

Promoting the future of innovative higher education through thousands of master's programmes STEM, interdisciplinary and business programmes in a changing labour market

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Received: May 14, 2021 • Revised manuscript received: August 18, 2021 • Accepted: September 23, 2021

Published online: October 29, 2021

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ABSTRACT

This paper discusses how leading innovative universities and their master's programmes reflect rapidly changing social-economic technological trends. The increasing focus on the STEM subjects, the changing profile of business and MBA programmes, and the ratio of interdisciplinarity provide insights into the development of future-oriented higher education. In the scope of this study, 2,708 master's programmes were surveyed globally based on their online representation, and 1,750 training programmes from this list were analysed in terms of employability rankings. According to our findings, Western Europe offers the largest number of master's programmes. STEM studies are overrepresented at the top innovative universities, and interdisciplinary studies account for fifteen percent of the programmes. Additionally, business studies with interdisciplinary programmes were identified in a higher proportion as compared to business-only studies. The findings signal the labour market's preferences toward future-oriented, personalised and responsive knowledge. The present study contributes to future education through a global analysis, and supports the strategy creation of higher education institutions (HEIs). Therefore, this article is especially informative to representatives, policy makers or researchers at future-oriented HEIs.

KEYWORDS

innovative universities, master studies, STEM, interdisciplinary studies, business studies, employability

JEL CLASSIFICATION CODES

A23, I21, I23

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1. INTRODUCTION

Education is *per definitionem* about the future. At least two facts support this: first, higher education (HE) must react to changes in social, economic, environmental and technological circumstances. Second, HE can also be an active agent in shaping society and the labour market. This “double vision” requires adaptation from higher education institutions (HEIs) and prompts them to assume an active change agent role in such processes.

One of the most crucial roles of HEIs is the provision of master’s programmes as these advanced programmes orient students towards academic, professional or research specialisations. Master’s programmes require complex knowledge and skills to be applied for problem solving and network building on the global or local labour markets, thus they strongly represent the profiles and future visions of the universities. Consequently, their online representation communicates and advertises the programmes to experienced professionals who typically have high expectations. This is especially true for top-class innovative universities, where future-orientated studies could considerably support the image of the university and offer a tentative prognosis of future directions in education.

To our knowledge, no global insight of master studies in the context of innovative HEIs and their interdisciplinarity has been published so far, especially not with a special focus on the ratio of STEM and business studies. Probably, there is a simple reason behind this: only manually conducted research can manage this kind of global sampling, which is definitely a very time consuming process. Our search in the Scopus academic database among titles, abstracts and keywords, has not yielded any publication in these fields. With the help of keywords including “innovation”, “higher education”, “master” and “STEM”, only a few papers were located, mostly in the context of engineering, technology and social science. Their key issues are specific, such as the gender gap, funding, or tested methods. Therefore, no insights into master studies and their interdisciplinary characteristics are available this way, not even through a summary or comparative research of HEI strategy papers or other officially published documents. Given this situation, we decided to collect related academic discussions in Section 2, providing the conceptual framework to analysing the master level study.

After establishing the connected concepts, there was an important decision about the sources of the data corpus. When we first tested different available online representations, we were confronted with a rich diversity of the amount and format of content about master’s programmes and university strategies behind them. In these texts, the only well-defined and comparable publicly available parts were those textual summaries of master programmes which represent and advertise education for potential applicants.

Accordingly, this study looks at the available 2,708 master’s programme descriptions offered by the selected thirty leading innovative universities in primarily three geographical hubs. By analysing the characteristics of the chosen innovative universities and the different ratios of STEM, business and interdisciplinary programmes these institutions offer, we could provide a comprehensive picture of the representation of interdisciplinarity in these programmes as one of the most important aspects related to the future of higher education. As for structure and content, after a short introduction of our conceptual framework, we present our results along four research questions. Next, the discussion summarises the results, and highlights the importance of online representation in competitive contexts regarding the future of higher education. Finally, a short conclusion about further research plans ends the paper.



2. CHALLENGING TRENDS AND THEIR REPRESENTATIONS: A CLASSIFICATION

First, the way how rankings of “innovative universities” are calculated was considered. This question is especially important if an innovative process is applied not only in teaching, but also in research or work-based projects (Jayantilal – O’Leary 2020; Talbot et al. 2019). According to the related rankings, the fundamental criterion is cited research by academia and private industry, primarily in the form of patent filings and research papers. In this case, innovation has a specific meaning beyond introducing something new to HEIs, but there is a strong focus on research and development assuming collaboration between universities and firms on patent grants, proactivity and measurable effects on academic performance (Salisbury et al. 2021; Lin 2019). This is concurrent with the growing complexity of socio-technical systems, thus cross disciplinary boundaries needs to be developed (Edmondson 2012). This approach requires focusing on interdisciplinary studies and also highlights the applicability of studies by STEM and business programmes. The first question is how social-cultural frameworks influence HEIs programme design regarding knowledge and employability skills.

2.1. Economic and social framework among changing trends

The function of universities is to prepare their students for the future, for unforeseen social, economic and technological changes (Hrubos 2011). If the body of “valid knowledge” is continuously changing, and if the future is radically unknown (Barnett 2012), then the mission of preparing students is not so much about teaching knowledge but primarily about supporting them to become adaptive and critical learners, as well as effective problem-finders and solvers (Aoun 2017). Following this trend, HEIs need to step out of their habitual and cultural patterns and tried-and-tested frameworks of teaching and learning (Schmidt et al. 2015), and should follow local or regional interests (Hancock 2019; Nováky – Monda 2015) or national and international strategies (Gesing – Glass 2019). The Tuning project represents this future direction in the Bologna process (Dugarova et al. 2016) with supplementary professional programmes and with a standard model of specialists labour activity. This way, the world of labour and education build a basis for intersecting fields and competency-based logic. At the same time, the concepts of entrepreneurship and innovation (Kiraly – Gering 2019) often feature as driving principles of change at universities.

Considering all these, it is necessary to study the approaches of universities that are future-oriented and want to keep or build on their leading role in the market. Therefore, the connection between future skills and present curricula needs to be investigated (Cotronei-Baird 2020).

2.2. Future skills and the need to cross disciplinary boundaries

How should HEIs design the curricula of their programmes? First, there is a consensus that the massive overproduction of information will continue to exist: the skill of processing, assessing, interpreting and synthesising complex sets of heterogeneous information will be one of the main skills (Raish – Rimland 2016). Second, the capacity to design, maintain and monitor complex socio-technical systems coupled with system-oriented thinking will also be highly valued both in



the future (Aoun 2017; Bakhshi et al. 2017) and also in the scope of collaboration in multi-cultural contexts (Hains-Wesson – Ji 2020).

These trends assume a necessity of interdisciplinarity (Edmondson 2012), which require reflections on the limitations of one-way knowledge (Sloman – Fernbach 2017) and a sense of ‘situational humility’. It is critical to have the ability to recognise when others’ professional knowledge and skills are needed in order to solve a problem or to deal with a difficult situation (Edmondson 2012). Beyond problem-solving, creativity and critical thinking are also key cognitive competences in the 21st century (Wechsler et al. 2018). These trends are also highlighted by learning outcomes-based and competence-based approaches explicitly supported by interdisciplinary learning (Hains-Wesson – Ji 2020; Ford et al. 2015).

Therefore, it is not enough to orient students towards becoming ‘I-shaped’ persons having deep knowledge in one field but they should be ‘T-shaped’ professionals with broad knowledge in their main field of expertise (Iansiti 1993) and be perspective changers to another field (Karjalainen et al. 2009). Some even argue for a π -shaped approach in terms of career building: this is about having extensive expertise not in one but in two fields. These synergies allow flexibility on the labour market (Jacob 2015; Oakley 2017).

Solving complex problems (Jacob 2015: 3; Holley 2017) with reflexivity or ethical sensibility (Tassone et al. 2018) is a competitive advantage. Based on an extensive review, Holley (2017) stresses the fact that interdisciplinarity can lead to several beneficial learning outcomes such as flexible and unconventional thinking, sensitivity to bias, tolerance for ambiguity, and abilities to evaluate and synthesise new information through critical thinking (Holley 2017: 11–12).

Several institutional strategies brand their interdisciplinary programmes as an advantageous means of offering individual educational pathways (Milian – Missaghian 2019). Moreover, interdisciplinary collaboration can still emerge at so-far unidentified ‘interstices’ (Lindvig et al. 2019). To sum up, personalisation strategy supports a higher level of flexibility under fast-changing circumstances and yields adaptive knowledge and skill sets.

2.3. Interdisciplinarity and the challenges of STEM and business programmes

As far as interdisciplinarity as opposed to versions of trans- or multidisciplinary is concerned, based on early feedback this research received at academic conferences and workshops, it was decided that to focus on a generally accepted approach. Thus, intersections of STEM and non-STEM or business and non-business studies are defined as interdisciplinarity in our study.

Also, the importance of the aforementioned T- and π -shaped knowledge (Oakley 2017; Jacob 2015; Iansiti 1993) is also highlighted this way: through expectations for high level employability. Additionally, interdisciplinary studies simply place HEI’s programmes in a dynamic situation, expecting them to observe requirements for continuous renewal and beneficial learning outcomes (Holley 2017). The global pandemic situation or rapidly spreading artificial intelligence technology with broad social-economic impacts (Feher – Katona 2021) are great examples of attesting the need for this flexible approach in education. Critical thinking, synthesised information flow (Holley 2017: 11–12) and personalised educational pathways (Milian – Missaghian 2019) are supported through such arrangements.



Through the application of the category of “interdisciplinary” in the scope of the present research, two trending areas are focused on: STEM and business studies. The challenge of future jobs and today’s digital and technological directions unequivocally put STEM studies – science, technology, engineering and mathematics (Julia – Antoli 2019) – at the forefront. Concurrently, business sustainability is also highlighted in interdisciplinary contexts (Onel et al. 2020). Both of them have direct connections to innovation and collaboration. The convergence or integration of STEM, non-STEM and business studies foreshadows options for experts of the future (Kelley – Knowles 2016). Thus, HEIs rankings and the study structure behind them are critical to pursuing research. Because the employability dimension is another important aspect of HE, the next section introduces this topic and related rankings.

2.4. Employability and master’s programmes

As stated in Section 2.1, the issue of employability is crucial in higher education (Römgens et al. 2020), especially in the case of graduate employability (Rodman et al. 2013). Thus, HEIs cannot ignore the question of employability if they wish to maintain or enhance their position in the competition for the best and brightest students (Jackson – Tomlisson 2020). Accordingly, employability rankings serve as significant orientation points that guide prospective students in their choice of studies. We are aware of growing criticism concerning the methodology and negative social effects of these rankings (Wedlin 2011; Soh 2017); nevertheless, given their importance in the field, we used them to find top institutions in terms of employability (see further details in Section 3.2). It is presupposed that institutions at the top of employability rankings exhibit higher sensitivity to changes in the labour market, and for this reason it was decided to compare findings of the present paper with related employability rankings.

As far as employability and innovation in university education are concerned, master’s programmes should be investigated first. These programmes represent a bridge between undergraduate and more advanced levels of study, and they also typically require a high level of autonomy, as well as research and/or professional interest on the part of the students. Often the contents of these programmes are market-oriented and offer up-to-date, hands-on and practical skills. In order to provide education of this kind, master’s programmes tend to change and adapt to external conditions at a faster pace than undergraduate studies. In conclusion, together with human and social capital and with individual aspects, employers’ focus on graduate employability is a key driver (Clarke 2017) in the context of hiring. Therefore, universities should advertise programmes capable of offering variability and the potential of personalisation. This is especially true for master’s programmes, where students exhibit basic knowledge, and interdisciplinary studies support a wide range of outputs.

This section discussed in what ways cross disciplinary boundaries and interdisciplinarity in STEM and business programmes, as well as issues of employability challenge the future of higher education, and especially that of master programmes. Our research contributes to this discussion by presenting a global overview of this field, investigating how current innovative master’s programmes shape the future of higher education.



3. METHODS

3.1. Research questions

Based on the future-related challenges of higher education indicated above, the goal of our research is to investigate how a wealth of master's programmes promotes the future of innovative higher education. We intentionally focused on the online representation of the master's programmes as this representation sells the programmes. Even if university strategy documents are sporadically available in public, they do not usually present the details of programme innovation, levels of study or disciplines in one document. In addition, even if these documents are available, the applicants are interested in the specific study descriptions as befits their backgrounds and goals.

We are aware that representation-analysis is only one dimension of possible investigations. It, however, is a very important aspect, because it provides the first meeting point between the university and the applicants. Furthermore, online available programme descriptions also serve as image-building tools. From these numerous possible characteristics, our focus – based on our theoretical considerations – is on interdisciplinarity as one of the key issues related to the future of higher education. Accordingly, our research questions take into consideration the interdisciplinary feature of the chosen MA programmes and group them according to the 'STEM' and 'business' categories.

Nonetheless, at first, we focused on the general characteristics of the leading innovative universities investigated, not only to describe our sample in more detail, but also to use these attributes (for example, the age or region of the universities) to group variables in the following analysis.

Along with this focus, the following research questions have been formulated:

- RQ1 What are the key characteristics of the leading innovative universities investigated?
- RQ2 How are STEM programmes and their interdisciplinary master's programmes represented?
- RQ3 What is the ratio of business-only and interdisciplinary business programmes?
- RQ4 What is the most preferred ratio of STEM, business and interdisciplinary knowledge for employability?

3.2. Methods, sampling, procedures and limits

In order to answer these questions, top innovative universities were selected, and information about their master level education and their employability levels was collected. Our procedures regarding these three steps are illustrated in Fig. 1.

First, the study built its institutional sample based on Thomson Reuters ranking of the top 100 innovative universities ([TOP innovative universities 2018](#)). Certainly, we were aware of the rationale voiced by the critics of the rankings ([Karran – Mallinson 2019](#); [Soh 2017](#)). However, if we look at these rankings as publicly available information sources and understand their role as an ongoing discourse about different leading institutions of the HE sector, they can appropriately function as a source for sample-building. The reason for choosing this ranking out of the many was to find the programmes which are labelled as most responsive to changes in economic-technological-social trends.



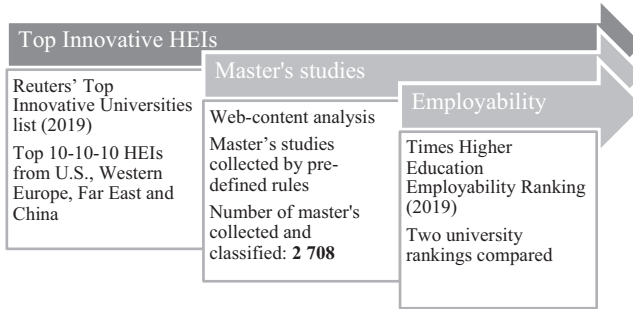


Fig. 1. Data collection procedure
Source: authors.

Our institutional sample contains thirty universities from the ranking of the top innovative universities (see list in the Appendix).

Based on the fact that the descriptions of master’s programmes vary from HEI to HEI, data mining was possible only manually through thousands of webpages: therefore the limited number of HEIs involved. Accordingly, the collection and coding required serious efforts in order to reach a comprehensive database of more than 2,700 master’s programmes. It is no wonder that other similar studies in this field are not available in academia. The codes used for processing the database were classification of STEM and non-STEM studies, interdisciplinary studies, business studies and interdisciplinary business studies. Based on this classification, manual analysis was conducted (see the details below).

A further sampling issue was the selection criteria of the 30 HEIs. One important aspect of criticism against rankings is that they compare and classify universities in very different social contexts (Kosztayán et al. 2019). Regional complexity, however, could serve as a sample-building principle. Furthermore, the goal of this selection was, on the one hand, to avoid the strong dominance of the United States at the forefront of the ranking, and, on the other hand, to gain a geographically balanced picture. Following the geographical considerations of the relevant academic sources mentioned above in connection with local, regional, national and international aspects (Hancock 2019; Gesing – Glass 2019), the key hubs of the top 100 innovative universities were filtered. Through the identification of these hubs, the first 10 American, the first 10 European and the first 10 Asian universities were selected in order to provide a regionally comprehensive and comparable sample. Although some iconic universities (Karran – Mallinson 2019) were not included in this selection, a balanced geographical distribution was achieved with respect to the key aspect of “innovation”.

Regarding the countries in these selected regions, geographic locality is mainly narrowed down to the US, Western Europe, the Far East and China. Obviously, not only these regions have innovative universities and future-oriented education, but rankings serve as a point of orientation for students (and their parents) as well as a reputation management tool for universities (Christensen – Gornitzka 2017). Therefore, the geographical complexity of the sample is based on the ranking’s structure, even if it is somewhat limited.

Each selected region was studied, and the ranks of the institutions in the sample run from 1 to 53 (see Appendix). Furthermore, supplementary information about the selected thirty



universities was collected, based on their websites and additional online sources, as for their location, date of foundation and types (private or public).

In the second phase of data collection, in 2019 the master's programmes were listed according to the official web contents of the selected universities. This step yielded complex questions and several decision points. The master's programmes did not appear in a common and shared format. Different details were available from different departments at various universities. To illustrate this point, certain HEIs highlight the profile of the studies using curricula, others present well-known professors or famous names from the alumni without disclosing a detailed study programme. In fact, the online representation of master's programmes is not standardised. Therefore, the analysis had to be narrowed down to the content elements that are all available concerning thousands of master's programmes. Besides, certain universities publish course documents online while others only have short summaries about the goals of the master's programmes. Moreover, certain programmes are available only in the national language, others only in English or both in the native language and English. To sum up, overall comparison has been greatly impeded by these differences and data collection could not be performed with the help of a software application.

For unlocking this diversity and for creating a unified database of the master's programmes under scrutiny, manual screening was applied, and data-collection and classification were performed using a list of strict criteria:

- Only those master's programmes were studied which were available in 2019. Planned or inactive programmes were excluded from the research.
- Programmes with a study duration of at least 9 months of full time education and/or 2 years of part-time education were selected. Shorter studies, online-only programmes or MOOC courses were not included in the database.
- To filter the STEM, business and interdisciplinary master's programmes, only the basic curricula were analysed. The reason for this decision was that several programmes offer specialisations, optional courses, alternative credits from other faculties, participation in research, fieldwork, exchange opportunities, all with a view to personalising the studies. The only option that remained was to focus on the common curricula of the master's programmes.
- STEM and business programmes were also precisely defined before building the database. Considering the trends and terms mentioned in Section 2.2, STEM studies were defined as programmes offering a significant majority of their courses on science, technology, engineering and mathematics. In this case, "significant majority" was understood as 80%. In other words, if the programme offers some non-STEM studies but their share is below 20%, the programme is defined as a STEM-only study programme. Non-STEM-only studies are defined accordingly. Furthermore, if STEM studies integrate more than 20% of non-STEM disciplines or non-STEM programmes include more than 20% STEM fields, the respective category is 'interdisciplinary STEM/non-STEM'.
- Business programmes were also defined in terms of the same ratio of 80/20. The interdisciplinary business master's programmes category also includes integrated courses, for example STEM or technology studies to deliver up-to-date and marketable knowledge.

After defining these strict criteria, the websites of the selected universities were manually screened, and the results were coded in Excel files. As a result, our sample of master's programmes



contained 2,708 master's programmes with codes based on our classification. For translating relevant information from the national languages, translation software was used. In the last phase of the research, employability rankings published by the [Times Higher Education \(2018\)](#) was also considered. The specific ranking enabled the narrowing of the sample to 18 universities thus revealing the most preferred HEIs' models for the labour market (see the details in the Appendix).

4. FINDINGS

The findings are presented below in four subsections in line with the research questions.

4.1. Characteristics of the universities studied

The characteristics of the selected top innovative universities are summarised according to their year of establishment, and the type of foundation ([Table 1](#)). Almost half of the universities analysed were founded in the 19th century (middle-aged institutions), more than one quarter before that date (old ones), and the remaining ones were established in the 20th century (young ones). The average date of the establishment of the universities studied is 1,777.

According to the comparative data presented in [Table 1](#), universities in the Far East and China are overrepresented in terms of young institutions. Presumably, their innovative profile allows them to be on the top with only a few student generations behind them. Middle-aged universities, exhibiting the highest number in the whole sample, enjoy the support of their alumni through networks in business and governments, and they have enough experience to feature and include both old and new courses in a responsive way. The majority of the thirty institutes studied are public research universities. The US, however, is primarily present through privately funded universities in the corpus. Therefore, it is assumed that they have better staff-to-student ratios with higher incomes for research and costs (see also [Davidson 2017](#)). There is only one teaching university on the list with focus on teaching and learning instead of research. This university is from the Far East and China region. It may be obvious that research universities are dominant among the most innovative HEIs since these have an indisputable advantage with their focus on innovation through scientific publications, patents and industry-university collaborations. The analysis below also incorporates the role of type and localities of the examined universities in the interpretation of findings.

Table 1. Characteristics: number of universities by their region, age and type (N=30)

Geographical regions	Age			Foundation type		Profile type	
	Old	Middle- Aged	Young	Private	Public	Research	Teaching
U.S.	3	7	0	6	4	10	0
Western Europe	4	5	1	1	9	10	0
Far East and China	1	2	7	2	8	9	1
Sum	8	14	8	9	21	29	1

Source: authors.



4.2. STEM, non-STEM and interdisciplinary programmes

The number of master’s programmes is an average of 90 per university. This result confirms not only the diversity of the programmes, but also the wide range of options for master’s programmes per university. The geographical distribution shows that more than half of the 2,708 programmes are offered by the top Western European universities (Fig. 2).

Considering the STEM-related classification of master’s programmes based on our categories (see Sections 2.2 and 3.2), our results indicate the dominance of STEM fields: 60% of the master’s programmes are fully or partly STEM programmes (Fig. 3). However, there are regional

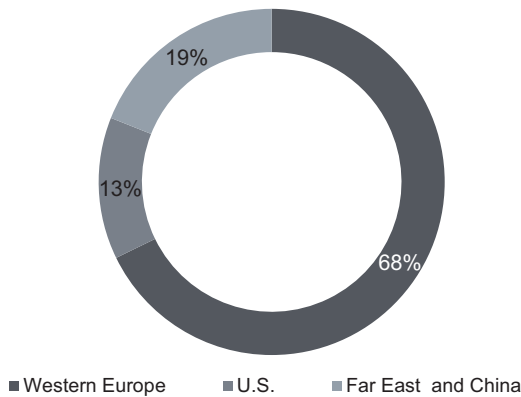


Fig. 2. The proportion of master programmes by geographical regions, % (N = 2,708)
 Source: authors.

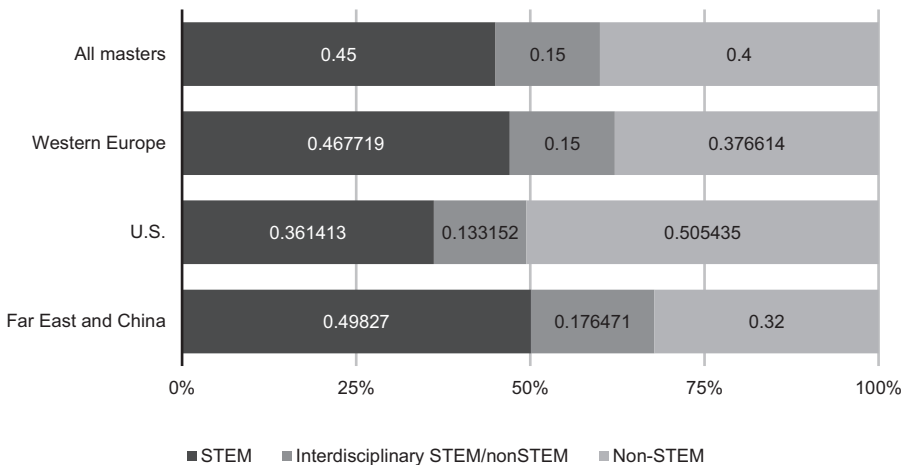


Fig. 3. Proportion of STEM, non-STEM and interdisciplinary STEM/non-STEM studies by geographical hubs, % (N = 2,708)
 Source: authors.



differences: in Western Europe, the Far East and China, the proportion of STEM-related studies is slightly higher than the average (62% and 68%). At the same time, in the American HEIs in our sample STEM-related master's programmes represent only 49% of the repertoire.

Interdisciplinary studies in the STEM field represent 15% of all programmes. That is, 15% of the whole sample is made up of interdisciplinary programmes with a minor proportion of STEM and a major proportion of non-STEM areas and vice versa. This proportion only marginally differs by region: the range is from 13% in the US to 18% in the Far East and China.

An additional but not expected aspect is that the non-STEM field is dominant at older universities established in the 18th century, while the situation is just the opposite in the case of young institutions funded in the 20th century: namely, more than three quarters of their master's programmes belong to STEM-related categories (59% STEM-only, 17% interdisciplinary STEM-related studies). This result indicates that newly-established universities are more responsive to changes in trends, and this can explain their fast ascent towards the top of the rankings.

Private and public institutions are slightly different in their STEM portfolio, since the proportion of private institutions is lower in the share of both STEM-only and interdisciplinary STEM/non-STEM master's programmes. To be more precise, only 53% of the programmes are STEM or interdisciplinary STEM/non-STEM at private universities compared to 65% at public universities. Since public universities are most common in Western European, Far Eastern and Chinese hubs, state incentives and pressure from regional markets are assumed to keep these HEIs in the STEM direction.

As attested by the manually scanned details behind the data, certain programmes are clearly STEM programmes ranging from Chemical Biology to Engineering, while certain programmes are obviously non-STEM programmes ranging from Literature to Cultural Studies. However, several programmes cannot be clearly classified based solely on their names. For example, studies on Linguistics occasionally include computer science and big data analyses as well, and architecture frequently involves engineering and art studies in different proportions. These and many further examples prove that the name of the programme in itself cannot describe the profile of a study programme properly.

Certain unique or emerging programmes that reflect changing trends in the economy and society are also offered. A few emblematic examples are Public Policy Data Science, Cybersecurity and Leadership, Digital Anthropology, Sustainability Leadership or Medical Humanities and Risk. These are not simply future-oriented but also provide an answer to market needs in the globalised market of higher education. Likewise, business programmes have also started to converge towards non-business programmes. After making the above observations based on our manual analysis, the ratio of business programmes was also studied.

4.3. Business-only and interdisciplinary business programmes

Among the 2,708 master's programmes examined of the thirty innovative universities involved in this study, only 430 (16%) offer business-related courses. As in the case of the STEM-based classification, here too, business-only and interdisciplinary business categories have been defined. Despite the relative low proportion of business-related master's programmes, their interdisciplinary programmes feature in a significant proportion. Namely, out of this 16% of the 2,708 master's programmes, 6% offer a business-only curriculum and the other 10% an interdisciplinary business version. Interdisciplinary business master's programmes are found in a



slightly higher proportion in Western Europe, but there is no significant difference as for the age or type of the universities concerned.

Although the proportion of business fields is relatively low among the master's programmes, the future-oriented trends outlined in Section 2 are reflected in the examples, which are embodied by such areas as Social Innovation, Global Prosperity, Sustainable Resources, or Technology and Management.

4.4. Employability-related comparative results

When interpreting the ranking of the top innovative universities in terms of employment, a strong focus on the preferences of the job market was observed. It can be established that the HEIs on the narrowed-down list prepare responsive and adaptive programmes in an answer to changing trends.

For international recruiters, HR Consultancy Emerging designed a global employability ranking with a list of the best universities. Even if this ranking used different methods from the above-discussed listing procedure of the most innovative universities, it is also featured in the [THE \(2018\)](#) and, through its data, supports an interpretative dimension of the above findings. Additionally, we are aware that the time horizons of the compared rankings are different if we think of the long term impact of innovation and the short term feedback by the labour market. However, we found that this issue is not so problematic in our research for two reasons. First, although the two rankings mirror results based on different time-horizon phenomena, with their yearly lists, they provide a snapshot in time, which made them connectable. In other words, we do not compare the two lists, but connect them in our research to choose those universities, which are labelled both innovative and highly employable by the rankings. Second, the order of the top innovative universities does not change significantly year by year, thus we could presuppose that their impact lies in the details of their research and teaching practices, and in their efficiency in collaborations between universities and firms or between universities and businesses.

After the comparison of the two rankings, a total of 18 universities remained on our consolidated list (see Appendix). More precisely, from the regionally selected top thirty universities only 18 can be found on the THE's top 100 universities list of employability. We can consider these 18 HEIs as the most innovative and – at the same time – the most labour market oriented universities of their regions.

After the supplementation of our initial sample with these employability data, in the new sample of 18 HEIs, Western European universities are overrepresented (50%) compared to their initial share. The average founding date of these institutions, i.e. 1,762, is almost the same as in the case of the above universities. The oldest and the youngest universities also appear in the list narrowed down to employability preferences. The majority of the 18 universities are public research institutions.

These 18 innovative and labour market oriented HEIs offer 1,750 master's programmes. Regionally, two-thirds of them are provided by Western European universities. As compared to the results of the innovative list only, Western European universities represent a much higher share of master's programmes with labour market success.

Upon comparing the master's programmes of the consolidated list with the STEM-based classification, it is observable that 64% contains STEM courses or interdisciplinary STEM/non-STEM courses ([Fig. 4](#)). Among labour market oriented HEIs, this suggests a higher



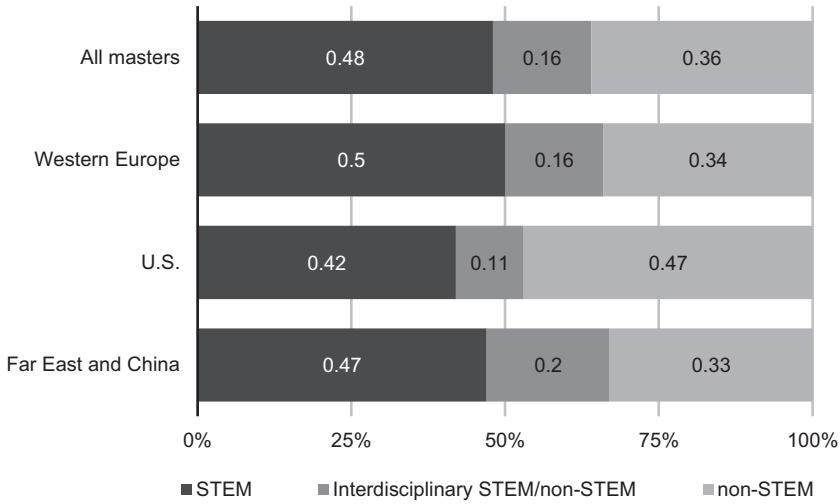


Fig. 4. Proportion of STEM, non-STEM and interdisciplinary STEM/non-STEM studies by geographical hubs at high-ranked innovative universities with high employability rank, % (N = 1,750)
 Source: authors.

proportion of STEM field courses compared to the innovative list. This indicates that the market and industrial pressure is stronger on STEM programmes as far as employability is concerned.

The highest rate of STEM programmes is 67%, and these programmes are found in the Far East and China, while the lowest rate is 53% in the United States. Western Europe closely reflects the average of the consolidated list. Thus, the above-mentioned high number of master’s programmes in Western Europe represents not only the most competitive geographical area but also a global average across disciplines.

When we look at the proportion of business programmes and interdisciplinary business programmes on the consolidated list, we can see that their proportions are exactly the same as the ones featured in the list of innovative universities. Moreover, Western Europe, the Far East and China show similar ratios to the ones with the top thirty universities. In terms of this comparison, the only exception is the US, which offers the smallest share of interdisciplinary business programmes with only 3% and a below average 5% in the case of business programmes (Fig. 5).

This is a surprising result regarding MBA studies. The details reveal that these types of business programmes are available but they are available mainly as extensions or as further narrow segments of business-only studies in Economics, Business Analytics, Finance, or Supply Chain Management. Additionally, interdisciplinary business programmes are more diverse compared to business-only programmes. To illustrate this diversity, Global Innovation Design, Techno-MBA, Creative Global Leader Program, Green Management Policy Program or Financial Engineering represent the ways in which disciplines are converging along with changes in social-economic circumstances.



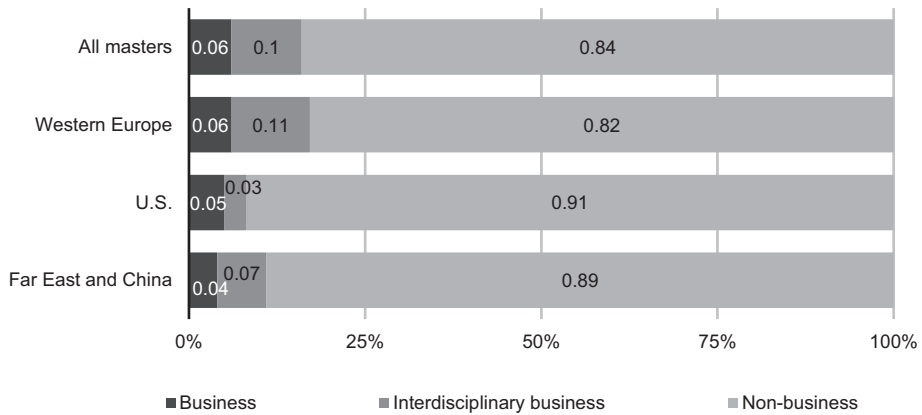


Fig. 5. Proportion of business and interdisciplinary business programmes in geographical hubs at high-ranked innovative universities with a high employability rank, % (N = 1,750)
 Source: authors.

5. DISCUSSION

Thirty innovative universities with 2,708 master’s programmes were studied, and eighteen universities were selected from this thirty as universities having top employability ranking through their 1,750 master’s programmes. According to the results, STEM studies represent more than sixty percent of master’s programmes, including STEM-only and interdisciplinary STEM/non-STEM programmes. An insight into these master’s programmes revealed that the category of interdisciplinarity is less applicable than the category of “interdisciplinary programme”. The selected universities offer multiple opportunities for their students to tailor their studies through personalisation and offer versatile options to learn different disciplines. To be more precise, complex skill sets and knowledge are available at these HEIs, which reflects newly-emerging trends from artificial intelligence technology to environmental changes.

As an answer to the research questions, it can be concluded that it is mostly middle-aged, research and public universities that represent the key characteristics of the leading innovative universities studied. Public universities have a stronger focus on STEM studies, whereas younger universities exhibit higher proportions of interdisciplinarity. 60% of the master’s programmes are fully or partly STEM studies, while STEM or non-STEM studies with interdisciplinary versions are available in 15% of the cases. This way STEM studies are overrepresented, but interdisciplinary studies have a pronounced role in orienting students towards complex knowledge and skill sets. Business programmes are underrepresented just like MBA studies. However, in the case of business programmes, the proportion of interdisciplinary programmes is 66%. Presumably, business orientation has infiltrated more master’s programmes of non-business fields with interdisciplinarity. When the employability index is applied for the purpose of obtaining comparative results, a higher interest of 64% in STEM programmes or interdisciplinary STEM/non-STEM programmes is detected. In the case of business programmes, there is no significant difference in contexts, areas of innovation or employability. The master’s



programmes studied represent personalised and responsible programmes suited to the actual technological-economic-social trends.

To sum up, the leading innovative HEIs represent a majority of STEM studies with noteworthy options for interdisciplinary studies and with their significant role in business studies as innovation and employability. This curriculum-based representation of innovative HE is presumably a reflection of expected future competences and socio-economic trends in technology and sustainability. Interdisciplinary studies and the available personalised master programmes provide complex cognitive competences and responsible knowledge.

Although the analysis of university strategy documents with aspects of innovation or challenges of master programmes was not an option in the scope of this research, the findings of this study provide adequate contributions to recognising future signals in higher education.

6. CONCLUSIONS

This global analysis focused on current online representations of top innovative universities with reference to their master's programmes. The goal of our research was to investigate how a wealth of master's programmes promotes the future of innovative higher education. The findings clearly suggest that top innovative universities make serious efforts to strengthen their positions in the labour market. Growing interdisciplinarity and emerging study fields represent clear reactions to the impact of technology and sustainability.

The second milestone of our research will be a comparative study to be conducted in the future. Our research team will repeat the sampling in three years in order to reveal changes. There is an option to extend the research with a focus on social-cultural differences for deep understanding, as was mentioned in the theoretical considerations. Another further possible research orientation could be the analysis of the underlying reasons behind the discovered differences between the different groups of universities along their age, region and/or private-public status.

In any case, different circumstances are expected to be present due to and after the COVID pandemic. Even if significant geographical shifts are not expected, online-only study options as well as technological or sustainability trends are likely to fundamentally shape HEIs' future landscape.

The number of universities studied in the scope of this paper is relatively small. However, the number of programmes consulted embodies a wide range of innovation-oriented curricula. Based on this, the results reveal how and to what extent top innovative universities include among their master's programmes STEM and interdisciplinary programmes, thereby promoting the future of HEIs. Furthermore, the representation of MA programmes was analysed: more precisely, their descriptions. This approach does not allow for measuring the innovativeness of these programmes as the way these programmes are put into practice has not been analysed. However, for that purpose we can use 'proxy' measurements, like their interdisciplinary feature, as an indicator.

Funding: This paper was prepared as part of the project 'The future of business education' funded by National Research, Development and Innovation Office, Hungary (FK127972).



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APPENDIX

TOP 30 innovative universities of geographical hubs

Name	Region	Country	Available in employability ranking	Rank
Stanford University	U.S.	USA	X	1
Massachusetts Institute of Technology (MIT)	U.S.	USA	X	2
Harvard University	U.S.	USA	X	3
University of Pennsylvania	U.S.	USA		4
University of Washington	U.S.	USA		5
University of Texas System	U.S.	USA		6

(continued)



Continued

Name	Region	Country	Available in employability ranking	Rank
KU Leuven	Western Europe	Belgium	X	7
Imperial College London	Western Europe	United Kingdom	X	8
University of North Carolina Chapel Hill	U.S.	USA		9
Vanderbilt University	U.S.	USA		10
Korea Advanced Institute of Science & Technology	Far East and China	South Korea	X	11
Ecole Polytechnique Federale de Lausanne	Western Europe	Switzerland	X	12
University of California System	U.S.	USA	X	14
Pohang University of Science & Technology	Far East and China	South Korea		13
University of Southern California	U.S.	USA		15
University of Cambridge	Western Europe	United Kingdom	X	18
University of Tokyo	Far East and China	Japan	X	20
Osaka University	Far East and China	Japan		22
Kyoto University	Far East and China	Japan	X	26
University of Erlangen Nuremberg	Western Europe	Germany		31
Seoul National University	Far East and China	South Korea	X	34
Tohoku University	Far East and China	Japan		36
Sungkyunkwan University	Far East and China	South Korea		39
University of Oxford	Western Europe	United Kingdom	X	40
Tsinghua University	Far East and China	China	X	44
Technical University of Munich	Western Europe	Germany	X	45
Kyushu University	Far East and China	Japan		46
University College London	Western Europe	United Kingdom	X	48
ETH Zurich	Western Europe	Switzerland	X	49
University of Manchester	Western Europe	United Kingdom	X	53

Source: compiled by the authors.

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