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Pass or fail? Identifying European best practice regions of university-centered knowledge transfer for sustainability transformations

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Abstract

Sustainability transformation needs regional engagement of the entirety of actors within. One central actor is the university with its mission and activities to transfer knowledge. This paper provides a first approach to identifying best practice regions for sustainability transformation within Europe and addresses potential literature gaps. By composite indexing of systemic sustainability indices and knowledge transfer metrics on a regional level as well as a subsequent systematic literature review, this work aims at (1) providing best practice regions for sustainability transformation and actor collaboration as well as (2) future research avenues. The study selects Copenhagen, Zurich, Stockholm, and Helsinki as regions of interest. It advocates exploring the dynamics within entire regions, emphasizing the interplay of actors in Regional Innovation Systems (RIS).

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1 Introduction

In an era marked by global challenges, the pursuit of sustainability transformation stands as a paramount objective for societies worldwide. Universities have emerged as pivotal players in this endeavor, serving as catalysts for knowledge creation, dissemination, and application such as knowledge transfer (KT). The role of universities in driving sustainability transformation has gained increasing prominence, with their capacity to foster innovation, research, and the cultivation of future leaders, all essential components for addressing pressing environmental, social, and economic issues [1–5].

However, there is a lack in understanding the performance of regional innovation systems (RIS) in regard to KT for sustainability transformation activities by investigating the role of universities in it. The significant variation across countries' performance in sustainability transformation calls for the exploration of the driving forces behind that [6, 7]. The spatial diffusion of environmental innovation for systemic transformation remains marked by significant discrepancies between countries, with only a selected few nations assuming leadership roles in the global transition processes [8]. Consequently, the primary objective of this study is to identify and conduct a comprehensive examination of this high-performing cohort, with a specific focus on understanding the dynamics of KT. Especially, the role of university interactions with non-academic actor groups are of particular interest. The aim of the paper is to identify best practice regions within Europe using a systematic identification process and theoretically conceptualizing the quantification of sustainability alignments of regions through KT.

This research paper delves into the indispensable role of universities in advancing sustainability transformation, with a special emphasis on the European context by addressing the following research questions:

1. How can best-practice regions for sustainability transformation be identified?
2. Which literature gaps in regional university KT activities within sustainability transformations can be identified and answered in future research?

We answer these questions by conducting a multi-step analysis consisting of composite indexing and a systematic literature review (SLR) to showcase a region-specific analysis, current state-of-the-art case studies and a future research agenda. We use KT indicators measuring regional activities of university-centered entrepreneurship and engagement as well as regional actor collaboration combined with sustainable innovation indicators suggesting systemic transformation [9–11]. Hereby, we decided to include all sustainability dimensions for measuring the systemic alignment towards sustainability. We assume that the more the respective region is aligned towards the Sustainable Development Goals (SDGs), this institutionalization incentivizes a sustainability transformation within the region. Hereby, it is mainly focused on the environmental dimension of sustainability. It seeks to identify and showcase best-practice examples of European regions that excel in knowledge transfer (KT) for sustainability transformations. KT between different actor groups is used as a catalyst to leverage knowledge to innovation [12]. Since innovation is mostly considered as radical innovation, [13] suggest that this trait enables the pathway towards sustainability transformation. The formats in which knowledge is being transferred between different actors exhibit informal and formal activities, such as publications, contracting, as well as collaborations and networking events [9]. Especially universities are ascribed a focal role as knowledge drivers within the region and hence, for sustainability transformations [1, 14]. Ideally, these regions can serve as inspiration for others, demonstrating how universities can effectively leverage their resources, expertise, and networks to facilitate the transition towards more sustainable societies [2]. Especially by the institutionalization of the third mission, universities are attributed a leading role to contribute to the sustainability transformation of their surrounding RIS [15].Their surrounding RIS and actors are essential for solving grand societal challenges [16]. Their quality and innovativeness are crucial for KT and alignment towards sustainability transformation at large.

Our study contributes to the ongoing discussion of KT leaders for sustainability transformation [6, 7]. Because we a) suggest an approach to identify best practices and b) showcase a potential future research agenda to grasp their development towards sustainability transformation and prerequisites for it in specific.

2 Theoretical Background

The theoretical background portrays the literature gap which we approach to bridge on concepts of the regional innovation system (RIS) and the role of universities in it. In order to identify and analyze best practice regions within Europe for knowledge transfer (KT) practices tackling sustainability transformations in the nexus, an overview over the concepts has to be provided first. Approaches of prevalent case studies show a rather arbitrary and undertheorized selection of regions [17–19]. Hence, no approach exists in (1) measuring the regional systemic alignment towards sustainability transformations and (2) ranking regions according to their performance in sustainability transformations by the means of KT activities.

2.1 Innovation Policy, Innovation Systems and Sustainability Transformations

Passing the Sustainable Development Goals (SDGs) in 2015, the General Assembly of the United Nations (UN) assigned the overarching goal of sustainability 17 different dimensions and long-term achievements. For the achievement of these goals, the policy framework has to be aligned. However, it is debated on which system level amendments need to be undertaken. [20] criticized that purely system-centered level innovation policy neglects the impact of national policy frameworks. This translates into a requirement for considering multiple levels of policy frameworks and partially shifts the responsibility to amend policies toward regional and municipal institutions to align their activities toward systemic change [21–25].

An institutionalization of those amendments depicts innovation policy. Systemic change can be understood as systemic innovation implemented by innovation policy amendments [26, 27]. Innovation policy has evolved over time: while [28] define Innovation Policy 1.0 as focused on fostering R&D, Innovation Policy 2.0 aims at advancing the nexus between academic and non-academic organizations through enhancing actor collaborations and entrepreneurial activities in national innovation systems with special emphasis on networks [29]. The successor, Innovation Policy 3.0, is not limited to the interconnectedness of organizations within innovation systems and includes the objective of transformative change for improving environmental and societal welfare on a regional level [28]. Here, no actor in silo assumes the role of transforming, it is rather the interaction within the network contributing and being directed towards transformative change. [20] suggest a trade-off between multi-directional policy alignments for sustainability transformations and actually achieving transformative change through innovation policy. The lack of concrete policy implications for realizing system-level transformation marks its beginning. In that, innovation Policy 3.0 suggests experimentally searching for institutional collaborations that effectively foster systemic innovation [12, 16, 21, 28, 30].

To capture the shift towards Innovation Policy 3.0 and incorporate multiple levels for policy amendments, a spatial approach assists in realizing system-wide transformative change [20, 21]. Prevalent theories and approaches demonstrate, visualize, and explain the idea, the activities, and the dynamics of regions and their associated innovation system. It started from a national perspective to a narrower view of KT systems with a specific focus on university-industry collaboration (UIC) [14, 31, 32, among others].

Our focus lies in between those approaches - regional innovation systems (RIS) [21, 33]. KT is a mechanism capturing activities between RIS actors usable for systemic change [12, 33]. According to this approach, universities are key actors in a region's knowledge infrastructure, and their interactions with other RIS actors may be used for systemic innovation. The RIS concept focuses on the relationships between regional actors (universities, industry, government, and society) to encourage learning processes in the region. Institutions and policies promote and steer RIS collaboration and KT and may explain differences in regional innovation performance and economic growth. The RIS approach emphasizes universities as bridging the role between knowledge production and dissemination, leading to (systemic) innovation activities of the respective region [5, 34]. Extant literature discusses the idea of combining both innovation policy approaches: having actor collaboration for sustainability transformation and referring to the national as well as the regional level, culminating in the interface of Innovation Policy 2.0 and 3.0 [35]. The activities within a RIS can be captured by KT and innovation activities.

2.2 Knowledge Transfer of Academic - Non-Academic Collaboration for Sustainability Transformation

KT activities as prerequisite for innovation by universities depict the nexus to non-academic collaboration within the region. Universities are ascribed a central role for institutionalized KT dissemination and promotion. Within the following, KT activities are defined and followed by the universities' role over time.

Firstly, KT is to be defined. [9] claim that KT is not limited to activities of an entrepreneurial university like spin-offs and licensing. Hence, other actors relevant to the RIS and the national framework (businesses, public research organizations, governmental actors) are included within the European-wide harmonized set of KT indicators which reflects a rather holistic approach for mapping and measuring KT. They cluster KT in four main dimensions: internal context, environment, impact, and activity. While the first two describe input factors, the latter two refer to KT outputs. The four KT dimensions entail predominantly quantifiable indicators (see Appendix Table B1 for a detailed overview of included indicators).

The environment dimension covers national factors influencing KT. These are R&D spent as share of the GDP, divided in business and public sector (E1 and E2, respectively), direct government funding and governmental tax support for business R&D (E3), VC as share of GDP (E4), as well as public funding of KT, investment capital and ecosystem support and facilities.

The activity dimension of KT captures KT output as well as socioeconomic variables: disclosures, licenses and agreements, spin-offs, research contracts, trademark applications per billion GDP (A1), sales of new-to-market and new-to-enterprise innovations (A2), new doctorate students in STEM[1] aged 24-35 (A3), scientific collaborations (A4, A5), as well as the top 10% most cited scientific publications (A6), among others. The impact dimension entails long-term economic and societal returns: job creation and retainment, total investments in spin-offs, products on market, culture changes within public research organizations, knowledge-intensive services exports as percentage of total services exports (I1) and foreign doctorate students as a percentage of all doctorate students (I2) [9].

The internal context contains public research and KT office characteristics such as size and maturity, direct and indirect funding schemes, KT strategies and policies, research expenditure, and number of researchers. However, we did not include the dimension of internal context in our composite indexing because we focus on the external transfer processes between actors.

These KT indicators are captured by diverse university roles and functions. Within the last two decades, two university functions have prevailed after the traditional activities of research and teaching: firstly, promoting entrepreneurial activities as well as producing, disseminating, and commercializing KT into the industry. This refers to the notion of an entrepreneurial university and is institutionalized in the third mission [31, 36–38]. Entrepreneurial universities predominantly focus on economic sustainability. Hence, this concept lacks a systemic perspective since it subordinates other sustainability[2] dimensions and systemic actor collaboration other than university-industry collaboration (UIC) [5, 16, 39].

Secondly, the concept of an engaged university emphasizes its regional embeddedness and the related responsibility for partaking in it [5]. Thus, a broadened sustainability alignment and intertwined strategies for realization are naturally incorporated into university activities, encouraging them to actively engage in societal challenges within the region and contributing to systemic innovation [1–4]. Within the engaged university model, university-centered KT is not solely understood as a means to commercialize, it rather catalyzes actor collaboration for regional development [40]. The engaged university is also promoted in the political framework of the EU: it has shifted from focusing on national challenges and basic research to regional contexts, which demands university engagement. Europe's structural funding programs have encouraged universities to strengthen their focus on regional economic development within the EU [41].

We find the shift from the entrepreneurial to the engaged university concept on a par with the transition from Innovation Policy 2.0 promoting actor engagement and innovation systems to Innovation Policy 3.0 broadening the perspective towards systemic transformation to meet grand societal challenges.

2.3 Conceptualization of best practice university regions

By identifying the university as KT and innovation catalyst, and hence, a focal contributor to systemic transformation, empirical literature still lacks concepts and methods for identifying well-performing regions of academic and non-academic collaboration for systemic sustainability transformation. [25] emphasize the need for a region-specific approach according to its specific circumstances and neglect a unique best practice solution for several regions.

KT activities can be employed to describe institutionalized collaboration between academic and non-academic actors within a RIS. Based on this, a first conceptual approach to rank well-performing regions towards sustainability transformations can

[1] STEM means Science, Technology, Engineering and Informatics.
[2] In the remainder of the paper, we focus on environmental sustainability as sustainability dimension.

be realized. The focus is to shed light on the specific contributions of entrepreneurial and engaged universities in regional alignment toward sustainability transformations. It fills the blind spot of regions indicating high levels of KT and their endeavors toward sustainability transformations. Within this work, sustainability transformation is defined as the alignment towards the environmental dimension of sustainable development [11]. We portray the concepts of an entrepreneurial and an engaged university through appropriate KT activities by [9] as well as the alignment towards sustainability transformation through region-specific sustainability indices.

We aim to bridge the following literature gaps focusing on the collaboration between the university and non-academic actors for transformative change:

1. We focus on KT activities such as scientific collaborations and outputs, investments in university R&D as a proxy for the engaged university, and entrepreneurial activities as a proxy for the entrepreneurial university within the region. Furthermore, deriving from the national framework and its implementation responsibility for regions, we assume that the transformation process of regions from Innovation Policy 2.0 to 3.0 is the direct pendant for universities transitioning from being solely entrepreneurial to an engaged model.
2. We do not limit our research to an engaged university and Innovation Policy 3.0 since extant literature criticizes yet the sole existence of engaged universities and tangible realizations of Innovation Policy 3.0. We focus on the evolution toward the engaged university as well as Innovation Policy 3.0 [5, 16, 42].
3. In-silo activities of actors within RIS, referring to the university, municipality, industry, and the society, can be overcome by fostering certain, best practice actor collaborations which are institutionalized by high-levels of KT activities for tackling grand societal challenges [12, 43].

This paper suggests a first approach on how to identify best practice regions for KT and sustainability transformation within Europe as targeted institutional setting, combining (a) regional alignment and performance towards systemic, sustainability transformations and (b) regional performance in university-centered KT and (c) a SLR for future research avenues.

In order to measure the (a) regional alignment and performance towards systemic, sustainability transformations sustainability indices are utilized. Regarding (b) regional performance in university-centered KT, we filter for academic[3] KT indicators of the European-wide harmonized set of KT indicators by [9].

3 Methodology

The methodology of this paper aims to identify best practice regions in Europe. This broad geographical focus has been chosen because and Europe is seen as a frontrunner continent for sustainability transformations [44] and because a comparable institutional setting across countries can be assumed [28, 45]. Given the complexity of sustainability transformation and knowledge transfer (KT) processes, a systemic approach needs to be adopted assessing KT performance [6, 9, 46] which is why we decided to couple a composite indexing approach with a systematic literature review (SLR). The selected composite indexing method provides flexibility in the identification of ideal typical regions demonstrating high performance in university-centered activities within its embedded region and in sustainability transformation, where KT is used as a holistic indicator [6]. Our regional selection is identified in a three-step

[3] Academic activities mean entrepreneurial and engaged university activities.

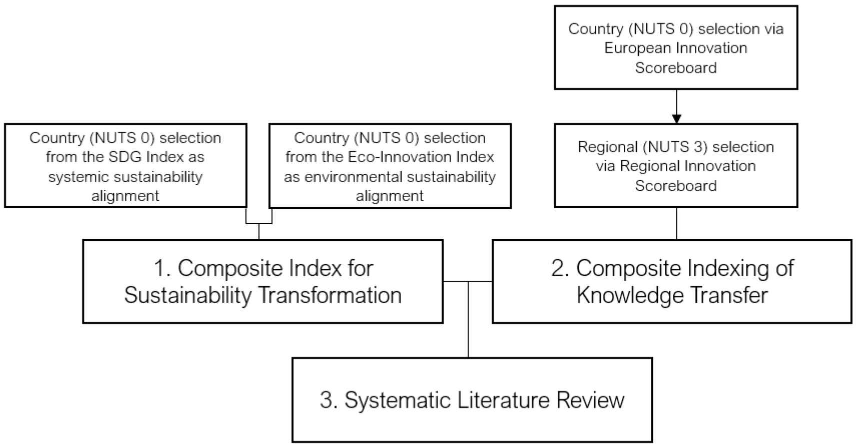

Fig. 1 Methodological Process

process (s. Figure 1). First, two composite indices, partly taken from research reports and in combination tailored to our research focus, are considered as proxies for sustainability transformation and for KT. They are included simultaneously (steps 1 and 2) to quantify sustainability transformation and university-centered KT activities. After that, a SLR is conducted to legitimize our selection and gain a deeper empirical understanding of the regions, portraying them in regional spotlights.

This approach allows for the incorporation of a wide array of actors and factors, including the interactions among multiple agents and the influence of policies across different countries. By doing so, a more comprehensive and holistic understanding of KT and sustainability transformation performance is achieved. More specifically, the result of our methodology is the identification of best practice regions as benchmarks in KT and sustainability transformation activities.

3.1 Composite Index of Sustainability

Before indexing the sustainability transformation and KT indices, some countries are purposefully neglected: Germany is excluded due to the extensive case studies conducted in four German regions against a similar theoretical backdrop with concrete policy implications [47]. Furthermore, Germany is considered to have a similar institutional background in following sustainability transformation like Switzerland [48]. The United Kingdom was excluded because of the political and economic uncertainties resulting from BREXIT. Moreover, the UK is excluded from EU-related databases which omits future replicability of the results. Furthermore, only countries with a population of at least one million inhabitants were included in the ranking (e.g., excluding Luxembourg, Iceland, and Malta) because the results would be rather context-specific and less transferable to larger economies which match our research focus.

As a first step of identifying best practice regions for sustainability transformation and KT, we developed a composite index by combining the seminal indices of the Eco-Innovation Index (S1), created by [49], and the SDG Index (S2), created by [11] (please consult Appendix Table B1 for operationalization and interpretation). In that sense, a composite index is the result of aggregating several indicators into one single measure which mirrors the multi-dimensional construct with a certain degree of complexity whilst not ignoring the limitations of these indicators [50]. The Eco-Innovation Index measures the environmental innovation performance of the EU member states mapping eco-innovation inputs, activities, outputs, resource efficiency outcomes, and socio-economic outcomes, combining the equally weighted and averaged 12 indicators to the overall Eco-Innovation Index [49]. Hereby, a holistic measurement for national alignment towards environmental sustainability is generated in a several dimensions. The utilized Eco-Innovation Index includes national performances of the reference year 2021.

On a global level, the Sustainable Development Goals (SDG) index is an annual assessment of each UN country in achieving the SDGs [11]. This index is considered to ensure a certain systemic perspective and sustainability alignment of the selected regions, highlighting the environmental dimension of its sustainability alignment. The analysis is based on the latest version of all indices. For each indicator, the top-ranking eight countries were collected. Due to the lack of regional data, we approximated the regional selection through best practice countries regarding systemic sustainability alignment. The ranks were weighted reversely (rank $1 - 8$ points [...] rank $8 - 1$ point). No further weighting of the dimensions is applied because we consider both indices as equally important.

Table 1 Composite Index of Sustainability

Rank	Country	Eco-Innovation Index	SDG Index	Score
1	Finland	7	8	15
2	Denmark	5	6	11
3	Sweden	4	7	11
4	Austria	6	4	10

Note: No standardization applies since we used indices of the same standardization beforehand.

As demonstrated in Table 1, the best-scoring countries for sustainability are in descending order: Finland, Denmark, Sweden, and Austria. Finland is top-performing in both sustainability domains resulting in 15 from 16 possible points, mirrored in the first place. Denmark and Sweden score equally well with a sum of 11 points while Denmark is slightly better in eco-innovation activities, and Sweden ranks slightly higher in achieving the SDGs. Austria comes in fourth place with only one point less than Sweden and Denmark.

3.2 Composite Index of Knowledge Transfer

Our composite index for KT considers the intricate and evolving dynamics of sustainability transformations, which involve various actors and factors, such as knowledge mobilization, entrepreneurial activities, and technology development [46]. Based upon the KT indicators introduced by [9], our composite index portrays input and output factors which are subdivided into four groups: internal context, environment, activity, and impact (for further explanation of KT metrics and used indicators, please see chapter 2.2). These dimensions and sub-dimensions are matched with the existing indices at hand and summed up to a composite index (please consult Appendix Figure A1 for the matching between KT indicators and European Innovation Scoreboard and Regional Innovation Scoreboard data). In total, we consider a sum of 12 indicators. All variables, their source data, definitions, and interpretations can be obtained in Appendix Table B1. These indicators reflect classic KT activity indicators and university-centered indicators (indicators E1 through I2).

Our composite index maps the KT indicators [9] with existing indices at hand: the European Innovation Scoreboard [51] and the Regional Innovation Scoreboard [52] (please consult Appendix Table B1 for operationalization and interpretation). The European Innovation Scoreboard is a comparative index and assesses the research and innovation performance of the EU members and neighboring states on a national level [53]. The Regional Innovation Scoreboard is the regional extension of the former, assessing the innovation performance on a regional level [52]. The analysis is based on the latest version of all indices (as of 2023). The rationale of the KT indexing approximates each rank through a national level, combined with regional KT performance by implementing the data of the Regional Innovation Scoreboard. Hereby, it is ensured that by incorporating the national as well as the regional level into our analysis, we have a broad picture regarding KT performance as well as an alignment between the Composite Index for Sustainability Transformation (measured on a national level) and the Composite Index of Knowledge Transfer.

After creating the composition of indicators, the analysis is conducted. For each indicator, the top-ranking eight countries were collected. The ranks were weighted reversely (rank 1 − 8 points [...] rank 8 − 1 point). No further weighting of the dimensions is applied because we consider all dimensions equally important. The results of this analysis are the highest-ranked countries in Europe. In the first assessment, all data indicators are measured nationally (NUTS 0) to direct the selection process to the most innovative European countries. After the country selection, the regional level (NUTS 3) is considered to determine the regions for future data collection

Table 2 Composite Index of Knowledge Transfer

Rank	Country	Dimension			Score
		Environment	Activity	Impact	
1	Switzerland	9	25	7	41
2	Denmark	10	21	2	33
3	Sweden	20	13	0	33
4	Finland	9	13	4	26

As indicated in Table 2, the top-performing countries in KT are Switzerland, Denmark, Sweden, and Finland. Switzerland scores first place with an emphasis on its performance in KT activity. Denmark scores in second place and has a front-runner position in KT activity. Sweden scores in third place ranking especially high in its KT environment. Finland comes in fourth with its strongest performance in KT activity.

Merging both indices shows that Denmark, Finland, and Sweden are top-performing in both sustainability and KT activities. Switzerland, however, is not included in the Eco-Innovation Index[4] and only ranks 15th in the SDG index [11]. Although it does not show a high alignment towards sustainability transformation, it excels and outperforms other countries in KT activities over a mid-term trend (over 10 years) which indicates a strong prospective innovation framework. We claim that this collaborative dynamic and high level of KT performance can be seen as a potential for future sustainability pathways. This is why we decided to include Switzerland as an exception. In order to identify best practice regions and to shed light on KT dynamics, we decided to further undergo the regional drill down to a NUTS 3 level

[4]Within the Eco-Innovation Index, solely EU member states are taken into account.

with the following countries: Sweden, Switzerland, Finland, and Denmark. Each country's selection, its driving and hindering factors, as well as its regional drill-down, will be presented in the regional spotlights in chapter 4.1 through 4.4.

3.3 Systematic Literature Review

With an initial framing of the composite index, the consecutive SLR is conducted. It should serve as the qualitative legitimization of the regional selection and provide insights into existing literature. The familiarization with existing literature and identification of literature gaps aids in providing a future research agenda.

Our analysis was run in September 2023 by means of *Google Scholar* and *Web of Science*. Please consult Appendix Table B2 to see the search strategy and keywords used. Since the focus of this paper is the role of the university in KT and the interaction between actors (academic and non-academic) for sustainability transformation, we focused on keywords combining the focal actor university (engaged OR entrepreneurial) within multiple actor frameworks (e.g. entrepreneurial ecosystem, regional innovation system), country selection deriving from the composite indexing process (e.g. Switzerland, Sweden, Denmark, Finland), and activities (e.g. third mission, knowledge transfer, absorption, dissemination). Only peer-reviewed case studies in English are included. After the initial keyword search for each keyword combination, a maximum of the top 10 most relevant papers per combination are collected, and a total of 381 papers are accumulated. After the first scanning of the abstracts, 48 papers were considered suitable to match our research purpose due to their focus on case studies of universities in Europe and KT.

We focused on case studies applying the role of the university in the context of sustainability transformation with a focus on environmental sustainability. Hence, papers were excluded that did not cover the role of the university, not thematizing environmental sustainability [16], and/or thematizing social sustainability [e.g. 54, 55], or focusing on countries other than the ones selected [e.g. 56, 57]. Furthermore, case studies of the selected regions that deal with KT in a broader sense, the role of the university and also UIC are included. Finally, after reading the full papers, 14 papers were considered relevant and then consulted for their regional focus, topic, legitimization of regional selection, role of the university and regional spotlights (see Table 3). The sampled papers are then utilized to identify spotlights for the selected regions and to formulate a future research agenda (see chapter 4).

What becomes apparent is that the previous, broad sample narrows down to a relatively small selection of 14 papers. Also, while entrepreneurial universities in different contexts (second mission) are covered to a large extent in the first literature sample (381 papers), none of the remaining papers include the engaged university as a concept for KT, therefore also neglecting the holistic societal role of universities (third mission). Many of the papers focusing on the engaged university concept, simultaneously focus on social sustainability [54, 55, 57, 58].

Table 3 Systematic Literature Review

Author	Case Study	Legitimization of Regions	Role of University	Driving Factors	Hindering Factors
Sweden					
[59]	Single case study	Best practice: data availability, well-established and recognized for promoting entrepreneurship; Commitment to its societal role	ENT: Institution promoting entrepreneurship	Low power distance; High autonomy of HEI, reform of 2010; VINNOVA and The Swedish Foundation for Strategic Research encourage academic entrepreneurship initiatives, directly and indirectly.	Academic entrepreneurship is not a top-down requirement of the main financing agencies (e.g., when applying for research funding).
[60]	Single case study	n/a	KT: Proactive initiator of UIC	Government pushes universities by a mandate to make research useful to society; Professor's privilege: researchers own their research	KT is highly dependent on researchers seeking knowledge transfer channels due to the professor's privilege; KT is often reactive toward researchers
[61]	Comparative case study	Difference of entrepreneurial formats	ENT: Teaching mission to entrepreneurial institution	Large technology firms and a social welfare system; HEI combine a system of hierarchical chairs with egalitarian feature	n/a
[62]	Comparative case study	Case examples of institutional background	ENT: Transformation of universities into entrepreneurial entities and the broader adoption of entrepreneurial goals.	Focus on entrepreneurship education may explains growth in new firms; Many academic spin-off firms arise from entrepreneurship teaching programs	n/a
[63]	Comparative case study	Explanation of European's innovation lag	ENT: Entrepreneurial universities for bridging innovation lag.	n/a	Lecturers and researchers as separate career paths, hard to navigate both demands
[31]	Comparative case study	Difference in institutional frameworks	KT: Entrepreneurial university starts shift to a knowledge-based economy.	VINNOVA encourages the formation of heterogeneous research consortia; Funding agencies act as intermediaries	Difficulty to retain domestic innovation: many corporations and entrepreneurs move abroad and UCI represent a gradual transformation with relatively modest initiatives by the state
[18]	Comparative case study	In-depth comparative studies with different national and regional contexts, also differing in developmental stage	TRANS: Transition Second to Third Mission	Teacher's exemption which allows researchers to retain full rights to their discoveries	n/a

continued from **Table 3**

Author	Case Study	Legitimization of Regions	Role of University	Driving Factors	Hindering Factors
[59]	Single case study	Since 90s: Swedish national research policy transformed into innovation policy	ENT: Entrepreneurial university	Creation of VINNOVA agency for innovation systems; long history of public–private collaboration; Concentrated resources on facilitating commercialization of university-based knowledge	The tendency that the third mission only accounts for commercializing and commodifying university knowledge creates uncertainty
[7]	Comparative case study	High income countries have more entrepreneurial activity	ENT: University as active entrepreneurial actor and ICT developer	Entrepreneurial activity in Sweden positively influences sustainable development	n/a
[64]	Single case study	Researchers own the intellectual property of their research; unique case where data can be found on which choices researchers make when presented various channels	KT: UIC, researchers proactively seeking transfer channels.	The researchers own the intellectual property of their research	n/a
Finland					
[61]	Comparative case study	Difference of entrepreneurial formats	ENT: Teaching mission to entrepreneurial institution	n/a	n/a
[15]	Comparative case study	Case examples of institutional background	ENT: Entrepreneurial university, its institutional surroundings, and its role of accelerated innovation	Accelerated diffusion of the entrepreneurial academic model by purposefully creating universities of transdisciplinary character	n/a
[18]	Comparative case study	Indepth comparative studies with different national and regional contexts, also differing in developmental stage	TRANS: Transition Second to Third Mission	Universities and the government have addressed the increased pressure to transform its HE systems by emphasizing greater autonomy, and multidisciplinary teaching and research	n/a
[19]	Comparative case study	Emerging entrepreneurial universities in peripheral region	ENT: Nexus university and entrepreneurial ecosystems / entrepreneurial university ecosystem	Entrepreneurship promotion has prioritized by the Ministry of Education and Culture with different reports and recommendations; Universities enjoy strong autonomy in their implementation	Entrepreneurship policies can only be promoted through non-binding incentives and steering; Universities are not rewarded for the successful implementation of entrepreneurial actions, like for research and education

continued from **Table 3**

Author	Case Study	Legitimization of Regions	Role of University	Driving Factors	Hindering Factors
Switzerland					
[65]	Comparative case study	Identified frontrunner universities in cocreation activities.	TRANS: Universities as frontrunner for transformation.	Institutional priorities have changed drastically since the new presidency on the ETH board in 2008.	n/a
[66]	Single case study	The largest technical university is portrayed since the focus is on academic scientists likely to generate research results with commercial potential.	KT: University as active actor in the commercialization of technologies.	n/a	n/a
[7]	Comparative case study	High income countries have more entrepreneurial activity	ENT: University as active entrepreneurial actor and ICT developer	Entrepreneurial activity in Switzerland positively influences sustainable development	n/a

4 Findings

With the initial framing of the composite indexing, we aim to provide a contextualized future research agenda for the selected regions utilizing the systematic literature review (SLR). The results of the SLR show that with one exception [65] comparative international case studies for best practice regions are still lacking. Even though [67] also select their region of interest due to an approach of best practice criteria, they only focus on a singular case. Generally, case studies predominantly examine one case or region [59, 66, 67]. In a comparative setting, the plurality of cases has solely been employed for their heterogeneity regarding different contexts, e.g., institutional setting, entrepreneurial formats, or developmental stages [15, 31, 61–63] neglecting inter-regional comparability.

In the end selection of the papers, the university's role is either that of a knowledge transfer (KT) initiator in the form of university-industry-collaboration (UIC) [31, 60, 64, 66] or purely entrepreneurial in different regards, e.g., organizational nature as entrepreneurial university [7, 15, 59, 62], caiteaching [61], creating academic spin-offs [67], or the ambition of transitioning into an entrepreneurial organization [19]. Only two papers portray the role of the university as expanding to an engaged university, hence attributing them to a bigger societal role [65, 68].

Moreover, the concept of the engaged university has been primarily applied in the context of social sustainability [58, 69], especially in peripheral contexts [54]. Therefore, we propose further investigation of metropolitan regions, under the banner of engaged universities for environmental sustainability.

The following chapters should serve to further explain the country selection employing spotlights in national characteristics, sustainability characteristics, and the subsequent regional selection (NUTS 3 drill down) from the SLR complemented by extensive desk research.

4.1 Sweden

National characteristics: Sweden is the only country in Europe that maintains the so-called Professor's Privilege which means that the researcher owns the research – and not the university [60, 64, 68]. This and the repeated resistance towards the demand to change its system makes Sweden an exception within Europe. Indeed, research over the past years has shown that against expectations, dropping the Professor's Privilege in other countries leads to a decrease in academic patenting [70]. However, therefore KT in Sweden is highly dependent on researchers actively seeking commercializing channels, hence highly reactive to researchers or patent owners seeking transfer channels. Sweden's higher education system is characterized by flat hierarchies and a resulting low power distance [67] by combining a system of hierarchical chairs with egalitarian features, for instance, equal salary in across all disciplines. Furthermore, universities in Sweden are granted a high autonomy [67] since the implementation of the autonomy reform in 2010 [71]. Further, it is unique that Sweden maintains separate career paths for lecturers and researchers which makes it difficult to navigate both the demands of the evolving mission of universities [31], and complicates the dynamics of academic entrepreneurship.

Generally, academic entrepreneurship is not a top-down requirement of the main financing agencies (e.g., when applying for research funding) [67]. It is however shown that entrepreneurial activity in Sweden positively influences sustainable development [7]. Hence, several policy actors such as the national agency VINNOVA for innovation systems and the Swedish Foundation for Strategic Research have been encouraging academic entrepreneurship initiatives [59], both directly and indirectly [67], for instance, by funding heterogeneous research consortia rather than tech-based firms. Hence, acting as an intermediary between academia and industry, facilitating UIC. Hence, Sweden has a long history of public-private collaboration [59, 72]. Additionally, the government pushes universities to innovations and research that are useful to society.

However, others claim that UIC only enhances gradually with relatively modest initiatives by the state. According to our indexing, Sweden excels at public-private co-publications as well as international scientific co-publications and hosts a lot of foreign doctorate students [72]. Further, it is constantly increasing its performance in venture capital expenditures while more recent trends are improvements in business process innovators and the population with tertiary education [72]. Compared to the EU's average, Sweden has a higher income per capita but a less growing economy. Large corporations take up a large share of the economy while manufacturing accounts only for a smaller share [72].

Sustainability: Regarding sustainability, Sweden has long been considered a leader in sustainability with ambitious sustainability aims [73] scoring first repeatedly in the Eco-Innovation Index [10]. The country scores especially high in sustainable resource management and business [73].

Regional selection: Across Sweden, Stockholm (NUTS region SE11) is the most innovative region and the fourth most innovative region in Europe [72]. Especially, due to the mix of universities, large corporations, policymakers, and innovative startups coming together in one condensed space, this will be an interesting setting to research. It would be especially interesting to observe the interplay between the long history of public-private collaboration and the governmental focus by creating the VINNOVA agency. Further, Sweden's leading position in innovativeness has been taken over which makes it intriguing to investigate. In conclusion, Sweden's uniqueness in the sense that it is the only country where the professor's privilege is still intact makes KT observable from a specific point of view.

4.2 Finland

National characteristics: Despite Finland's high per capita income relative to EU average, the economy itself shows a relatively slow growth rate since 2016. Another factor which sets Finland apart from EU average and justifies Finland's pole position in innovation is its entrepreneurial activity, and high shares of R&D spending [51].

In EU comparison, Finland is a designated innovation leader after Sweden and Denmark, with a 34.3% above EU average regarding its innovation and KT performance. Especially since 2019, Finland has experienced an upsurge in its innovation rate. This is partly due to a high rate of collaboration between innovative SMEs as well as sales of innovative products [74]. Having a closer look at Finland's current strengths and weaknesses, Finland's top rank in KT activity within our KT composite index has been promoted through international scientific co-publications as well as new doctorate students in STEM aged 24-35 [see Chapter 3.2; 74]. These KT activities experienced a mid-term to recent upsurge (since 2016) which underlines a certain transformation pathway of Finland.

Contrasting these positive developments, weaknesses in KT activities across Finland apply for governmental support systems for business R&D and resource productivity (Hobza et al., 2023a). Despite low rates of non-R&D innovation expenditures, the main driver for R&D purposedly derives from the private sector. The KT nexus between public and private organizations decreased from 2022. Having these trends at hand suggests that RIS of Finland are strongly dependent on private sector financial support for R&D.

Finland actively accelerates the diffusion of the entrepreneurial academic model under the umbrella of entrepreneurship and innovation by purposefully creating universities of transdisciplinary character, such as the Aalto University in Helsinki, which has recently been founded by combining engineering and specialized arts schools. In general, the Finnish government and universities address the increased pressure to transform the higher education system by granting greater autonomy to universities and increasing multidisciplinary research and teaching efforts [68]. The promotion of the entrepreneurial university model has been a high priority for the government [19]. However, since these incentives such as reports and recommendations remained non-binding for universities their effect and impact are blurry and unknown.

Sustainability: Finland shows a pole position in environmental sustainability with several moments of fluctuation. Strikingly, the rate of environmental sustainability has strongly decreased since 2016, with a short upsurge in 2022 [74]. This is supported by the Eco-Innovation Index: Finland scores first in the Overall Index across the EU as of 2022 [75]. Especially in topics such as Circular Economy and its implementation Finland scores above EU average. In 2021, the Prime Minister of Finland released a Circular Economy Program [75]. This strategy is implemented at several levels and policies. Furthermore, over 50% of the country's strategy is based upon green transition [75, , 3].

Regional selection: Helsinki-Uusimaa (NUTS region FI1B) is denoted as the most innovative region in Finland with a growth rate of 18% over time [76]. It was the second city across the globe to align and report its city legislation to the Sustainable Development Goals (SDGs) by the UN [77]. It started off in the 1990s, with a higher specification towards social, environmental as well as ecological perspective. Furthermore, the City of Helsinki tackles municipal challenges by an experimental, open innovation bottom-up approach and understands itself as testbed e.g., in the form of participatory budgeting [78]. This strong alignment towards regional actor engagement serves as a catalyst for sustainability transformation and is mirrored in above-mentioned indicators. Helsinki- Uusimaa as best practice region denotes an interesting research field since the exploratory and participatory approach emphasizes the role of society within transformation activities.

4.3 Denmark

National characteristics: In the 2023 European Innovation Scoreboard, Denmark is ranked the new top innovative country within the EU and has overtaken Sweden after a few years as a leader [79]. Overall, our indexing shows that Denmark is comparatively strong in the domain of KT activity: specifically in public-private co-publications, international scientific co-publications, foreign doctorate students, and environment-related technologies. Further, a constant increase in performance can be observed in venture capital expenditures [79]. Furthermore, Denmark's R&D expenditure in the public sector (HERD & GOVERD) is the strongest in our indexing, while its expenditure in the business sector (BERD) is the weakest, indicating a clear focus of its governmental expenditure. However, Denmark's business sector is highly subsidized by private financial institutions, such as industrial philanthropic foundations of domestic large corporations. An estimated value of 68% of the total market capitalization of the Copenhagen stock exchange can be accounted to companies controlled by Danish foundations [80], hence, leaving a lot of power in the hands of large, incumbent firms.

Additionally, more recent trends are improvements in non-R&D innovation expenditures and sales of innovative products [80]. In general, Denmark compared to EU's average has a higher income per capita but a less growing economy. SMEs take up a large share of the economy while manufacturing accounts only for a smaller share. In Europe, Denmark is the most business-friendly country and the registration for starting a business is comparably the fastest [81].

Sustainability: Regarding sustainability, Denmark is known as a pioneer in the green transition and circular economy with a parliament that is known for ambitious targets and initiatives [82].

Regional selection: The capital region Hovestaden (NUTS region DK01) is ranked the most innovative region in Europe [79]. The fact that Denmark is not reflected in the SLR, strongly suggests including it as a region of interest because it has after many years of Sweden's leadership in innovativeness taken its place [82]. It is also reflected in both indices as one of the top-performing countries. Further, the identification of Copenhagen, Hovedstaden as being Europe's most innovative region matches our aim to further investigate metropolitan regions. The unique financing landscape of philanthropic industrial foundations heavily influencing the business sector while the government controls the HEI spending makes it an interesting interplay to observe.

4.4 Switzerland

National characteristics: Switzerland's innovativeness can be shown in different facets. It depicts the most innovative country across 132 countries, measured in patent and publication metrics. Switzerland holds this global pole position for 13 years in a row [83, e.g., Global Innovation Index Database]. Switzerland is especially outstanding in their knowledge and technology development.

Within our composite index, Switzerland ranks first regarding new doctorate students in STEM aged 24-35, attracting international talents for doctorship as well as most frequently replicated (top 10% most cited) scientific, academic publications. Further strengths compared to the European average are public-private co-publications, foreign doctorate students, international scientific co-publications as well as doctorate graduates [84]. Switzerland's business R&D investments are predominantly affected by the private sector. Furthermore, due to the location of large, international enterprises, collaboration between smaller, innovative SMEs remains scarce [84]. Furthermore, studies have shown that in Switzerland entrepreneurial activity positively influences sustainability transformations. Vice versa, the Swiss leading university ETH has institutionally prioritized entrepreneurial activities [65].

Sustainability: Regarding sustainability alignment, Switzerland has to catch up with European standards. Switzerland's national framework has also committed to the Agenda 2030 and hence, introduced new partnerships and initiatives in order to fulfill those. Furthermore, although it is not included within the Eco-Innovation Index, Switzerland initiated several institutions and initiatives targeting SDG areas. Still, Switzerland demonstrates a lacking position in developing environment-related innovations [84]. Due to overall innovation performance by far, especially in university-centered KT, we decided to include Switzerland as an exemptional nation. Since Switzerland's endeavors towards sustainability transformations are still in their infancy, the high level within our KT composite index outweighs the lack in sustainability transformation. Regarding the discrepancy of an exceptionally high level of KT activity compared to sustainability transformation, it denotes a unique and interesting research focus, compared to the sustainability-aligned regions. Furthermore, the presence of initiatives towards sustainability transformations shows a transformation pathway interesting to examine.

Regional selection: In the regional drill down, Zurich (NUTS region CH04) is broadly surpassing other Swiss regions. Zurich is Switzerland's most innovative region by far [85]. Especially in tertiary education, international scientific co-publications, and public-private co-publications Zurich remains undefeated. Hence, it depicts our selection to investigate as best practice region for KT activities and university engagement.

5 Discussion

The paper asks (1) how best practice regions for sustainability transformation can be identified and (2) which literature gaps could be addressed in future research. We answer the questions by providing a first approach of a best practice ranking through composite indexing by combining (a) regional performance towards systemic, sustainability transformations, (b) regional performance in university-centered knowledge transfer (KT), and (c) a systematic literature review (SLR). We apply an SLR and collect empirical results about case-specific sustainability practices covered in extant literature. Those case studies provide state-of-the-art insights into the regional and national context in which universities are situated and to reflect and adapt these characteristics in regional spotlights for our research purpose.

According to our methodology, the regions Copenhagen, Zurich, Stockholm, and Helsinki are selected. Here, the aim of future research should focus on the interplay and dynamics of regional actors within an entire region, such as its multiple universities and the surrounding regional innovation system (RIS) [68]. We suggest studying these regions as potential case studies, mapping the RIS holistically either quantitatively or qualitatively according to the specific research purpose. Foss and Gibson [18, 105] highlight the relevance of case studies despite their limited explanatory power of "university, regional and national cultural dimensions". It is crucial to collect data systemically with representatives from all stakeholders included. As a qualitative case study, it would be advisable to sample interviewees theoretically according to the phenomenon under examination. A first approach to identifying regional phenomena is achieved by the regional spotlights which mirror the status quo of our regions of interest and hence, depict a starting point for further research avenues.

In our extensive literature review, it became clear that the role of universities is either that of a KT initiator in the form of UIC [31, 60, 64, 66] or purely entrepreneurial in its functionalities [7, 15, 19, 61, 62]. Only two papers portray the role of the university as expanding from a sole university-industry-collaboration (UIC) catalyst, hence attributing a broader societal role [65, 68]. However, the interplay of the different actors and functions in the RIS is an angle that cannot be neglected and should be portrayed in future research. As such, regional actors positively interact and influence each other, making it a necessary prerequisite to understanding systemic, regional development, such as sustainability transformations [46]. Still, the interplay between collaboration and engagement, such as KT for sustainability transformation in particular, largely remains a blind spot in literature and depicts a future research avenue. Hitherto, the focus of extant studies depicts the function of actors in silo and less the interplay of actors, lacking a holistic and systemic perspective [86]. This is partly due to the nature of systemic change and the difficulty of measuring its causes. Therefore, investigating regions with high levels of KT and several endeavors toward sustainability transformations could provide insights into the dynamics. Hence, our regional sample depicts an initial starting point to build upon.

Although institutional researchers should ensure broad applicability by taking multiple countries into account, a clear reasoning for the choice and selection criteria of regions is inevitable. A heterogeneous sample legitimized for the sake of heterogeneity complicates the implications and explanatory power deriving from it. Hence, a comparison of regions that do have institutional similarities while maintaining a heterogeneous sample seems reasonable. Therefore, the suggested sample, though indeed quite similar at first glance (high-income countries, mostly Scandinavian, sharing a cultural proximity and showing high innovation metrics) bear many differences. Sweden as the only country in Europe maintains the professor's privilege, Switzerland is not bound to EU legislation even though they are gravitating towards it, Denmark is a newly selected innovation leader and has been pioneering in sustainability, Finland with its experimental approach for societal engagement.

It is undeniable that our work comes with certain limitations due to the selected indices as well as differing sustainability approaches across the examined regions. At this point, it needs to be mentioned that our composite index does not claim any generalizability regarding further assertions. The index has been created to match the aim of the paper. Further, we are aware that the indices serving as a base for our composite indexing are partially viewed critically. However, we do think that they are equipped and suitable to give an overview and a tendency of best practice notions, and this data would not be available through other databases. Further, we mitigate the effect by mapping 14 different indicators to determine our selection.

In our SLR, Sweden is over-represented (10 out of 14 papers), while Finland (4 out of 14) and Switzerland (3 out of 14) are just partly covered. Denmark is not to be found in the end selection of the SLR. A possible reason could be the fact that one of the most active publishing authors, [15, 61, 62] mainly coined the terminology of the entrepreneurial university and has been publishing with comparable regional foci including Sweden. Also, Sweden's political uniqueness in the sense, that researchers have the property rights of their own research, makes it a unique setting to observe KT, especially in the region around Stockholm which has been leading in innovation and sustainability for years.

In the SLR, Denmark is not represented in literature which might have been due to its lagging position behind Sweden or because of our thematic focus. Nevertheless, we propose to investigate it by analyzing KT activities through regional actor dynamics because it has repeatedly put itself on the map by being an innovation leader over time, now even portraying the most innovative country in Europe [82] and the region of Copenhagen, Hovedstaden as being Europe's most innovative region [87].

Next, Finland and especially the NUTS 3 region of Helsinki-Uusimaa, is an experimental testbed for bottom-up approaches and hence, especially relevant for the research focus of KT and actor engagement within the RIS [77]. This depicts an extraordinary situation also for university engagement as well as municipal decision-making. Hence, experiences of effective KT processes within actor engagement can be transferred from this case study by investigating this RIS further.

Lastly, Switzerland contrasting the Scandinavian regions, depicts an interesting starting point where sustainability transformation of the region is still in its infancy but approximates to European standards. It depicts an interesting field of research because it shows the greatest potential in transitioning towards sustainability transformations with a recent upsurge in sustainability initiatives as well as voluntary commitment to the Sustainable Development Goals (SDGs). Since Switzerland's institutional framework converges with the EU legislation in the past, also sustainability topics will probably succeed on the political agenda. Hence, it should be investigated over time in their transition pathway towards sustainability transformations and how the transformation process from a purely innovation country evolves towards a sustainable one [59].

Declarations

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Appendix A Additional Figures

Matching of KT indicators with EIS/ RIS data

Environmental Indicators

KT indicator	EIS/ RIS data equivalent
HERD	R&D expenditure in public sector (% of GDP)**
BERD	R&D expenditure in business sector (% of GDP)**
Public funding for KT	Direct government funding and governmental tax support for business R&D (% of GDP)
Investment capital	VC as % of GDP

Activity Indicators

KT indicator	EIS/ RIS data equivalent
Licences & assignments	Trademark applications per billion GDP**
	Sales of new to market & new to enterprise innovations as % of turnover**
Research contracts	New doctorate students in STEM aged 24-35
Research collaborations	International scientific co-publications per million population**
	Public-private co-publications**
Research Quality*	Scientific publications among the top-10% most cited publications worldwide as percentage of total scientific publications of the country**

Impact Indicators

KT indicator	EIS/ RIS data equivalent
Jobs created and retained	Job-to-job mobility of Human Resources in Science & Technology
Products on market	Knowledge-intensive services exports as percentage of total services exports
Internal culture change (PRO)	Foreign doctorate students as % of all doctorate students

* Not included in the KT indicators according to Campbell et al. (2020) but considered to be of importance for the research objective.
** Measured on the regional (NUTS 3) level and part of the Regional Innovation Scoreboard.

Fig. A1 Matching of the knowledge transfer indicators by [9] with the European Innovation Scoreboard and the Regional Innovation Scoreboard. Source: own compilation.

Appendix B Additional Tables

Table B1 Indicators and Interpretations

Indicator	Definition	Interpretation
Sustainability		
S1 - Eco Innovation Index	The environmental innovation performance of EU Member States is measured by the summary Eco Innovation Index, which is a composite indicator obtained by taking an unweighted average of the 12 indicators included in the measurement framework [49].	The Eco-Innovation Index is used to measure the impact of sustainable innovations within the country.
S2 - SDG Index	The overall score measures the total progress towards achieving all 17 SDGs. The score can be interpreted as a percentage of SDG achievement. A score of 100 indicates that all SDGs have been achieved [11].	The overall score of the SDG Index is used as a proxy for the regional, systemic alignment towards sustainability in all sustainability dimensions.
Environment		
E1 - R&D exp in bus sector (% of GDP)	All R&D expenditures in the business sector (BERD) (Eurostat).	The indicator captures the formal creation of new knowledge within firms. It is particularly important in the science-based sectors (pharmaceuticals, chemicals and some areas of electronics) where most new knowledge is created in or near R&D laboratories [53].
E2 - R&D exp in public sector (% of GDP)	All R&D expenditures in the government sector (GOVERD) and the higher education sector (HERD) (Eurostat).	R&D expenditure represents one of the major drivers of economic growth in a knowledge-based economy. As such, trends in the R&D expenditure indicator provide key indications of the future competitiveness and wealth of the EU. Research and development spending is essential for making the transition to a knowledge-based economy as well as for improving production technologies and stimulating growth [53].
E3 - Direct government funding & gov tax support for bus. R&D	Sum of GTARD as a percentage of GDO and Direct funding of BERD as a percentage of GDP (OECD R&D Tax Incentive Database).	Public financing of R&D can take two forms: Direct funding for R&D through instruments such as grants and public procurement, and Indirect support through the tax system. Direct funding is well captured in the official data on R&D expenditure by source of fund, differentiating between the following sources: Business enterprise sector, Government sector, Higher education sector, Private non-profit sector, and Abroad. Data on R&D funded by the Government sector are available from Eurostat (EU Member States and other European countries), OECD (OECD member states) and UIS (global coverage). Over time, more and more countries have introduced R&D tax incentives. The OECD has started to collect data on such systematically since 2017 and with the support of the EC data are currently being collected on an annual basis and made available in the 'OECD R&D Tax Incentives database'. In the EU, 21 countries were offering R&D tax relief in 2018, a significant increase compared to only 12 countries offering R&D tax relief in 2000 [53].

continued from **B1**

Indicator	Definition	Interpretation
E4 - VC as % of GDP	Venture capital expenditures is defined as private equity being raised for investment in companies. Management buyouts, management buy-ins, and venture purchase of quoted shares are excluded. Venture capital includes early stage (seed + start-up) and expansion and replacement capital (Invest Europe).	The amount of venture capital is a proxy for the relative dynamism of new business creation. For enterprises using or developing new (risky) technologies, venture capital is often the only available means of financing their (expanding) business [53].
Activity		
A1 - Trademark applications per billion GDP	Number of trademark applications applied for at EUIPO (European Union Intellectual Property Office (EUIPO)).	Trademarks are an important innovation indicator, especially for the service sector. The Community trademark gives its proprietor a uniform right applicable in all Member States of the European Union through a single procedure which simplifies trademark policies at European level. It fulfils the three essential functions of a trademark: it identifies the origin of goods and services, guarantees consistent quality through evidence of the company's commitment vis-à-vis the consumer, and it is a form of communication, a basis for publicity and advertising [53].
A2 - Sales of new to market & new to enterprise innovations as % of turnover	Sum of total turnover of new or significantly improved products, either new-to-the-enterprise or new-to-the-market, for all enterprises (Eurostat)	This indicator measures the turnover of new or significantly improved products and includes both products which are only new to the firm and products which are also new to the market. The indicator thus captures both the creation of state-of-the-art technologies (new-to-market products) and the diffusion of these technologies (new-to-firm products) [53].
A3 - New doctorate studs in STEM aged 24-35	Number of doctorate graduates in science, technology, engineering, and mathematics (STEM) (Eurostat).	The indicator is a measure of the supply of new second-stage tertiary graduates in all fields of training (ISCED 8). For most countries, ISCED 8 captures PhD graduates. There is a complex relation between STEM-graduates and innovation in the private sector. STEM-graduates do well as an employee within firms with many of them taking up managerial positions. However, non-STEM graduates are more likely to be involved in entrepreneurial activities. Graduates with a STEM-background who have completed a non-STEM study next to their core curriculum, show as much entrepreneurial activity as non-STEM graduates.
A4 - Intl. Scientific co-publications per million pop	Number of scientific publications with at least one co-author based abroad (where abroad is non-EU for the EU27) (Scopus)	International scientific co-publications are a proxy for the quality of scientific research as collaboration increases scientific productivity [53].

continued from **B1**

Indicator	Definition	Interpretation
A5 - Public-private co-publications	Number of public-private co-authored research publications. The definition of the "private sector" excludes the private medical and health sector. Publications are assigned to the country in which the business companies or other private sector organisations are located (Scopus)	This indicator captures public-private research linkages and active collaboration activities between business sector researchers and public sector researchers resulting in academic publications [53].
A6 - Scientific publications among the top-10% most cited publications worldwide as percentage of total scientific publications of the country	Number of scientific publications among the top-10% most cited publications worldwide (Scopus)	The indicator is a measure for the efficiency of the research system, as highly cited publications are assumed to be of higher quality. There could be a bias towards small or English-speaking countries given the coverage of Scopus' publication data [53].
Impact		
I1 - Knowledge-intensive services exports as percentage of total services exports	Exports of knowledge-intensive services is defined as the sum of credits in EBOPS 2010 (Extended Balance of Payments Services Classification) items SC1, SC2, SC3A, SF, SG, SH, SI, SJ and SK1 (Eurostat)	The indicator measures the competitiveness of the knowledge-intensive services sector. Competitiveness-enhancing measures and innovation strategies can be mutually reinforcing for the growth of employment, export shares and turnover at the firm level. It reflects the ability of an economy, notably resulting from innovation, to export services with high levels of value added, and successfully take part in knowledge-intensive global value chains [53].
I2 - Foreign doctorate students as a percentage of all doctorate students	Number of doctorate students from foreign countries (Eurostat)	The share of foreign doctorate students reflects the mobility of students as an effective way of diffusing knowledge. Attracting high-skilled foreign doctorate students will secure a continuous supply of researchers [53].

Table B2 Key Word Search Strategy

Key Word	AND	AND/OR	Number of articles
“Knowledge Transfer”	“Entrepreneurial University” OR “Engaged University”	“Best Practice” OR “Sweden” OR ”Finland” OR “Switzerland” OR “Denmark”	118
“Sustainable Development” OR “Sustainable Transition” OR ‘’Sustainability Transition” OR “Sustainability Transformation”	“Entrepreneurial University” OR “Engaged University”	“Best Practice”	90
“Absorption” OR “Dissemination”	“Entrepreneurial University” OR “Engaged University”	“Best Practice”	60
“Regional Innovation System*”	“Entrepreneurial University” OR “Engaged University”	“Best Practice”	32
“Entrepreneurial Ecosystem*”	“Entrepreneurial University” OR “Engaged University”	‘’Best Practice”	23
“Entrepreneurial University” OR “Engaged University”	“Europe”		20
Sum			381