as a mechanism for enhancing organizational ability to adapt to a changing environment [4]. HEI do not tend to have the same incentives as businesses to innovate [5], but in order to maintain and improve their position in the education and research market HEI are seeking to be innovative, with studies showing that pedagogical, process and education innovations are significantly related to HEI efficiency [6]. Yet, HEI are often slow or limited when innovating, and they are found to face numerous barriers - external, internal, and people-related - on their innovation journey [7]. The strict boundaries of ethics committees can prevent research being undertaken in universities that can be easily done in the industry; boundaries to knowledge exchange and the requirements to publish in peer reviewed articles delay the dissemination and utilization of research findings to the point that they are almost obsolete by the time of publication; the slowness of implementation of the accreditation process means that changes to the curriculum lag in relation to changes in the industry [8].

Policy makers are focused on expanding innovation beyond the private sectors and are pushing and supporting innovation in education in order to maximize the value of previous public investments in HE and boost public satisfaction by enhancing productivity and containing costs [9]. Nevertheless, public support for HE is declining due to increasing competition for limited public resources between HE and other public sector services [10] and university research funding is becoming dependent on its direct contribution to the economy [11]. The chronic lack of capital is a strong motivational factor for HEIs to be innovative and efficient on the one hand and to continuously seek for additional resources on the other. In order to attract external capital, HEIs are expected to be efficient and innovative, so the need to increase innovative performance is an urgent issue for HEIs [12].

Since education plays a crucial role in creating a sustainable future, the need for educational innovations has become acute [13]. In order to increase innovation performance the HEI must be able to assess the level of its innovativeness, and to do this HEIs need to be capable of identifying innovations in different areas of their work, which raises two important research questions: What are the innovations in the various areas of operation of the HEI and how to measure innovation in HEIs? Therefore, the goal of this paper is twofold:

a) To enrich understanding and offer a classification of innovations in the HEI domain, and
b) To propose parameters and a methodology for their measurement.

Understanding and measuring HEI innovation performance is important for policy makers so that they can track the results of their interventions [14], and it is also important for the HEI as they need to be able to monitor the level of their innovation activities and assess the success of their innovative initiatives and efforts, which ultimately leads to improvement and the HEI competitiveness. Although there is increasing interest in HEI innovation, this topic still needs further study [15], since the current literature is fragmented and under-theorized [16]. This paper aims to fill this gap by offering an integral view of HEI innovation, and by proposing a framework for measuring innovation at HEI level that will go further than the usual indices, which rely on a number of patents and published scientific papers, or other publicly available data, and also beyond the usual focus on strictly pedagogical innovations.

We begin with a review of the literature related to innovations in education and measuring innovation in HE. Next, we provide an overview of the proposed Framework for measuring HEI innovativeness. Following this, we present the results of innovation performance research at six faculties and our experiences in the application of the developed framework. We conclude by emphasizing the value of the proposed framework, its limitations and directions for future research.

2 LITERATURE REVIEW AND PREVIOUS RESEARCH

2.1 Innovation in Education

A review of the literature on innovation offers no unified or agreed definition of innovation, nor is there a singular approach to the study of innovation [17]. Most of the literature defines innovation as the implementation of new or improved ideas, knowledge and practices [18]. More precisely, the Oslo Manual defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" [19]. This definition is widely accepted and OECD argues that it can be applied to education as educational organizations introduce new products and services, new processes, new marketing techniques and new ways of organizing their activities [20]. Brennan [21] defines innovation in HEI as a new or significantly improved product, process, organizational method or an organization itself developed by or having a significant impact on the activities of a higher education institution and/or other higher education stakeholders. Foray and Rafo [22] define educational innovation as the act of creating and then diffusing new educational tools, as well as new instructional practices, organisations and technologies, but they later emphasize that the definition of education innovation should be left somewhat open because within the very concept of education as an activity, goals and objectives are very broad and not well defined. Halasz [23] defines innovation activity in the educational context as deviation from routine operations and as the presence (or adoption or sharing) of novel solutions. Other authors emphasize that it is important to distinguish innovation from reforms in HE, as a reform does not necessarily mean the application of something new or improved; rather, reform is a structured and conscious process of producing change no matter its extent [24].

Significant attention in the literature is devoted to the topic of pedagogical innovation that can be defined as any new teaching practice that differs from the traditional lecture with the purpose of improving learning [25]. Pedagogical innovations are dependent on lecturers as they are the most important agents in improving the process of learning and teaching in educational practices [26] and as such pedagogical innovations are beyond the scope of this work, which is not aimed at measuring innovation activities at the level of the individual lecturer, teacher-led innovation [23].

Several different classifications of innovation in education can be found in the literature. Hannan [27] classifies education innovations according to their origin as individual innovations that are based on the ideas of enthusiasts, guided innovations that are derived from national programs and supported by institutional funds, and directed innovations that are completely driven by the institution. Haelermans and De Witte [6] cluster education innovations along five types: (1) profiling innovations, with respect to curriculum changes (2) pedagogical/didactical innovations, which are mainly associated with the content of the courses and the way classes are taught (3) process and organizational innovations (4) teacher professionalization and (5) education chain innovations arising from collaborations. Chen [12] extracts 17 indices which are suited for HEI evaluation and argues that academic innovation, member innovation, marketing innovation, administration innovation, and organizational structure innovation are among the most important critical innovative factors. Lubienski [28] identifies two categories of innovations in the educational sector: educational innovations, which include product and process innovations and administrative innovations, which include marketing and other organizational innovations.

As establishing a definition of innovation is an essential element for data collection and indicator development [29-30], based on previous definitions and classifications of innovation in education and the context of this paper, innovation from the HEI perspective is understood as new educational, research or third mission products or services and intended changes/improvements in HEI processes and organizational structure.

The expression "third mission" implies university engagement and collaboration with society and industry with a focus on technology/knowledge transfer or social engagement and third mission activities become an integral part of university structures and primary goals [31].

2.2 Measuring Innovation in HEI

The measurement of innovation and its effectiveness in education is still in its infancy, since despite a plethora of indicators we still lack data that measure innovation performance of education systems or that link innovations to actual improvement [20]. Indeed, it is hard to measure innovation in the education context where the goals and objectives of educational activities are not well defined and since the very concept of education as an activity is a broad one [22]. Additionally, factors such as HEI type and size, type of ownership, and geo-economic factors all influence the nature of HEI innovation. Unlike companies in the private sector - where the main economic goal is productivity improvement and where success is defined through profit, sales or growth - public organizations such as HEI need to measure their improvements with objectives such as increased quality, equity, coverage and efficiency, which may be less commensurable [20].

In recent years innovative university rankings have received significant public attention; innovative university rankings are of great importance to universities and they attract the attention of the general public despite their monodimensionality and other shortcomings [32]. Reuters, the news and media division of Thomson Reuters, created a ranking of the world's most innovative universities by using indicators relating to patent and research papers, including how often a university's patent applications were

granted, how many patents were filed with global patent offices and local authorities, how often the university's patents were cited by others, how often universities' research papers were cited in patents and the percentage of articles that featured a co-author from industry [33].

In order to identify the Top 100 most innovative universities in the world Times Higher Education introduced a ranking based on university-industry collaboration (resources from industry as a percentage of total research budget, or co-authorships and bibliometric patent citations [34].

Based on the 2005 Research into Employment and Professional Flexibility (REFLEX) and the 2008 Higher Education as a Generator of Strategic Competences (HEGESCO) survey databases, the OECD's Centre for Educational Research and Innovation has developed a simple measure of innovation in education, whereby it has found that 80% of HEI staff consider their workplace to be highly innovative and higher education is above the economy average in terms of the speed of adoption of innovation. However, this approach to measuring innovation has questionable validity as measurement is solely based on the HEI employees' subjective perception (they responded to questions such as: "How would you characterize the extent of innovation in your organization or your workplace?") [9].

The second approach to measuring innovation used by the OECD uses micro-data collected in schools, and innovation is captured as a significant change in some key practices in educational institutions by drawing on the PISA, TIMSS and PIRLS databases. These datasets make it possible to identify changes in educational and teaching practices in the classroom (pedagogical practices), schoolwork practices and resources or external relations practices and to map the trends over time, leaving the unanswered question of how much a variable describing pedagogical or organizational practices in schools needs to change before it is considered an innovation [35].

The European Commission funded the AQUAMETH project (Advanced Quantitative Methods for the Evaluation of the Performance of Public Sector Research) that was followed by the EUMIDA project (EUropeanMIcroDAta project) and ETER (the European Tertiary Education Register), which provided the information on individual HEIs in Europe, concerning their basic characteristics such as information on staff, expenditures and revenues, education production and research output. Based on that data it is possible to track the position and evolution of some HEI innovative activities outputs, such as the share of PhD recipients over the total population of undergraduate students and average number of publications per unit of academic staff [36].

The latest approach to measuring innovation used by the OECD in partnership with European Commission's DG Education and Culture is called HEInnovate. It is a self-assessment tool that helps HEIs to assess their innovative potential by using a number of statements in eight key areas (Leadership and governance, Organisational capacity: funding, people and incentives, Entrepreneurial teaching and learning, Preparing and supporting entrepreneurs, Digital transformation and capability, Knowledge exchange and collaboration, and the Internationalised institution). As it can be seen from these eight areas, this tool is aimed at identifying the entrepreneurial capabilities of the university and the university's entrepreneurial ecosystem [37].

A wide range of studies on other subjects relating to innovation in HE have been done: Keinänen [38] provided a tool for measuring students' innovative performance in HE, Kampylis [39] provided a classification and mapping framework of ICT-enabled innovation for learning. Chen and Chen [40] developed an innovation support system for Taiwanese higher education with seven measurement dimensions: academic research, administrative process, faculty and staff, market development, organizational structure, organizational culture, and leadership style. Thang et al. [41] analysed the effects of HEI knowledge management process on administrative and technical innovation. Riccomini et al. [42] constructed a conceptual model of HEI innovation trends by analysing perceptions of experts in university education.

Although the previous approaches have provided significant information on innovation activities in HEI, they point only to the fragments of HEI innovativeness, giving a very limited picture of the real scope of HEI innovation activities. Covering only one particular innovation could over- or underestimate causal effect between an innovative change and its results [6]. For example, when assessing academic innovation, Chang et al. [43] (2006) focus strictly on intellectual property-related activities such as patenting, licensing, and incubated startups; Faria et al. [44] (2018) compile an innovation indicator solely from the number of university-affiliated patents; Hewitt-Dundas et al. [45] observe only introductions of new study programs as an indicator of higher education innovation; Huang and Chen [46] use a number of published scientific papers and a number of patents to measure the academic innovation performance of universities; Lin [47] measures the impact of academic innovation simply as the number of paper citations received per university per year.

HEIs need relevant, multi-dimensional, and reliable data to monitor their innovation progress and evaluate the success of innovation efforts. Therefore, dedicated comprehensive metrics and a framework for measuring HEI innovation output that would be applicable to different higher education institutions, is needed. To achieve this, innovation indicators in the education sector should be [20]:

1. Linked to specific social and educational objectives;
2. Measured at different levels;
3. Measured according to different stakeholders' perspectives when objectivity is questioned.

3 FRAMEWORK FOR MEASURING HEI INNOVATIVENESS

In the effort to extend this line of research, elaborating on existing classifications and definitions of innovation, we propose a mapping framework comprising five components that address key perspectives relevant for this challenging task of measuring HEI innovativeness at intra-organizational level. Having in mind that HEIs vary significantly among themselves regarding size, structure, ownership, and orientation, this framework should be mostly observed as an indication on what to measure,

rather than how to measure. In other words, since the proposed framework identifies and quantifies HEI innovation outputs based on questions "What kind?" and "How much?" [48], we do not seek the answer to the questions "How?" and "Why?", since the application of the framework will surely depend on contextual factors in which a specific HEI operates.

The dimensions of innovations that the proposed framework comprises are:

1. Curriculum innovation,
2. Innovation in research,
3. Innovation in the field of third mission,
4. Process innovation and
5. Organizational innovation.

The first three dimensions represent the well-known and thoroughly studied dimension of product/service innovation, which in the sense of this paper implies new or improved products and services provided by the HEI to the education, research and society/industry markets, as universities have moved from focusing exclusively on teaching and academic research to third mission activities and collaboration with industry and society. Following on from product/service innovation in HEI, in order to create a comprehensive model, we included innovation in HEI processes and innovation in HEI organization in the proposed framework. These two types of innovations have received less attention than product and service innovation in the innovation literature [49-50]. From the perspective of defining HEI innovations, process and organizational innovations have been recognized [6, 20, 28] but from the perspective of measuring innovation in HEIs, they have mostly been ignored [9, 34, 36, 44, 46], something the proposed framework seeks to correct.

In accordance with the recommendations of Oslo Manual [19], identified innovations do not have to be new to the HEI's markets or new to the world, they have to be new to the HEI; equally, an innovation does not need to be developed by the HEI itself, it can be acquired from other institutions through the process of diffusion.

The following section gives a more detailed explanation of the proposed dimensions and selected innovation parameters.

3.1 Curriculum Innovation

Curriculum innovation directly determines the structure of education services. It indicates the ability of HEIs to predict the needs of the education and labor markets and offer appropriate education. This form of innovation in HEIs is recognized by other authors: Haelermans and De Witte [6] use the term "profiling" innovations, while OECD [20] and Lubienski [28] refer to them as product innovations and educational product innovations, respectively. Quantification of innovation at this level depends on whether the HEI offers master, bachelor and PhD programs to students and if there are different study modules within one program. Besides new modules and programs, important quantifiers of innovation at this level are new courses. These quantifiers may or may not be causally related, new programs do not have to entail new courses, they can be a new mix of existing courses.

Parameters selected for quantifying curriculum innovation are:

- the number of new or significantly improved bachelor/master/PhD programs;
- the number of new or significantly improved study modules;
- the number of new or significantly improved courses.

3.2 Innovation in Research

Academic research is the next traditional HEI activity and the most utilized evaluations used for the innovation performance of HEIs emerge from academic research results [47, 51] as HEI research output is generally available and easily quantified. Research expectations in developing countries, which previously had minimal expectations for faculty research, are increasing rapidly and even the teaching-focused HEIs are under the pressure to meet research expectations [50]. HEI research activities are most highly rewarded and so HEI are tempted to concentrate their efforts on research at the expense of teaching [52-54]. Academics are tempted to do the same, as research remains the main activity of choice for those seeking career progression, personal recognition and reward [55]. Published scientific paper can be considered as a new product at the research market, as well as each new project (significantly different from the existing HEI projects), starting of a new scientific journal or new scientific conference and PhD thesis defended at HEI.

Accordingly, parameters selected for quantifying innovation in the field of research are: the number of scientific papers published in scientific journals; the number of scientific papers published at international scientific conferences.

- the number of new international research projects;
- the number of new national research projects;
- the number of new scientific journals;
- the number of new scientific conferences organized;
- the number of defended PhD theses.

3.3 Third Mission Innovation

After teaching and academic research, third mission activities oriented towards technology transfer and innovation, continuing education and social engagement have become the third pillar of universities [56], although the focus of third mission activities varies considerably in different countries and different contexts between technology transfer and social engagement [57]. Rothaermel et al. [58] argued that third mission refers to the activities and assets of an entrepreneurial university such as technology transfer, university licensing, science parks, incubators and university spin-offs. Hsu et al. [59] remarked that the key role of third mission is activities such as contract research, consulting services, technology licensing, advanced training for enterprise staff and other forms of information transfer with the external environment. Third mission indicators are the subject of constant debate given their high level of ambiguity [60] and there is a significant lack of measurement of third mission entrepreneurial activities within universities [61].

From the innovation measurement perspective, elements of third mission activities can be found as the only measure of HEI innovativeness [43-44] or used in addition to scientific production indicators [33, 34, 46], while other

authors ignore third mission activities in their definitions and classifications of HEI innovation activities [6, 20, 22, 28].

The parameters selected for quantifying innovation in the field of third mission are:

- the number of new projects/contracts with companies and public bodies;
- the number of new reported technical solutions;
- the number of new applied patents;
- the number of new startup and spinoff companies;
- the number of new training events and seminars for companies and public bodies.

3.4 Process Innovation

Process innovation has often been considered a second-order innovative activity, next to product innovation [62] although research has shown that effective process innovation may enhance organizational efficiency and responsiveness [63] and that improvements in performance as a result of process innovations may include increases in capacity, flexibility and quality, process rationalization and lowering of costs [49]. A lack of improvements in these areas is usually the source of public dissatisfaction with HE. Reichstein and Salter [62] define process innovation "as new elements introduced into an organization's production or service operations". OECD [19] describes process innovation as "the implementation of new or significantly improved production or delivery methods". Khazanchi et al. [64] argue that process innovation involves creating or improving methods of production, service or administrative operations, stressing that process innovations do not have to be primarily production oriented.

In terms of definitions and the types of products and services that HEI offer, process innovations in HEI can be divided into innovation in teaching processes - pedagogical innovations, innovation in research processes and innovation in the third mission and other "administrative" processes. As already mentioned, pedagogical innovations are beyond the scope of this work, and the same applies to innovation in research processes, since we are not focused on measuring innovation activities at the individual level of researchers.

In our understanding and in the context of this work, process innovations refer to the number of new or significantly improved processes in the offices, services or departments that are on the HEI organizational scheme. Parameters selected for quantifying process innovations are:

- the number of new processes in the work of HEI management;
- the number of new processes in the work of student services;
- the number of new processes in the work of libraries;
- the number of new processes in the work of IT services;
- the number of new processes in the work of the marketing department;
- the number of new processes in the work of the accounting department;
- the number of new processes in the work of the human resources office;
- the number of new processes in the work of the legal and administrative service;
- the number of new processes in the work of the technical and maintenance service;
- the number of new processes in the work of the technology transfer/licensing offices;
- the number of new processes in the work of science parks, business incubators, accelerators, idea labs, etc;
- the number of new processes in the work of other services, offices, etc.

3.5 Organizational Innovation

The concept of organizational innovation overlaps with concepts such as administrative innovation, process innovation and, in more recent papers, management innovation [65]. Edquist et al. [66] introduces the concept of organizational process innovation as new ways of organizing business activities. The OECD [19] provides a definition for organizational innovation as "… the implementation of a new organizational method in the firm's business practices, workplace organization or external relations". Battisti and Stoneman [67] define organizational innovation as "Innovation involving new management practices, new organization, new marketing concepts and new corporate strategies". Damanpour and Aravind [68] use the term managerial innovation, for the sake of brevity, to represent management innovation as "New approaches in knowledge for performing management functions and new processes that produce changes in the organization's strategy, structure, administrative procedures, and systems".

In the context and scope of this work, organizational innovations are limited to the identification of innovative activities in the organization of the HEI, i.e., changes in its organizational structure. This narrow way of looking at organizational innovation is chosen to clearly differentiate organizational from other types of innovation in HEI. Parameters selected for quantifying the organizational innovation are:

- the number of new laboratories;
- the number of new departments;
- the number of new faculty services and offices;
- the number of new boards and committees;
- the number of new scientific/research centers and institutes.

4 APPLICATION OF THE FRAMEWORK: HEI INNOVATION PERFORMANCE SURVEY

To determine the extent to which the defined framework and parameters can be used as a tool for gathering information on HEI innovativeness two consecutive surveys have been conducted. This attempt should be observed as a pilot activity to test the soundness of the concept and the possibility of empirical application in HEIs.

Firstly, survey of innovation performance was conducted at six faculties in order to collect hard data on HEI innovation performance (survey questions available upon request from the corresponding author). Based on the developed framework, an innovation performance questionnaire with series of questions on the level of

aforementioned innovation parameters for a period of two academic years and some supplementary questions on general HEI information was created and sent to the HEIs.

With the explorative approach of a pilot study in mind, based on HEI availability and willingness to participate, six faculties have been selected to test the HEI innovation performance survey, four of which are in the Republic of Serbia and two are in Bosnia and Herzegovina.

In the second step, in order to better understand the measuring process and availability and reliability of the requested data, a semi-structured interview was developed and 14 persons in charge of completing the innovation performance questionnaire at the 6 surveyed faculties were interviewed about their experiences in collecting the data. Interviews with persons appointed to fill out the questionnaire were conducted in person and over the phone. The basic idea behind the interviews was to determine whether the innovation indicators defined by the framework and presented in the questionnaire were clear and understandable to those who had to fill out the questionnaire, the extent to which the required data was available, whether a reliable methodology could be used for providing the data, and the number of resources needed to obtain it.

4.1 Survey Results and Discussion

Although the HEI innovation performance survey has been conceived as a pilot study with the aim of exploring the capability of the developed framework to measure HEI innovation results, we will briefly present the innovation performance of the surveyed faculties based on data obtained from innovation performance questionnaires. Next, we will discuss some of the most significant information received from interviewees about the availability and reliability of the requested data.

In accordance with the sample size and the purpose of the research, the applied statistical methods are descriptive and unless otherwise stated, results are presented as the value of a given parameter for a period of two academic years. The order of the faculties listed in the tables is consistent throughout the tables.

4.1.1 Curriculum Innovation

Before the results of the research into curriculum innovations are presented it should be highlighted that the professor teaching load is significantly different at the surveyed faculties (Tab. 1). The number of students per professor varies between 9.1 and 107.8, and the number of courses per professor varies between 2.9 and 7.3 (Tab. 1). The results of the research into curriculum innovations indicate the existence of significant innovative activities in this field at the five faculties (Tab. 2). One of the faculties did not report any activity in this area because the study programs were accredited before the period covered by the research, which we learned later from the interviewees. This leads to the conclusion that the volume of curriculum innovation largely depends on the accreditation/re-accreditation cycles and the research time frame. In many countries curriculum accreditation is mandatory and the period of accreditation validity varies between countries. However, in some countries, such as the United States, accreditation is not obligatory and is usually conducted by associations of educational institutions or professional societies [69]. Updating and adaptation of existing study programs is usually prepared prior to a forthcoming accreditation round, as the accreditation process consumes a lot of resources. New study programs can be accredited before the next accreditation cycle, but this is a rarer case, mainly reserved for a first accreditation of completely new programs. Therefore, in order to cover the full range of curriculum innovations the research should be initiated after the re-accreditation round or the time frame should be extended to the period from the previous accreditation round.

Interviewees at large faculties stated that collecting information on curriculum innovations turned out to be a very demanding and time-consuming process. The surveyed faculties did not keep records on the number of new or significantly improved courses, study modules and programs, so they had to ask the department chiefs about the new or significantly improved courses, study modules and programs offered by their departments and then their lecturers were asked about the number of new or significantly improved courses that they had developed. Thus lecturers and departments were responsible for determining the level of novelty, which is a good way to obtain reliable data as they are those who directly determine the composition and structure of courses and sometimes programs so they know if only the name of the course or program is changed or the content is changed significantly, without the name being changed. Still, the question of novelty in curriculum innovations requires special attention. If HEI reports only completely new courses or study programs there is a risk that a large portion of the curriculum innovation may not be covered so the term "significantly improved" must be carefully and precisely defined. In this research, the limit for a significantly improved course/program was set to 50% or above, which was outlined in the questionnaire in order to provide a comparable result. The research organizer can set this threshold lower or higher, or it can be decided to separately collect information on new and significantly improved courses or study programs in order to get more detailed information for data analysis and interpretation or to customize quantifying of curriculum innovation for some discipline-specific HEIs.

At the time of research we decided to collect information on the number of students enrolled in new study modules/programs (Tab. 2), even though we did not include these parameters in the presented framework. The number of students enrolled in new study modules/programs nevertheless points to the success of HEI curriculum innovation activities as HEIs develop new programs to attract and retain students [44], although these new programs do not have to be recognized as attractive by students since new lecturers can be seen as a new resource that has a significant impact on HEI innovation [26]. At the time of research, we decided to collect information on the number of newly employed lecturers even though we did not include this parameter in the presented framework. Although, the percentage of new lecturers can be related to HEI growth as can be seen at the example of the 2nd faculty (Tab. 2) that reported as many as 35% of new professors or lecturer fluctuation as can be seen at the example of the 5th

faculty (Tab. 2) that reported 5.2% newly employed professors and 12% newly employed teaching associates engaged in the period when there were no new courses.
It should however be borne in mind that accreditation rules generally allow for a certain percentage of the accredited course content to be changed during the implementation, or the course must be re-accredited, which means that newly employed lecturers have to wait for a new accreditation cycle if they want to significantly change the course. However, accreditation standards can actually play a positive role in fostering innovative change [70, 71].

4.1.2 Innovation in Research

It is important to note that during the initial research period there were no minimum academic production criteria for lecturers' career advancement and that getting as much as possible scientific references was not a priority for lecturers, so the level of reported results in the field of research (Tab. 3) was fairly modest, especially if the number of published papers is observed. The numbers of new scientific journals per lecturer and new scientific conferences per professor were expectedly modest and at the time of the research Faculty 2 and Faculty 6 did not have PhD programs.

Table 1 Professor teaching load

Title 1	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Average
Number of students per professor	9.1	107.79	5.95	23.04	21.68	18.15	30.96
Number of courses per professor	2.93	4.64	5.02	2.45	6.21	7.31	4.76

Table 2 Curriculum innovations (1 New or significantly improved 2 Some of the faculties offer more modules within one study program)

Parameter	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Average
The number of new[1] courses per professor	0.78	0.14	0.45	0.41	0	0.77	0.42
The percentage of new[1] courses	26.9	3	9	16.8	0	10	11
The percentage of new[1] study programs	14.3	0	16.7	28.6	0	40	16.6
The percentage of new[1] study modules[2]	20	20	0	35.3	0	0	12.5
The percentage of students enrolled in new study modules/programs	8.2	1.8	6.8	8.5	0	4.5	5
The percentage of newly employed professors	9.7	35.7	10.1	16.3	5.2	11.5	14.8
The percentage of newly employed teaching associates	30.3	18.7	7.8	41.5	12	25	22.6

Table 3 Innovation in the field of research

Title 1	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Average
The number of published journal papers per lecturer/researcher	0.25	0.56	/	0.05	/	/	/
The number of published conf. papers per lecturer/researcher	1.6	0.2	/	1.02	/	/	/
The number of published papers per lecturer/researcher	1.86	0.76	1.76	1.07	2.36	1.61	1.57
The number of new scientific journals per lecturer	0.04	0.29	0.01	0.01	0.05	0	0.07
The number of new scientific conferences per professor	0.12	0.5	0.02	0.08	0.05	0.04	0.13
The number of new research projects per professor	1.63	0.43	0.56	0.3	0.53	0	0.57
The number of defended PhD theses per professor	0.23	/	0.3	0.22	0.37	/	0.29

According to interviewees, collecting information on innovation in the field of research was less demanding as all faculties examined already had data on academic production, but three faculties submitted only the total number of published papers per institution instead of the detailed numbers that were requested in the questionnaire and at the time of research we collected only the total number of research projects. The aggregated nature of data on scientific production that was available prevented further analysis of innovativeness in this field.

4.1.3 Third Mission Innovation

The results for innovations in the field of third mission showed that half of the surveyed faculties reported almost no results in this area (Tab. 4).

Based on information obtained from interviews, gathering information on innovation in the field of third mission was difficult. Interviewees stressed that lecturers were not obliged or motivated to report industry cooperation as it is not a career advancement criterion, and the problem of non-reporting on industry cooperation can be seen in some highly-developed countries too [72]. They explained that faculties can monitor projects with public bodies or industry only if financial transactions go through faculty accounting and that in reality the volume of cooperation with industry is greater than they can report.

Determining the number of spin-offs and start-ups was also an issue because these terms can be interpreted differently by the HEI. The numbers of spin-offs and start-ups quoted on faculty and university reports and websites are not always reliable. For promotional purposes faculties often publish the list of companies "created" at the faculty and owned by students or lecturers and these companies do not have to exploit knowledge and results produced from academic activities or be connected with the faculty or university in any way. These quoted numbers are debatable

because lecturers and researchers are not required to inform the HEI about their new companies, in general. In our research, we focused our attention only on those companies that had a formal affiliation with the HEI, with the awareness that some start-ups that are not formally linked with the HEI may exploit the unrestricted results of HEI research, since HEIs in Serbia are not obliged to protect research-based intellectual property rights and they rarely do so. For these reasons, it is necessary to precisely define the level of affiliation between the spin-off or start-up companies and the HEI and to clearly state this in the questionnaire.

4.1.4 Process Innovation

In the field of process innovation, only two faculties reported some activities, more precisely, 0.078 and 0.082 new and significantly improved processes per non-teaching staff member.

In order to prevent HEIs from registering process innovation only on the basis of new procedures we clearly stated in the questionnaire that we need the number of new and improved processes regardless of whether there were written procedures for them or not. Likewise, we instructed the HEI in the questionnaire not to count process changes that were mainly a consequence of changes to legal regulations, as a number of the HEI processes are regulated by government bodies. Again, the limit for a significantly improved process was set to 50% or above, which was outlined in the questionnaire.

Interviewees pointed out that faculties are not interested in monitoring processes outside of the teaching process and that there is a lack of resources and motivation for non-teaching staff to improve these processes. In order to collect the requested information, the faculties examined asked their non-academic department managers about new processes and process improvements in departments and offices that are under their jurisdiction, which is a good way to obtain reliable data.

Table 4 Innovations in the field of third mission

Title 1	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Average
The number of new projects with companies and public bodies per lecturer/researcher	0.69	0.09	0	0.11	0.07	0	0.16
The number of reported technical solutions per lecturer/researcher	0.11	0	0	0.01	0	0	0.02
The number of patents per lecturer/researcher	0.003	0	0	0.01	0	0	0.001
The number of established companies per lecturer/researcher	0.05	0.11	0	0	0	0	0.03

4.1.5 Organizational Innovation

The research into organizational innovation (Tab. 5) showed that this area was largely affected by the life stage of HEI at the time of research and by the HEI size. The youngest faculty (Faculty 2), expressed intense activity in the opening of new laboratories, new departments, new centers and institutes. The largest faculty diversified in many disciplines and fields (Faculty 1) expressed significant level of organizational innovation. According to interviewees, the parameters used for capturing organizational innovations were clear and obtaining the requested data was done without any major problems, even at larger faculties, despite the fact that HEIs usually do not track the number of new organizational parts.

Table 5 Organizational innovation

Title 1	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Average
The percentage of new departments	4.6	70	0	9.1	0	0	28
The number of new laboratories per professor	0.03	0.14	0	0	0	0	0.03
The number of new scientific/research centers and institutes per professor	0.05	1.36	0	0	0	0	0.23
The number of new faculty services and offices per non-teaching staff member	0.003	0.05	0	0.15	0	0	0.01

5 CONCLUSIONS

It was argued in the introduction that HEIs should respond to innovations in the global economy by innovating themselves. To effectively innovate, Barber et al. [73] argue that universities "could pursue a new system of ranking which puts greater weight on outputs and outcomes and less on inputs". The innovation measurement framework presented in this paper follows this recommendation and by observing holistically the outputs of innovation activities it enables the HEI to measure the results of innovative efforts in multiple areas of its work, whether this is in introducing new products and services to the education, research and third mission markets, new elements of organizational structure or new and improved processes. This approach is an attempt to solve the problem of focusing only on some dimensions of HEI innovativeness, that has been identified in the review of literature on measuring innovations in HEI. Multidimensional approach allows us to measure HEI innovative performance through more complex and more informative indicators, which remedies the fact that the current means of measuring HEI innovative performance are based on few aspects.

The two pilot surveys attempted to test the usability of the proposed framework and to understand how the process went inside the observed HEIs. Gathering of information on innovation in the fields of curriculum innovations, third

mission and process innovation turned out to be very demanding for these faculties, while the collecting of information on organizational innovations and innovations in the field of research was significantly easier. In order to provide reliable data, HEI innovation quantifiers have to be very precisely defined and this information must be clearly communicated with the persons responsible for completing the questionnaire. The timing of the research needs to be matched to accreditation/re-accreditation rounds.

It should be noted that the framework for measuring HEI innovativeness should mostly be used at the faculty/school level rather than at the university level, as universities mostly consist of multiple faculties or schools that cover a variety of disciplines, and different disciplines have their own peculiarities in terms of innovative output. For example, life sciences have a higher scientific output over engineering [69], so there should be a separate ranking for each faculty/school, which will facilitate subsequent benchmarking at the university level and benchmarking with similar faculties or schools among universities, although even HEIs with similar disciplines can be different in their teaching, research and third mission orientation and objectives. In addition to adjusting the level of research to the organizational specificities of a particular university, the level of research can be further customized according to specific HEI innovation research objectives. The faculty can partially apply the developed framework to measure and benchmark the curriculum, research and third mission innovativeness of its departments as long as they have a decision-making autonomy in those areas.

National and institutional context affects the levels of some suggested innovation parameters. Different cultural traditions, national HE contexts and financial schemes put HEIs in quite different conditions: an old metropolitan university and a new agile HEI set up mainly for third mission purposes will have different innovation output; humanities, arts and social sciences universities and the hard sciences and technical universities will also have different innovation output.

In addition to self-evaluation, the developed framework can be used as a benchmarking tool within HEIs, although even HEIs with similar disciplines, size and age can be different in their teaching, research and third mission orientation and objectives.

In this case, it was shown that the surveyed faculties have achieved the best innovation results in the area of curriculum and research innovations, while weaker results have been achieved in innovations in the field of third mission and organizational innovation, and that the process innovation (outside of the teaching and research process) have somehow been neglected by HEI management, and display the lowest level of innovation although the literature has shown a great significance of process innovation for organizations of any kind [49, 63].

The developed framework is limited to innovations at the institution level (HEI), which in no way diminishes the importance of pedagogical innovations at the level of lecturers and their relevance for improvement of the learning process. It should be clear that this paper does not outline a theory of HEI innovativeness, it does not deal with the sources of, barriers to or effects of HEI innovativeness. The focus is rather on developing a comprehensive set of HEI innovation performance indicators and to establish a better understanding of HEI innovative performance. In terms of magnitude, the developed framework does not differentiate incremental and radical (revolutionary, disruptive) innovation or give preference to one in relation to others, which can be viewed both as a strength and as a weakness of the framework. In our research we covered only the innovation implemented at HEI and we did not collect any information on the ongoing innovation or innovation abandoned before the implementation, so the scope of our research is limited on measuring only the successful innovations efforts.

Future research should consider the development of customized parameters for quantifying innovation performance that are better suited for some specific HEIs (e.g. art faculties) or parameters customized to the HE national and social context, which can differ significantly across countries and regions. It would be interesting to see the effect that the measurement of innovation performance has on HEI innovation behavior, as well as the influence of information on achieved HEI innovation performance on policy makers. Additionally, future research could combine the proposed measurement with other measurements previously published, in order to establish validity of the instrument.

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