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The Evolution of International Collaborations in the Light of Disciplinary Interplay at Eötvös Loránd University in Budapest, Hungary – a Bibliometric Case Study

Abstract

Scientometric and bibliometric analyses, focusing exclusively on the written output of research, are well-known methods to analyse the scientific performance of researchers and higher educational institutions. However, most studies lack the analysis of the interplay between different scientific disciplines or interdisciplinary research, often associated with higher research impact. The remaining studies intend to explore the connection between major scientific outputs and interdisciplinary nature of collaboration; however, the research interest is focused on a generalized national or international environment with a focal point on individual research fields. These studies do not take into account the contribution of individual universities, higher educational institutions and research facilities. To fill this gap, the paper combined a bibliometric analysis and measured the interplay between individual scientific disciplines of the written research output of Eötvös Loránd University in Budapest, Hungary. The novelty of this paper lies in the data correction of the parameters of the published papers marked as international collaboration on the Web of Sciences database; and the subsequent longitudinal evaluation and visualisation of interdisciplinary nature of research. The presented method establishes a new, potential framework being able to measure the scientific performance of higher educational institutions and its possible relevance during their evaluation. In the practical domain, the study can stimulate an incorporation of a new approach for higher educational institutions and decision-makers to analyse the interdisciplinary nature of research of written scientific outputs, which can serve as a potential indicator of research performance.

Keywords: international collaboration, bibliometric data, interplay between disciplines, data correction of parameters, interdisciplinary nature of research

INTRODUCTION

The bibliometric analysis of research publications is an effective tool to describe the scientific performance of countries (Schubert et al., 1989), universities, research groups (Seglen–Aksnes, 2000) and individual researchers (van Raan, 2006). Moreover, it can be used to examine the knowledge interplay between and across scien-

tific disciplines (Ming et al., 2011). As the structure of science has been observed to change over time (Wray, 2015), it has driven the emergence of new forms of collaboration not only between different organisation (D'Este– Fontana, 2007; Porac et al., 2004) but also between diverse scientific fields (Liu et al., 2012).

Several papers have analysed the relationship between research performance and interdisciplinary research by bibliometric tools; however, the chosen methodological approaches as well as the source and extent of data show remarkable differences. Whilst Leahey et al. (2016) measured the impact of interdisciplinarity of scientists' research by the use of more than 32,000 papers from nearly 900 research-centre-based scientists in the U.S., Okamura (2019) used the Web of Science database to analyse more than 10,000 papers without geographical restriction. According to Yegros-Yegros et al. (2015), interdisciplinary research is not a monodimensional property, and it has a significant impact on different aspects of written research outputs.

We acknowledge that interdisciplinary research has its effects on research performance (Leahey et al., 2016; Okamura, 2019); however, there is a lack of univocal methodology capable of capturing the evolution of interplay between disciplines and its relation to the impact of individual publication. To this end, through the 15-year publication activity of Eötvös Loránd University in Budapest, Hungary, we introduce a potential method suitable for analysing interdisciplinary research manifested in research papers, its spatial and temporal evolution, as well as its relation to basic outputs of publications. Our main goal is to provide a potential tool to be used as a common measure of interdisciplinary research and its relation to publication outputs, regardless of the geographical location and type of institutions.

The paper is organized as follows: the first part discusses the relevance of bibliometric data analysis and presents a review of interdisciplinary research and international collaboration. The second section describes the used measures and methods. The third part contains the results of case study. The fourth section presents the conclusion.

1. LITERATURE REVIEW

1.1. BIBLIOMETRIC DATA AS A POTENTIAL TOOL TO EVALUATE RESEARCH COLLABORATION

Researchers' access to bibliometric databases in combination with a collaboration network analysis has enabled the identification and labelling of co-operations among organisations, researchers and scientific disciplines (Youngblood–Lahti, 2018). However, bibliometric analysis cannot capture the scientific efforts, which are not manifested in publication (Taşkın–Aydinoglu, 2015). Despite this disadvantage both Stokols et al. (2008) and Wagner et al. (2011) emphasize the use of bibliometric tools and network analysis of collaboration and interdisciplinary

research to evaluate publications and collaborative efforts of research organisations, research groups and researchers.

The bibliometric analysis in combination with a visualization software led to a science mapping approach, which can be used to capture not only different scientific domains, but also their size and connection among them (Taşk n–Aydinoglu, 2015). For example, Porter and Rafols (2009) investigated the degree of interdisciplinarity change between 1975 and 2005 over six research domains by the combination of bibliometric indicators and a science mapping visualization method. They found notable changes in how research is conducted in the given time period. Porter and Rafols (2009) conclude that science in general is becoming more interdisciplinary, but in small steps. Klavans and Boyack (2006) mapped the world-wide scientific literature and generated maps directly from the data on the relationships between the presented documents, and visualised the journal citation interactions. Ceballos et al. (2017) analysed fifteen years of publication data at a Mexican university with 2,400 researchers who produced 24,000 works in fifteen research disciplines. They found through data that the knowledge management model increased research collaboration and boosted the number of publications and citations. In addition, it has also been shown by Williams et al. (2013) that the bibliometric analysis of cross- or interdisciplinary research can be used to elucidate the relationship between scientific fields.

Thus, bibliometric analysis of the scientific performance and the interplay between different scientific disciplines can be used to understand the changes and trends of interdisciplinary research at the organizational and personal level.

1.2. THE INTERPLAY BETWEEN SCIENTIFIC DISCIPLINES AND INTERNATIONAL COLLABORATION AS INDICATORS OF RESEARCH OUTPUTS

Researcher complex problem-solving strategy can be achieved by bringing together different scientific fields (e.g. by conducting interdisciplinary research) (van Rijnsoever and Hessels, 2011). Interdisciplinarity is stimulated by a variety of funding instruments, at the university (Sá, 2008), national (Lepori et al., 2007), as well as on international levels (Bruce et al., 2004). The goal of these initiatives is not only to foster scientific collaboration among individual researchers but also to produce new knowledge by bringing together skills, techniques or concepts originating from various researchers from disparate scientific fields (van Rijnsoever–Hessels, 2011). According to Kyvik and Reymert (2017), the majority of research is undertaken in collaboration; moreover, the active participation of researchers in international networks is more likely to increase the quality of ongoing research and consequent publication productivity.

It has been shown by Matthews et al. (2009) that effective international collaboration among researchers can provide several benefits, such as reduced unnecessary duplication of research efforts, enhanced economies of scale and scope in

research teams, improved ability to exploit synergies between different capabilities and the types of instrumentations, improved knowledge transfer, enhanced skills development and recruitment, more effective work addressing global challenges, contributing to constructive international relations, stimulating foreign investment flow, and finally, facilitating access to research infrastructure. The authors also highlighted that the total publication output can reflect the fields of international research activity; however, not all international collaboration initiatives are captured by publications.

At present, one of the primary sources of information on international cooperation of researchers is bibliometric data. Besides international co-authorship, the qualitative outputs of papers as well as the involvement of scientific disciplines in papers can be used as a proxy for measuring the level and impact of international research collaboration. Nevertheless, bibliographic information by itself cannot reveal other factors relevant for international collaboration, such as input factors, motivation, drivers of research, and other projects involved in international co-operation (Wagner, 2005). Therefore, in a narrow sense, international research collaboration represents those activities which directly affect the beginning, ongoing process and completion of research projects, and can be evaluated by bibliometric approach (Jeong et al., 2014).

Another possible reason explaining the increasing international research collaboration among researchers and research groups is the growing number of scientists applying for research grants. In this highly competitive environment, the increased collaboration between researchers can contribute to greater competitiveness and specialization at the individual and organizational level (Iglič et al., 2017). However, Kyvik and Reymert (2017) found significant differences in international collaboration across different scientific fields. They have shown that researchers in humanities working "alone" have significantly more publications compared to those who work in an international network. On the other hand, social scientists, natural scientists and researchers in medicine who work in international networks have significantly more publications compared to researchers working "alone". Kyvik and Reymert (2017) conclude that participation in international networks is the most important in the natural sciences, and researchers' participation in international networks is likely to increase not only the publication activity but also the quality of research.

1.3. INTERNATIONAL COLLABORATION AND THE INTERPLAY BETWEEN SCIENTIFIC DISCIPLINES AS A POTENTIAL INDICATOR OF RESEACHER COLLABORATION AND THEIR OUTPUTS?

Besides the positive relationship between research collaboration and research output, He et al., (2009) highlighted that there is a lack of longitudinal analysis of research collaboration and subsequent research output. Moreover, as far as we know, the interplay between different scientific disciplines and its relation-

ship to international collaboration at the article level in Hungary has not been investigated. To address these identified gaps in the literature, we used the Web of Science (Wos) Core Collection database and performed longitudinal analyses of papers published through international collaboration at the Eötvös Loránd University in Budapest, Hungary between 2005 and 2019. We examined how the publication activity and therein the proportion of international collaboration have changed over time. This was followed by an analysis of the temporal profiles of major scientific disciplines and the interplay between them. The main goal of the present study is to introduce a new approach of data correction and visualisation capable of capturing the evaluation of international collaboration and interdisciplinary content of research outputs, with the potential to be extended to other higher educational institutions.

2. METHODOLOGY

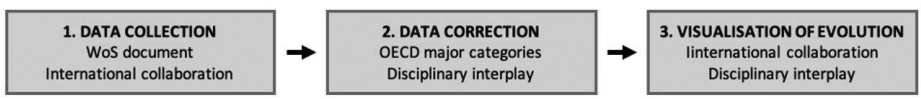
The WoS is not just a catalogue of academic publications. It is a complex database with a wide range of information (Birkle et al., 2020) suitable to fulfil the requirements of our study – to evaluate the relationship between international collaboration and the interplay between scientific disciplines by the use of bibliometric data. To this end, the study started with the selection of the Hungarian model university.

Based on the WoS database search for publication activity of Hungarian universities between 2005 and 2019 we found that Eötvös Loránd University has the highest proportion of international collaboration (53.82%) compared to other Hungarian universities. It is published on www.elte.hu/en that Eötvös Loránd University (ELU) is the oldest continuously operating university in Hungary (since 1635), located in Budapest, Hungary. The mission of ELU is to preserve and increase national and universal culture and literacy, to cultivate scholarships, to pass on scientific knowledge, and to express and fulfil the substantive, long-term needs of the Hungarian society and of humanity as a whole. Nearly 30,000 students are organized into eight faculties (Faculty of Law and Political Sciences, Bárczi Gusztáv Faculty of Special Education, Faculty of Humanities, Faculty of Informatics, Faculty of Education and Psychology, Faculty of Social Sciences, Faculty of Elementary and Nursery School Teacher Training, and Faculty of Sciences) and the Institute of Business Economics. According to the Quacquarelly Symond Ranking 2020, featuring the top universities in Europe and Central Asia, ELU is the best Hungarian university with its achieved 28th ranking, based on academic and employer reputation, faculty/student ratio, the number of papers published and their online appearances, the proportion of academic staff with PhD, the citation of publications, web impact, as well as the proportion of international members and international students. Based on the 2020 Times Higher Education World University Rankings by subject, ELU has proved to be the best higher education institution in Hungary in the fields of the arts and humanities and psychology, as well as life and natural sciences. Taking into account the proportion of international collaboration, the educational and research portfo-

lio, as well as the ranking of ELU in national and international rankings, we used Eötvös Loránd University as a model university.

Figure 1 shows the three stages of WoS data analyses. During the first, data collection stage, we collected all WoS documents and publications marked as *International collaboration*, for three, five-year time periods: 2005–2009, 2010–2014 and 2015–2019. In the second, *data correction stage*, we marked each *International collaboration* paper with the corresponding OECD classification of major scientific categories: 1. Natural sciences, 2. Engineering and technology, 2. Medical and Health sciences, 4. Agricultural sciences, 5. Social sciences, 6. Humanities. In the case of multiple classification, we marked all present major disciplines. In the third, *data analysis* stage we visualised the evolution of publishing activity, domestic collaboration, and international collaboration; the publishing activity and international collaboration activity in the identified major scientific categories; and the disciplinary interplay (or interdisciplinarity) between the major scientific categories.

Figure 1 The three stages of data analysis



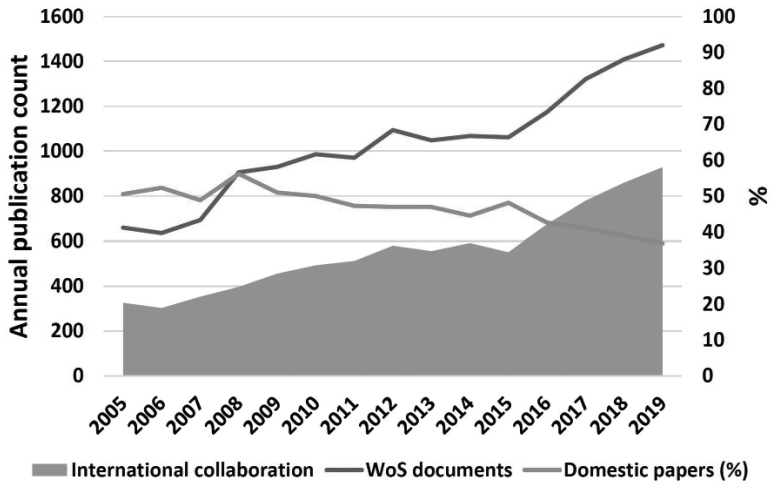
Source: Compiled by the authors

3. RESULTS

3.1. THE EVOLUTION OF INTERNATIONAL COLLABORATION AT EÖTVÖS LORÁND UNIVERSITY

In order to analyse the evolution of publication activity of Eötvös Loránd University, we used the WoS InCites database and collected the annual publication activity of the selected university in a 15-year time period between 2005 and 2019. As a first step, we extracted not only all WoS documents but also the number and proportion of papers marked as international collaboration.

Figure 2 The total, domestic and international research output of the Eötvös Loránd University indexed on WoS, between 2005 and 2019



Source: Compiled by the authors. Input data source: Web of Science database

Notes: X axis shows the 15-year time period. The left-hand Y axis is the annual output of WoS documents. The continuous blue line represents the total number of papers, the grey shape refers to the number of international collaboration. The right-hand Y axis shows the percentage of domestic papers without international co-author (orange line).

According to the WoS database, a paper is marked as international collaboration when it contains one or more international co-authors. Therefore, the publication activity and international collaboration activity can be visualised and analysed quantitatively by plotting the publication results against time. Figure 2 shows that the total research output of Eötvös Loránd University has more than doubled over 15 years, from 659 papers in 2005 to 1,472 in 2019. Moreover, the international collaboration has also more than doubled, reaching the proportion of 63.11% in 2019 compared to 49.47% in 2005. This proportion was calculated as the percentage of international collaboration by the given year to the total number of WoS documents of the same year.

Our results indicate that the total increase in research outputs depends on international partnership. To support this finding, we calculated the ratio of the so-called domestic papers (without international co-authors) to all WoS documents in each year. It is also shown in Figure 2 (orange line, right Y axis) that the number of domestic papers increased from 333 to 543 between 2005 and 2019 (by 61%); however, this growth is slower compared to international collaboration, and it represents only 36.89% of all WoS documents in 2019 compared to 50.53% in 2005.

Although the total number of domestic collaborations is increasing, its proportion to all WoS documents is decreasing at the same time. Thus, the growth in research output of the last 15 years has been produced by international collaboration.

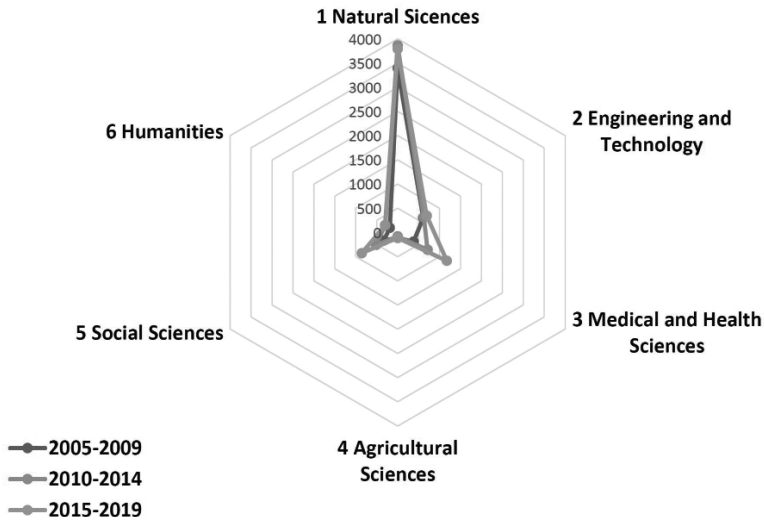
3.2. DISCIPLINE-SPECIFIC PERFORMANCE OF INTERNATIONAL COLLABORATION AT EÖTVÖS LORÁND UNIVESITY

In order to visualise the discipline-specific outputs and temporal evolution of the international collaboration at Eötvös Loránd University, first, we divided the 15-year time period into three quinquennials: 2005–2009, 2010–2014 and 2015–2019. Based on the OECD classification, we extracted publications based on the OECD categorization of six major disciplines: 1. Natural sciences, 2. Engineering and Technology, 2. Medical and Health sciences, 4. Agricultural sciences, 5. Social sciences, and 6. Humanities. To this end, we used three different parameters: 1. the time period (2005–2009, 2010–2014 or 2015–209), 2. Eötvös Loránd University as organization, and 3. the OECD categorization (1. Natural sciences, 2. Engineering and Technology, 2. Medical and Health sciences, 4. Agricultural sciences, 5. Social sciences, and 6. Humanities). This means that we performed altogether 18 searches (six different disciplines for all three time periods). We included only the papers which were marked as international collaboration.

The identification of input data to perform appropriate data search on WoS allowed us to obtain the discipline-specific number of all WoS documents, as well as the ratio of international collaboration for each time period. However, we have to highlight that the number of major OECD disciplines was not restricted to only one. Therefore, those papers, which contained two or more main scientific OECD disciplines, were grouped simultaneously into those groups, which represented their disciplinary affiliation. Quantitatively, in the three subsequent five-year time periods the number of international collaboration papers containing two or more scientific publications was 186, 452 and 516, respectively.

For the comprehensive evaluation and visualisation of discipline-specific performance of international collaboration of Eötvös Loránd University we used a radar chart. The chart has six axes (six major OECD scientific disciplines) along which we plotted the number of WoS document for three subsequent time periods: 2005–2009, 2010–2014 and 2015–2019 (Figure 3).

Figure 3 The total number of international collaborations for the six major scientific disciplines based on OECD categorization



Note: Blue line 2005–2009, orange line 2010–2014, grey line 2015–2019. Note the prevalence of 1. Natural sciences

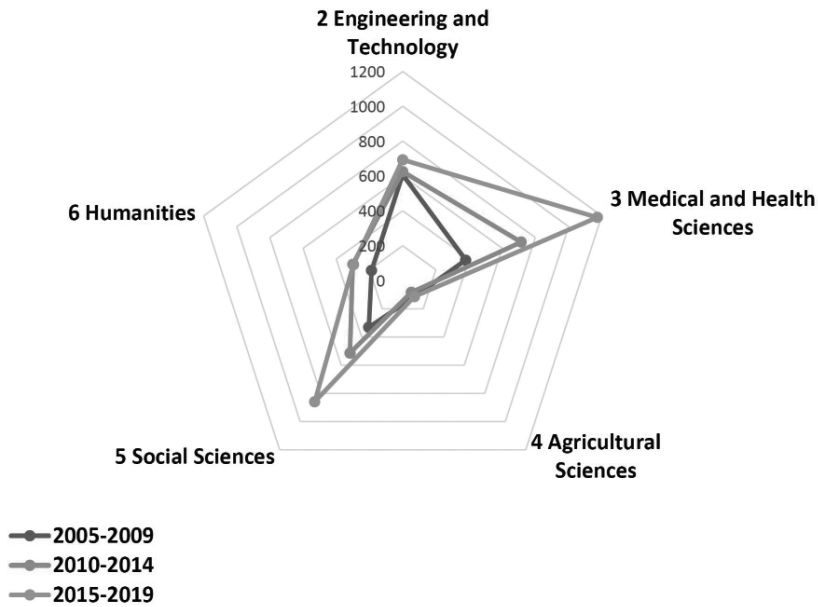
Source: Compiled by the authors. Input data source: Web of Science database

The most abundant number of papers was observed in 1 Natural sciences, reaching 3,398, 3,864 and 3,793 in the three subsequent time periods. As is shown in Figure 3, the visual representation of the high number of published papers in the research field 1. Natural sciences "covered" the results of the remaining major five disciplines. To better visualise the output of international collaboration in the remaining five major OECD categories, we cut out 1. Natural sciences category and created and another radar chart with five axes (Figure 4). In case of 2. Engineering and Technology, 4. Agricultural sciences and 6. Humanities we observed only a slight increase in the number of total international collaboration. However, in case of 3. Medical and Health sciences and 5. Social sciences the total number of international collaborations showed a more rapid growth compared to the remaining three major scientific fields.

In both cases, the number of publications increased by more than 1.8 and 1.5-fold (3. Medical and Health sciences and 5. Social sciences) between 2010–2014 compared to 2005–2009 and more than three-fold and 2.5-fold (3. Medical and Health sciences and 5. Social sciences) between 2015–2019 compared to 2005–2009. Whilst the volume of international collaboration increased in the last 15-year time period (Figure 2), the relative contribution of major scientific disciplines showed remarkable differences (Figure 3–4). These disciplinary differences are in accordance with the finding of Butler and Visser (2006), who have shown

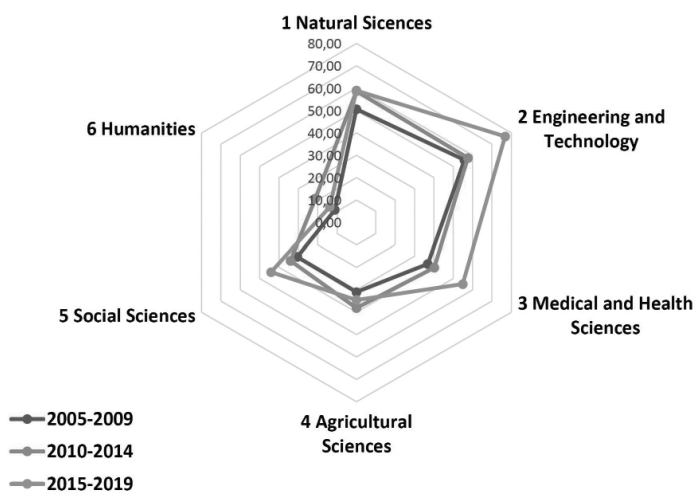
that the research output of dissimilar research fields is not identical; moreover, the dissemination outputs are also discipline-dependent.

Figure 4 The total number of international collaboration for the five major scientific disciplines based on OECD categorization



Source: Compiled by the authors. Input data source: Web of Science database

Figure 5 The ratio of discipline-specific international collaboration and all WoS documents.



Source: Compiled by the authors. Input data source: Web of Science database

We have shown that the growth of all WoS documents is attributed to the increase of international collaboration (Figure 2). However, it is still unclear how individual scientific disciplines contribute to that increase. Therefore, for each major scientific field, we calculated the proportion of disciplinary international collaboration to all disciplinary WoS documents in all three time intervals. The results are summarized in Figure 5. We obtained a slight increase in 1. Natural sciences and 5. Social sciences compared to 2. Engineering and Technology and 3. Medical and Health Sciences, and a slight decrease in 4. Agricultural sciences and 6. Humanities. The total discipline-specific ratio of international collaboration during the whole 15-year period is as follows: 2. Engineering and Technology (63.39%), 1. Natural sciences (56.06%), 3. Medical and Health sciences (43.98%), 5. Social sciences (36.25%), 4. Agricultural sciences (34.52%) and 6. Humanities (15.41%).

In addition to the main OECD categories, we believe that a more detailed analysis of scientific fields can be used to reveal the more comprehensive contribution of individual scientific fields to the development of international collaboration. If our classification goes a step further by dividing the main OECD categories into the subsequent 42 subcategories (OECD, 2007), it could possibly allow us to refine this process. For example, the Faculty of Sciences at Eötvös Loránd University is the largest faculty of the university (the number of international publications is the most abundant in 1 Natural sciences), and its teaching and research activity is organised into more than 60 degree programs at six different institutes: the Institute of Biology, the Institute of Geography and Earth Sciences, the Institute of Environmental Studies, the Institute of Chemistry, the Institute of Mathematics, and the Institute of Physics. Thus, the more detailed analysis of results has the potential to help us understand in further detail the discipline-dependent development of international collaboration and research outputs, and to provide a quantitative framework for future qualitative analysis of the driving force behind research collaboration.

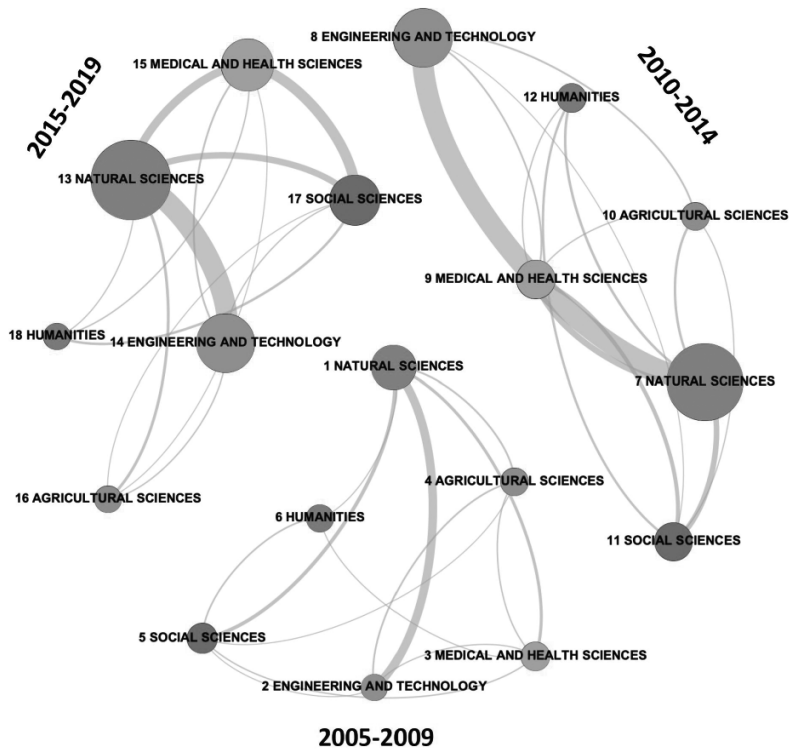
3.3. THE DISCIPLINARY INTERPLAY OF INTERNATIONAL COLLABORATION AT EÖTVÖS LORÁND UNIVERSITY

In order to visualise the interdisciplinarity of international collaborations, first of all, we extracted all WoS documents marked as international collaboration and divided them into three groups according to the year of publication: 2005–2009, 2010–2014 and 2015–2019. As a next step, for all selected papers, we identified the six major scientific disciplines based on OECD classification (OECD, 2007). To do this, we defined three input factors of search in the WoS InCite database: the first one was the time period (2005–2009, 2010–2014 and 2015–2019), the second one the organisation (Eötvös Loránd University), and the third one the research area classification (OECD classification). We obtained three datasheets (one for each time period) with all necessary information for further analysis.

Based on the OECD categorization we coupled the papers with the marked major scientific fields (the number of scientific fields for individual papers varied

between 1 and 4), enabling us to calculate the number of disciplinary interplays for each paper. Following this logic, we could narrow the analysis to publications with two or more disciplines present. In the presence of two distinct disciplines, the number of connections was 1. When the number of disciplines was 3 or 4, the number of connections was calculated for each possible unidirectional connection. For example, in case of Publication no. 270, published in 2009, three major scientific disciplines were identified (3. Medical and Health sciences, 2 Engineering and Technology, 1 Natural sciences), and the number of connections was calculated as follows: 3. Medical and Health sciences to 2 Engineering and Technology (1), 3. Medical and Health sciences to 1 Natural sciences (1), and 2 Engineering and Technology to 1 Natural sciences (1).

Figure 6 The interplay between different scientific disciplines. The six types of OECD classification-based scientific disciplines are marked by coloured circles



Notes: The grey curved lines represent the connection between different scientific fields. Whilst the size of circles corresponds to the contribution of the given scientific field to the number of total connections for a given time period, the thickness of grey lines represents the number of connections between different scientific fields

Source: Compiled by the authors. Input data source: Web of Science database

The identification of the main disciplines and the number of connections between them through the three different time periods allowed us to visualise the disciplinary interplay between different scientific fields, as well as the strength of connections between them (Figure 6). The total number of connections increased from 180 between 2005–2009 to 455 between 2010–2014 and to 547 between 2015–2019. Thus, in parallel with the growth of international collaboration (Figure 2), the interplay between different scientific disciplines also increased. This tendency was also seen in case of individual connection pairs. The most powerful growth was observed between 1. Natural sciences and 2. Engineering and Technology (85 – 299 – 299), 1. Natural sciences and 3. Medical and Health sciences (23 – 58 – 80), 1. Natural sciences and 4. Agricultural sciences (10 – 17 – 21), 1. Natural sciences and 5. Social sciences (30 – 52 – 62), 3. Medical and Health sciences and 5. Social sciences (5 – 35 – 108), and 5. Social sciences and 6. Humanities (8 – 16 – 17). Moreover, the contribution of individual scientific fields to the total number of connections also expanded: 1. Natural sciences (150 – 374 – 396), 2. Engineering and Technology (98 – 249 – 248), 3. Medical and Health sciences (37 – 109 – 205), 4. Agricultural sciences (25 – 34 – 28), 5. Social sciences (44 – 106 – 190), 6. Humanities (12 – 40 – 25).

Thus, with the increasing number of total research output and international collaboration the interplay between different major OECD disciplines is also growing. However, the contribution of individual major OECD scientific disciplines is changing over time. To obtain a more detailed contribution of scientific fields, the subdivision of main OECD categories into subsequent subcategories, as well as their further analysis is required. This could be a potential tool to analyse the research output of higher educational institutions both quantitatively and qualitatively.

4. CONCLUSIONS

The purpose of this case-study was to provide evidence that scientometrics and bibliometric analyses of research outputs can serve as a potential tool to provide a metrics capable of capturing the evolution of research outputs and interdisciplinary nature or research.

In this paper, our data suggest that the bibliometric data provided by the WoS database are a suitable tool to analyse and evaluate the quantity and quality of research collaborations. This research illustrates how publications focusing on international collaboration, in combination with an appropriate data correction (identification of major scientific fields and the interplay between them at individual research papers) can be a suitable tool to analyse the research outputs of universities. Our findings demonstrate a case of Eötvös Loránd University in Budapest, Hungary, in which the temporal evaluation of international collaboration boosted scientific performance (Figure 2).

The research was complemented by a longitudinal analysis of major scientific fields (Figures 3–5) and the interplay between them (Figure 6). Our results

show that with increasing international collaboration, the contribution of individual scientific disciplines also reveals a growing tendency albeit in a discipline-dependent manner. Moreover, the interplay between various scientific fields has also increased measurably.

Based on our data we suggest that a longitudinal bibliometric comparison of publications with the appropriate data collection and data correction is a suitable tool to measure and evaluate the research outcomes of higher educational institutions both quantitatively and qualitatively. The international collaboration characteristics as well as the interplay between scientific disciplines are promising variables, which have the potential to be incorporated into the evaluation process of research collaboration and their outcomes.

Nevertheless, the use of bibliometric data should be used cautiously, as the proportion of publication captured by databases may be incomplete and scientific discipline-dependent (Matthews et al., 2009). For example, it has been shown by Butler and Visser (2006) that the proportion of total research collaboration output in WoS ranged from 90% in chemistry down to 6% in law. It is important to recognise that research fields vary in the extent and type of international collaboration and research dissemination. It should be considered that the coverage of WoS is not universal for all scientific fields; moreover, the dissemination of research and international research output differs according to the type of research.

Our study has shown that even in the presence of research field differences, the integration of interplay between disciplines and its longitudinal analysis is a suitable tool to describe the extent of the international collaborations which were manifested in a form of publication captured by the WoS database. In order to understand other forms of international collaboration and their dissemination outputs, a considerable amount of additional analysis needs to be undertaken. Our pilot study suggests that integration of the outputs of international collaboration (publication) and interdisciplinarity (interplay between major OECD disciplines) can cover the quality of cooperation to some extent, but the study needs to be extended by analysis capturing field-specific characteristics, as well as by the interplay between the "minor" scientific disciplines. The main six OECD categories are subdivided into additional 42 subcategories, which may suggest a more robust application of bibliometric performance. Moreover, the expansion of analysis with other quantitative and qualitative indicators of research outputs (the number of citations, the impact factor of journals, the number of authors, their research field, the H-Index, and the driving force beyond research cooperation) is particularly desirable for all disciplines, including also the fields where publications/journals are not the most important means for disseminating research.

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