European Commission

Measuring the contribution of higher education to innovation capacity in the EU

Study

Education and Training

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Study on measuring the contribution of higher education to innovation capacity in the EU

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Glossary

The table below provides a list of acronyms and abbreviations used in this report.

AUTM	Association of University Technology Managers
CPD	Continuing professional development
FTE	Full time equivalent
HC	Human capital
HE	Higher education
HEI	Higher education instituion
HEBCI	UK Higher Education Business Community Interaction
IP	Intellectual property
IPR	Intellectual property rights
ISCED	International Standard Classification of Education
KBE	Knowledge based economy
KICs	Knowledge Innovation Communities
KE	Knowledge exchange
KT	Knowledge transfer
NGO	Non-Governmental Organisation
PhD	Doctor (in) Philosophy
STEM	Science, Technology and Engineering
TTOs	Technology Transfer Offices
UBC	University-Business Collaboration
UCIC	University Contribution to Innovation Capacity
UIRCs	University-Industry Research Centres
WIPO	World Intellectual Property Organisation

Executive Summary

Context of the study

The current study is part of the actions taken aiming to analyse the links between the operations and **effects of higher-education institutions on the capacity to innovate in the economies in Europe**. Providing insights into the contribution of higher education to the innovative capacity of the EU economies is crucial for policy making and the direction of policy measures in a fast-changing market environment. Universities contribute to societal development and innovation through their three core missions. Firstly, teaching aims to create human capital in the form of more highly skilled labour, more endowed with competences to boost innovation activities. Secondly, research produces knowledge capital that is transferred into innovating businesses, although it is usually embodied in individuals and thus, it is not easily codified and transferred. Finally, the third mission of higher institutions involves knowledge exchange between universities and society in various ways, including consulting and technical services, providing policy advice or contributing to territorial economic development strategies.

The traditional and underlying models for the analysis of the contribution of higher education on innovation capabilities have mainly followed the R&D perspective focusing on the second mission of Higher Education Institutes (HEIs). In this context, indicators measuring this contribution focus on the ownership of intellectual outputs by HEI staff members, providing a framework that relates higher education to innovation outputs. Although this approach includes more than only research and development activities, it seems to "tell only part of the story". Innovation and the capacity to innovate are also determined by factors such as the supply of human capital, skills, entrepreneurship, intrapreneurship and others. These factors have been increasingly taken into account in policy-driven data collection exercises, although we still lack a complete stock-taking exercise that includes all relevant factors that *adequately measure the contribution of higher education to innovation capabilities.*

There has been a massive expansion of higher education across European countries in recent decades as they attempt to provide their workforces with the skills necessary to successfully compete in the knowledge based economy (KBE). Economic strength in the KBE is being driven by innovation, taking existing resources and assets and using them to do new things better, and increasing overall welfare levels. Whilst the pursuit of innovation is essential for all economic agents, universities are at the heart of policy attempts to increase the overall knowledge capital for innovation, as well as a proving ground for future innovators.

Recently however, there have been concerns that universities are failing to adequately respond to these new demands and are continuing to act as 'ivory towers' outside of society, rather than driving society forward (Galan-Muros, 2016). There is, in particular, a perception that universities have tended to expand their existing activities rather than create new courses, pedagogies and learning environments that best meet society's needs. Where universities contribute effectively to innovation, they can create whole new industries and sectors, and transform the fortunes of particular places. But at the moment, these conflicting narratives make it hard for policy-makers to determine whether and how universities (and indeed, which kinds of universities) can leverage innovation capacities.

A key challenge for European policy-makers is therefore to determine the extent to which universities are realising their innovation potential to meet the needs of the KBE. **In this study, we seek to understand the extent to which universities are supporting innovation[1].**

Objectives of the study

The goal of the study has been the provision of evidence on the key factors determining the contribution of higher education institutions (HEIs) to innovation capabilities and to expand the understanding of this contribution beyond traditional measures of the role of HEI on innovation capabilities. In this context, the general objective of the study can be verbalised as being: ***"to develop a more comprehensive model of the contribution of higher education to innovation capacity".***

More specifically, the objective of the project has been to **develop an indicator set that is capable of providing some degree of measurement of the contribution of universities in Europe to innovation capacity.**

In doing so the study has aimed to develop a prototype set of indicators that will capture the effects of higher education on innovation capacity.

Introduction to the literature review: the HEI activities contributing to innovation capacity

The theoretical analysis producing the study's literature review starts off with the development of a formal conceptualisation of the process by which **universities specifically** contribute to external resources for innovation in ways that improve innovation activities. Universities undertake particular activities that spill over from their main missions into this knowledge pool, thereby offering potential future innovation resources (this includes cases where universities work in practice with innovators directly to make those knowledge resources directly available). Knowledge is created in core university activities, but at the same time some of that knowledge transforms *in various ways* that allow it to have a non-academic value (that is, a specific value to users).

Universities' 'contribution to innovation capacity' comes through providing resources that innovators need as they attempt to deliver change processes. From that, we define the measurement challenge as fairly quantifying the resources that facilitate innovation. We ideally would measure 'spillovers', but that is not empirically possible: spillovers are a conceptualisation we use to understand a regularity rather than something 'out there' that can be measured. Spillovers are also a conceptual "residual", i.e. something that is defined as that which cannot be measured (Breschi & Lissoni, 2001).We therefore focus on measuring those outputs which, in association to other additional resources, can help innovators to expand their innovation frontier.

Having made explicit this abstraction, we identify the kinds of university-derived outputs that feed into activities which ultimately expand innovators' access to innovation resources. Measurement therefore requires defining variables – the output conceptually connected to

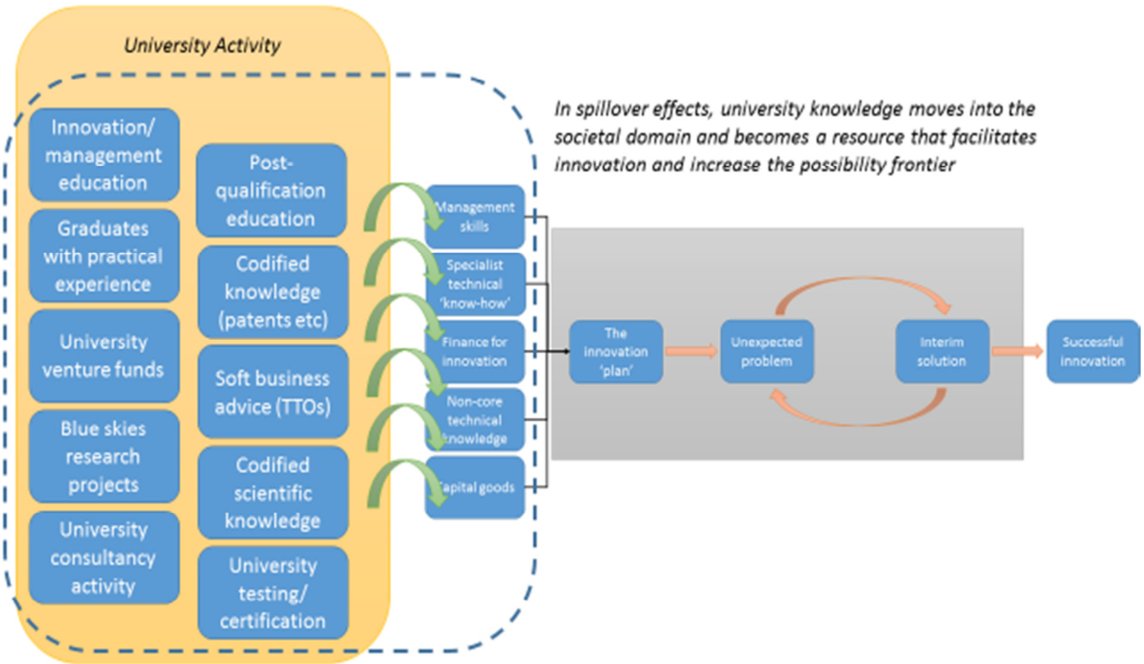
[1] We define 'innovation' as the result of a set of activities by which different kinds of knowledge are combined to create solutions and interventions to solve problems, ultimately making society a better place (a form of Schumpeterian perspective). Those societal improvements may be through:

(a) raising competitiveness and creating new markets and sectors,
(b) improving the delivery of public services, particularly to vulnerable social groups, or
(c) reducing our environmental impact.

the innovators' resource frontiers. We therefore seek to identify data that can be gathered and which measure in some way those contributions. Some of these variables will be relatively easy to gather data for, whilst for others they may be largely absent: if there are substantial gaps in coverage, then there would be a case for investing substantial efforts into designing new measures and collecting them in order to be able to better measure this university contribution to innovation capacity.

This in turn helps us to better specify the overarching research problem, namely the fact that there are many measures available that capture direct transactions, whilst relatively few cover the indirect contributions by via the knowledge pool. Whilst knowledge transfer indicators may be a good way to understand the contribution to individual ongoing innovation activities, what they do not provide is a good measure of the 'knowledge pool' from which later activities emerge.

University activity creating externalities that spillover into a knowledge pool (shown by dashed line) facilitating innovator resource access



Key principles leading to the proposed prototype set of indicators: Knowledge transfer and human capital spillovers

Next to what has been briefly analysed in the previous paragraphs, another goal of the literature review has been to identify appropriate empirical dimensions for each of those assets in order to inform the elaboration of appropriate indicators. The analysis has shown that spillovers can be conceptually divided into two sorts:

First, there are those that occur when a piece of knowledge is transferred from within the university into a societal context (e.g. firm, local authority) where it can be used to fill an innovation resource shortage (**knowledge transfer**). Here we distinguish between three varieties of knowledge transfer-related spillovers:

(a) where there is an activity in which the knowledge is specifically transferred through a transaction with a user in which the knowledge is translated (e.g. licensing a patent)

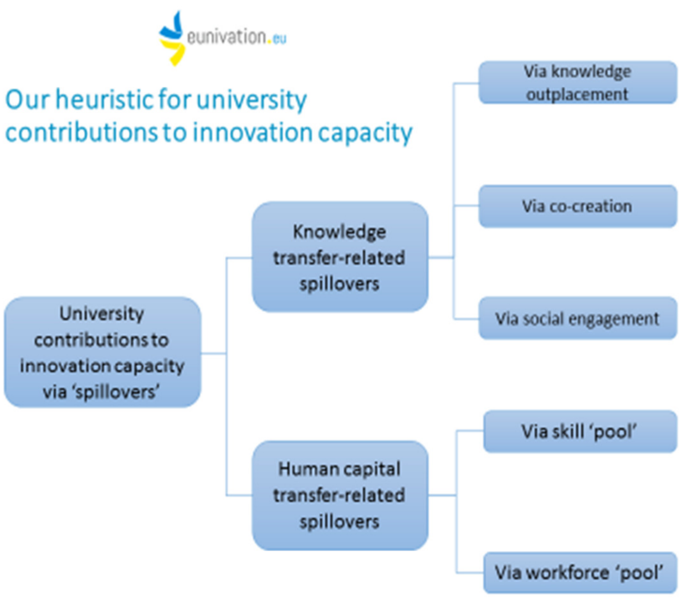
(b) those that occur when the university and innovator co-create knowledge and the innovator uses a share of that co-created knowledge as an innovation input (e.g. a shared research project), and
(c) those that occur when university knowledge strikes a chord with a non-innovator, and that serves as the antecedent to possible innovation activities (such as media reports of academic activity).

The second class of spillovers are those that happen when students move into the labour market and make use of the knowledge acquired within the university (**human capital**). They embody knowledge capital that is used as a resource that facilitates new innovations, whether in the economic, public or societal sectors. We further distinguish two ways by which universities contribute in this regard, namely

(a) the direct education of individuals who then add to the total stock of human capital as they move into the labour force, and their education becomes an innovation-frontier extending resource, and
(b) the other labour market effects that universities may have by enriching the overall human capital in a place that provides innovation-frontier extending effects, such as in attracting highly skilled graduates, post-qualification education and institutions that improve labour market 'matching'.

These two classes of spillovers and the subdivisions are shown in the schematic below and form the basis for the measurement approach that has been applied.

Overview of the main structure of the literature review



There is a clear geography to individual university contributions. Some universities will create most spillovers at a very local level, when for example they deliver highly-skilled students specifically attuned to particular locally-rooted sectors. Other universities may make their contributions at national or European levels, for example those that are active in providing Ph.D. training and Horizon 2020 research leadership within wider consortia. Spillovers are an emergent property and are not contained by particular territorial boundaries – universities in border regions will create opportunities for benefit across national and EU borders. In the context of this study, we have primarily been concerned with ***contributions to European knowledge pools, and contribution to European innovation***

capacity, although that might be at a pan-EU level, within member-st**ates**, within macro-regions or even within localities, cities and rural areas.

Prototype set of indicators: validation phase

During the phase that developed the prototype set of indicators, the challenge lay in the operationalisation, in ensuring that the choice of proxies is such that they maximise the indicators' technical validity and political legitimacy. The study has considered that the indicators are conceptually 'good' and legitimate and address current critiques, as in the following:

(a) they must be proxies that are measuring something in which a rise can conceptually be considered to be associated with 'increased spill-over benefits',
(b) they must suggest that there is a university stock that flows and creates an impact, namely they are a university output, suggestive of real world activity, and in which innovators are signalling their interest, and
(c) they must be improvements on the current state-of-the-art, capturing university mechanisms and behaviours for knowledge exchange, and a broad scope of human capital contributions to innovation capacity.

On that basis, the study proposed a selection of the variables (see sections 2.2 and 2.3) in order to present a first indicator selection for measuring university contribution to innovative capacity. In this, we have firstly sought to ensure that the indicators represent a fair balance of measures by ensuring that they cover a broad spectrum of the dimensions identified in the literature review. There are 19 possible facets by which we can measure elements of university contribution, set out in the final indicator set that follows. These indicators have been the subject of discussion and validation (including feedback for improvement) in a series of interviews with HEI representatives, policy makers and industry representatives across Europe aiming at capturing their personal opinion on the prototype set of indicators. This process, together with a feasibility analysis, resulted in the final proposition of the study about the prototype set of indicators.

Prototype set of indicators: the proposition

The indicators that have been developed are intended to present a balanced score card of university contributions to innovation capacity. It is important to state that we here make a difference between the university as the unit of reporting (data gathering) and what will be chosen as the unit of presentation. We have chosen universities as the unit of reporting because the spillovers originate from university activities, and universities are most strongly positioned to report on that data. But we are clear that we see the unit of presentation as being a territorial one, aggregating data from a number of universities to demonstrate where universities are contributing more or less strongly. Our justification for this is that spillovers depend as much upon take-up as outflow, and in weak regional environments, active, successful universities may make a lesser (or less visible) contribution through no fault of their own. We draw an analogy here with the Community Innovation Survey which presents its results regionally and nationally, and not at the level of individual companies. We envisage that a putative University Innovation Contribution scoreboard would report at a territorial scale, sufficiently aggregated to prevent the distinction of individual institutions.

The final prototype indicator set is presented in the table below. This indicator set was arrived at through a multi-stage optimisation process which sought to choose the best indicators on the basis of a synoptic analysis of their characteristics, the results of the expert feedback consultations, as well as the results of the Field Studies and the questionnaires.

We note in making this optimisation that there is one of the dimensions that is inadequately covered, but for which there were as yet no appropriate indicators: that is the contribution of universities to innovation capacity through the work their academics take on through public engagement, informal interactions with societal partners and other forms of informal outreach. More detail is provided on the optimization process in Chapter 6 and 7 of the current document.

Final indicator set[2]

Category	University activity	Indicators
Human capital	Lifelong learning	Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)
Human capital	Mobility	Percentage of PhDs undertaken jointly with a private (non-academic) partner
Human capital	Curricula	Participation of non-academic agents in the definition of curriculum development (level measure)
Knowledge transfer	Collaborative R&D	University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)
Knowledge transfer	Consultancy	Income, total value, number of contracts (by: SME, large firms, commercial, non-commercial)
Human capital	Teaching & Learning	Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS)
Knowledge transfer	Infrastructure for commercialisation	Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)
Knowledge transfer	Education outreach	HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)
Human capital	Internationalization	Number of ECTS awarded to international exchange students (ERASMUS student) as a percentage of total ECTS
Knowledge transfer	Student start up activity	Student start-ups (total active start-ups, turnover, private funding raised)

This final indicator set has been the result of an optimization process involving various procedures. The aim has been to retrieve an indicator set that is the most legitimate, most technically suitable, most limited in number and has a large extent of university activity coverage. These various elements have been brought together to propose a final indicator set optimised in terms of the following considerations:

- Provision of the broadest possible coverage of the full range of dimensions of UCIC
- Inclusion of indicators that are technically the most suitable for measuring these dimensions and are regarded by policymakers as having sufficient legitimacy
- Inclusion of indicators that have a degree of external validity (expert validity and arguments put forward by stakeholders)

The first step in the optimisation process was to eliminate the indicators that have been weak in one of the three dimensions against which they have been evaluated: (1) being closely associated with a process that results in 'UCIC', (2) being intrinsically good and (3)

[2] The shading separates out the three indicator coverage spans corresponding to the core (5), optimal (3), extensive (2) coverages

being positively evaluated by the stakeholders. On the basis of these evaluation criteria, we deleted 9 indicators from the indicator set.

The indicators analysed best were included in the core indicator set. The first consideration in choosing a **core indicator set** has been to balance the important university activities that contribute to innovation capacity. The most important activities to cover have been the human capital contribution via skills and knowledge, and the knowledge transfer contribution via collaborative research activities with external users. Three human capital indicators have been selected, with one of them (mobility) reflecting both human capital and knowledge transfer. The other two indicators facilitate the uptake of skills by non-academic agents and the involvement of these agents in defining the curriculum. The two knowledge transfer indicators selected on collaborative R&D and consultancy are activities that demonstrate the interest of an external actor in the knowledge that emerges from universities. In addition, the indicators received the strong support of the stakeholders and experts.

The first consideration in choosing the indicators for the **additional indicator s**et has been to sustain the balance between the university activities and to include the activities missing in the core set. As regards the human capital indicators, student throughput was missing and therefore the indicator covering teaching and learning has been included. Concerning the knowledge transfer activities, public engagement and commercialisation had not been covered and these two activities received most support during the optimisation process. The infrastructure for commercialisation provides an indicator of clear commitment to transfer knowledge and the education outreach activity demonstrates the commitment of universities to make research publicly available.

The consideration of the **extensive indicator set** has been to determine whether some dimensions have not been sufficiently covered and whether there are indicators that can provide added information, proportional to the overall further effort to retrieve the data. The internationalization activity has been included because it provides an additional activity of how skills can be activated and used within society. The information for this indicator is already available and/or easy to collect. The indicator for student start-up activity demonstrates the extent to which universities are creating raw materials that can be used for innovation and the extent to which they support the use of this raw material for generating new businesses. This university activity shows an informal innovation contribution and therefore covers an element not yet taken into account. Moreover, the information for this indicator is easy to collect.

Prototype set of indicators: the proposition of the indicators

In the present prototyping study, we have found that there is a **strong degree of coherence around university contributions to innovation capacity by considering the different kinds of spillover effects emerging from universities**. Our model has identified a number of dimensions by which universities generate resources that improve others' opportunities for innovation. These correspond with a wide range of university activities, and were broadly supported by the fieldwork. The prototype itself is not coherent or ready to immediately proceed unaltered towards the development of a Europe-wide scoreboard or indicator set. This is a function of the availability of the data to provide information on the indicators we have proposed.

The indicators that we have proposed emerged from the literature review, and have been used in some particular context by a particular policymaker or researcher to address a single process or mechanism that corresponded in some way with the dimensions we identified in the literature. But that does not necessarily mean that those measures are the only way of gathering useful data on that indicator. Unavoidably, the fieldwork gathered data on the basis of indicators that emerged from the literature review, partly as a means of trying to get respondents to have an understanding of the conceptual dimensions with which we are concerned. Any possible effects of this methodology should be considered when taking the prototype indicator set along the next step towards a European 'UCIC Scoreboard' or Survey.

Nevertheless, this study shows the support among a broad range of experts for the kinds of indicators that are used in the prototype indicator set. A balanced approach is required to measuring UCIC that does not assume that these contributions are exclusively generated via research activities, but also reflects the various other pathways by which university knowledge activities stimulate innovation.

Our overall recommendation is that the Commission proceeds to develop a **pilot scoreboard for UCIC using the conceptual framework** proposed above, and drawing inspiration from the prototype indicator set as well as the potential alternative indicators.

We specifically recommend that this be driven by a group of **lead users who have a strong intrinsic commitment to developing the indicators**, encompassing the Commission, a set of HEIs and an expert group.

The pilot can build on the more comprehensive understanding of UCIC that has emerged from this study, which should be disseminated to university representative groups, national higher education and research policymakers, as well as European-level institutions and stakeholders. The report presents more detailed recommendations for these categories.

1 Introduction to the objectives of the study and the content of the report

1.1 Objectives of the study

The general goal of the study is the provision of evidence on the key factors determining the contribution of higher education institutions (HEIs) to innovation capabilities and to expand the understanding of this contribution beyond traditional measures of the role of HEI on innovation capabilities. In this context, the general objective of the study could be verbalised as being: ***"to develop a more comprehensive model of the contribution of higher education to innovation capacity".***

More specifically, the objective of the project is to **develop an indicator set that is capable of providing some degree of measurement of the contribution of universities in Europe to innovation capacity.**

It is important to note here that the overall objective of this study, as stipulated also in the Specifications for the call for tender, is the **development of a (prototype) indicator set providing some degree of measurement of the contribution of universities in Europe to innovation capacity**, which will potentially form the basis for future projects aiming to apply the model by collecting data. Data collection and application of the indicator set is therefore not within the scope of the project.

The validation and feasibility phases have the purpose of validating the extent to which the proposed set of indicators have been a good choice and not to collect the data for the development of the proposed indicators.

In order to fulfil these objectives the project requires that

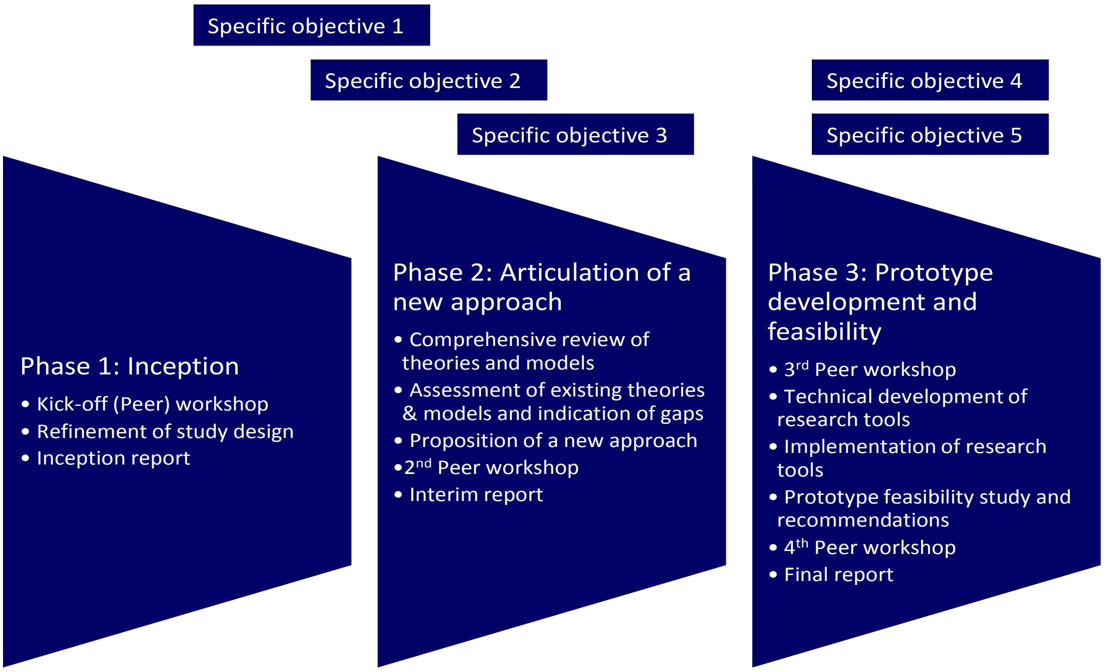
a) the indicator set is rooted in a strong **conceptualisation** of university contribution to innovation capacity (UCIC),
b) it reflects the **diversity** of UCICs as captured in a range of cognate literatures,
c) **measures** are identified to capture the diverse kinds of contribution, and
d) an **indicator set** is developed that captures those diverse measures.

The project has been broken down into three main phases of activities which have been designed in order to fulfil the above-mentioned five main objectives of the study.

Phase 1 (the Inception Phase) included the kick-off meeting, the first of the workshops with the expert peer group, and the refinement of the methodology of the study. **Phase 2** included a comprehensive literature review, the identification of gaps and inadequacies of the current theories and metrics applied for estimating the contribution of Higher Education Institutions (HEIs) to innovation capacity, as well as the definition of a prototype set of indicators. **Phase 3** includes all activities related to the validation of the prototype set of indicators through fieldwork, and the feasibility study along with the final proposition for the prototype set of indicators.

The graph below reflects the link of the objectives of the project to its activities.

Figure 1: Project phases



1.2 Guide for the reader of this report

The report is the final deliverable for the project of the Directorate General for Education and Culture (DG EAC) on the Measurement of the impact of Higher education on the innovation capabilities in the EU (EUniVation). The report provides all outputs of the project including:

- the **literature review of the project** about the current use of indicators for the measurement of the innovation impacts of higher education and the gaps noticed;
- **the fieldwork and case studies on the draft prototype set of indicators** that this project proposed; **and**
- **the feasibility study** and the **final proposition for the prototype set of indicators** proposed, accompanied by our feedback on recommendations about future actions tailor-made for the different relevant stakeholder groups (DG EAC, Other EU Bodies, National policy makers, Representative groups and Higher-education institutions).

Chapter 2 of this document provides the **literature review** with specific contributions about the challenges that have been lately encountered in the measurement of the impact of higher education on innovation capabilities. It also provides insights on the relevance of spillovers through knowledge-transfer mechanisms as well as through human capital mechanisms. It concludes with elements on shortcomings that need to be taken into account in our propositions for the prototype set of indicators.

Chapter 3 introduces the team's proposition for the **draft prototype set of indicators** that is proposed to measure the innovation impacts of higher education in future projects and which has been the object for the feedback asked for at the fieldwork of the project.

Chapter 4 provides the **summary of the feedback from the fieldwork** on the draft prototype set of indicators. It provides the main points of the feedback of all the stakeholders interviewed in 14 countries, structured under each and every indicator proposed as the draft set of indicators. Annex 1 to this report provides the description of the **research tools** employed at the fieldwork. These tools include the guide for interviews with higher-education institution representatives, policy makers and industry associations; the draft survey questionnaire for higher-education institutions and industry associations and the structure of the case study reports that summarise this information.

An introduction to the final selection of indicators and the **presentation of the final proposition of the prototype set of indicators** are presented in Chapter 5 and Chapter 6 respectively. Chapter 6 in particular describes each of the final ten proposed indicators and concludes with an analysis of the relevant data availability.

Finally, Chapter 7 concludes with a discussion about the next steps in the **future operationalisation of the indicator set,** as well as a tailor-made presentation of detailed **recommendations** for different relevant groups of stakeholders.

The Annexes provide additional information on the validation tools and the case studies developed during the project, as well as on the indicator fiches that explore in depth the available sources of statistical information for the proposed indicator set.

Part A: Literature review and proposal of draft indicator set

2 The literature review of the study

2.1 The challenge of measuring university contribution to innovation capacity

2.1.1 Universities contributing to innovation: a new policy imperative

There has been a massive expansion of higher education across European countries in recent decades as they attempt to provide their workforces with the skills necessary to successfully compete in the knowledge based economy (KBE). Economic strength in the KBE is being driven by innovation, taking existing resources and assets and using them to do new things better, increasing overall welfare levels. Whilst the pursuit of innovation is essential for all economic agents, universities are at the heart of policy attempts to increase the overall knowledge capital for innovation, as well as a proving ground for future innovators.

Recently however, there have been concerns that universities are failing to adequately respond to these new demands and are continuing to act as 'ivory towers' outside of society, rather than driving society forward (Galan-Muros, 2016). There is, in particular, a perception that universities have tended to expand their existing activities rather than create new courses, pedagogies and learning environments that best meet society's needs. Where universities contribute effectively to innovation, they can create whole new industries and sectors, and transform the fortunes of particular areas. But at the moment, these conflicting narratives make it hard for policy-makers to determine whether and how universities (and indeed, which kinds of universities) can leverage innovation capacities.

A key challenge for European policy-makers is therefore to determine the extent to which universities are realising their innovation potential to meet the needs of the KBE. By distinguishing which institutions are or are not able to address the innovation agenda, policy-makers can develop a more nuanced set of engagement stimuli that can help to optimise their contribution, and in turn, the returns that European societies receive for their substantial public investments in higher education.

In this study, we seek to understand the extent to which universities are supporting innovation. We define 'innovation' as the result of a set of activities by which different kinds of knowledge are combined to create solutions and interventions to solve problems, ultimately making society a better place (a form of Schumpeterian perspective). Those societal improvements may be through:

(a) raising competitiveness and creating new markets and sectors,

(b) improving the delivery of public services, particularly to vulnerable social groups, or

(c) reducing our environmental impact.

Integrating an innovation agenda into their core activities has the potential to create some challenges and problems for universities, in delivering their main missions of teaching and research (Pinheiro et al., 2015). For example, if universities tailor their course delivery too closely to the demands of particular sponsors and firms, their graduates may become less (and not more) employable than graduates with a more generalist education. Research cultures between universities and firms differ. When firms work together on joint research projects with other firms they may create new knowledge that is the basis for a unique competitive advantage. Firms will therefore have a strategic interest in protecting or hiding this knowledge. By contrast, the general academic norm is one of openness, of seeking to disseminate knowledge and findings as widely as possible. Whilst we acknowledge what Bozeman et al. (2013) call the 'dark side of innovation' for universities (see also Nature

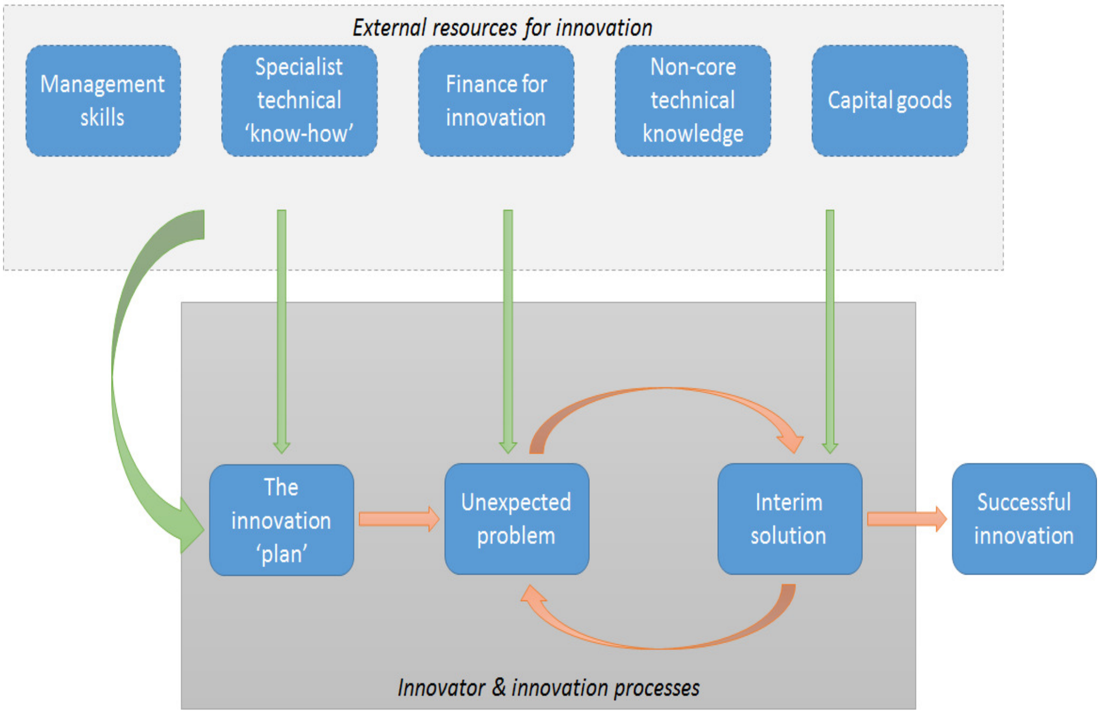
2015), we argue that it is the policy-makers' responsibility to ensure that via their interventions they do not incentivise public value failures by universities.

2.1.2 Towards fair measures of how universities contribute to innovation capacity

Measuring the extent to which universities contribute to societal wellbeing is fraught with difficulties, not least from a policy perspective because there is a long causal chain between activities that universities undertake and generalised societal improvements which we understand as innovation. Therefore in this report, we limit our consideration to the ways in which universities directly contribute to *increasing future potential innovation activity*.

We understand innovation in the Schumpeterian sense of taking a range of existing resources and combining them in a new way to create a solution to a problem. In the course of this process (creating new combinations), innovators may encounter further problems and uncertainties and seek solutions to these. Innovators rarely command all the resources that they need to successfully innovate (management, technical skills, commercial skills), machinery, finance). Firms may acquire these resources by directly purchasing them, although innovating firms typically do not have spare finance to acquire them on commercial terms. Firms may access these resources, indirectly through spillovers. These are economic benefits that accrue to them as a result of the purposeful actions of others. This is shown in figure 2 below, where universities **do not** specifically feature. In fact, there are many things that can drive these spillovers, such as the presence of clusters, firms with related variety to the innovator, a thriving venture finance market, as well as universities.

Figure 2: External innovation resources contributing to innovator/ innovation processes

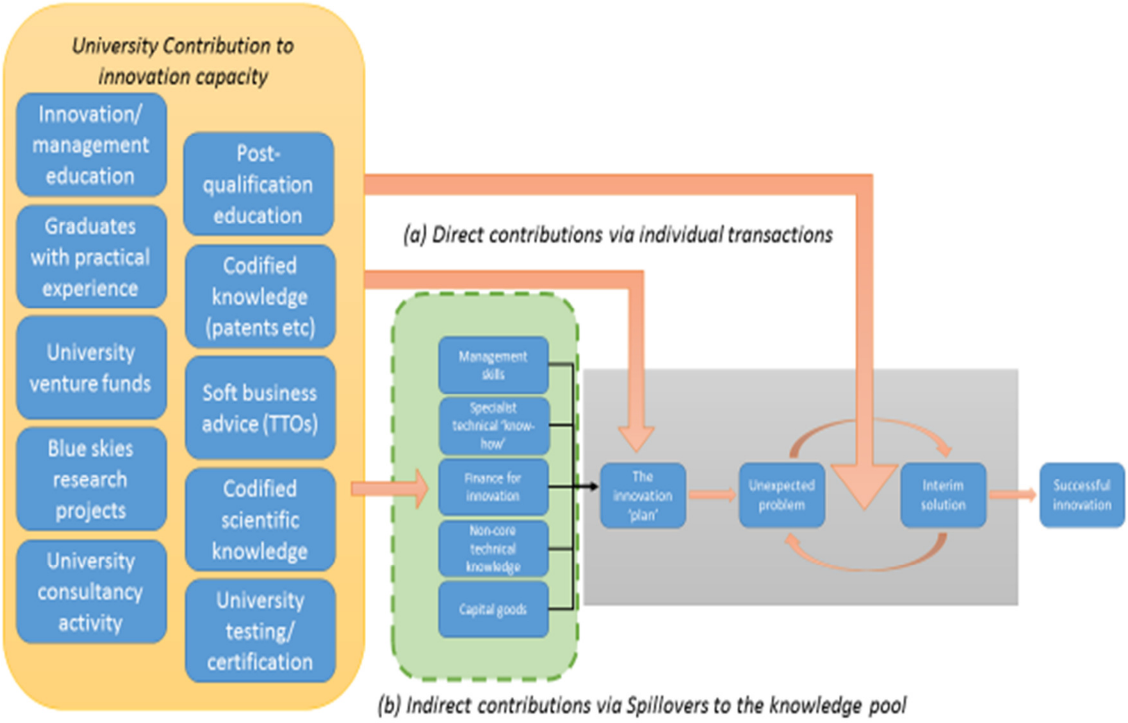


The first task is therefore to develop a more formal conceptualisation of the process by which **universities specifically** contribute to external resources for innovation in ways that improve innovation activities. We here understand these resources as emerging from a shared societal knowledge pool from which, as Sarewitz observes (1996), innovation seems to emerge almost serendipitously (see also Penfield et al., 2014). Universities undertake particular activities that spill over from their main missions into this knowledge pool, thereby offering potential future innovation resources (this includes cases where universities work in practice with innovators directly to make those knowledge resources directly available).

Knowledge is created in core university activities, but at the same time some of that knowledge transforms *in various ways* that allow it to have a non-academic value (that is, a specific value to users). These benefits may or may not be deliberate or purposive, and in some ways they are side-effects of what the universities do.

Spillovers in this context are externalities generated by universities and which are therefore more easily appropriable by others; the extent to which these externalities generate innovation is in part a consequence of innovators' efforts. Because we are concerned with capacity, we can therefore consider the knowledge externalities generated by universities as the contribution to innovation capacity. Our model (shown in figure 3 below) is of university spillovers topping up the knowledge pool and thereby creating innovation capacity via knowledge-related externalities[3]. In Figure 3 below we identify some more specific areas whereby the knowledge pool could provide contributions to innovation, either (a) direct contributions via individual transactions with current innovators or (b) indirect contributions via spillovers into the knowledge pool. This highlights the fact that these different knowledge pool connections may be actualised at different stages of the innovation (direct/ indirect):

Figure 3: University Contribution to innovation capacity (knowledge pool shown with dashed line)

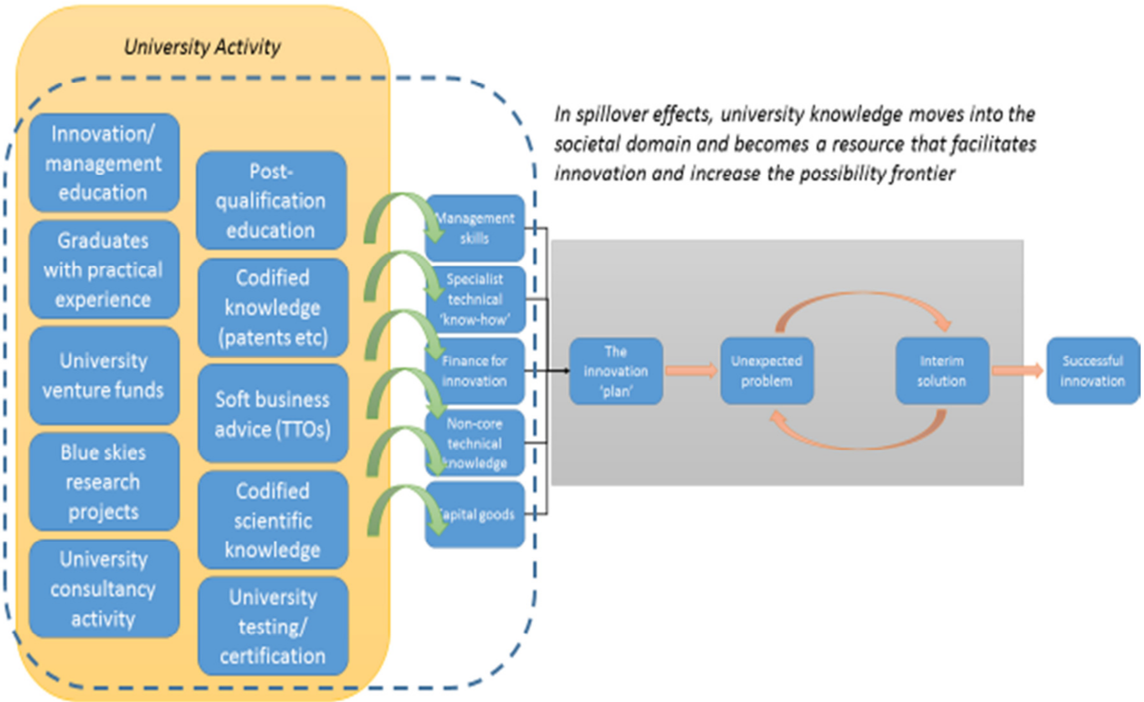


The balance between the two kinds of contribution to innovation capacity varies at the different stages of the activity. Much university consultancy is oriented towards dealing with problems that firms experience during ongoing innovation processes, rapidly providing knowledge to solve a problem that lies outside the innovating organisation's core competencies. Firms may buy in continuing professional development courses in anticipation of their innovation needs, in the project planning phase, and firms may undertake collaborative research with universities as a means of building up their own internal knowledge stocks, independent of the current research activities underway. Our contention is that understanding the university contribution therefore requires capturing the

[3] Although the knowledge is only exploited when particular innovators undertake innovation projects, the capacity exists in a latent sense when it is contributing to the knowledge pool.

contributions at each stage of the process and not just those direct contributions when firms are trying to solve problems.

Figure 4: University activity creating externalities that spillover into a knowledge pool facilitating innovator resource access



Universities' 'contribution to innovation capacity' comes through providing resources that innovators need as they attempt to deliver change processes. From that, we define the measurement challenge as fairly quantifying the resources that facilitate innovation. We ideally would measure 'spillovers', but that is not empirically possible: spillovers are a conceptualisation we use to understand a regularity rather than something 'out there' that can be measured. Spillovers are also a conceptual "residual", i.e. something that is defined as that which cannot be measured (Breschi & Lissoni, 2001).We therefore focus on measuring those outputs which, in association to other additional resources, can help innovators to expand their innovation frontier.

Having made explicit this abstraction, we identify the kinds of university-derived outputs that feed into activities which ultimately expand innovators' access to innovation resources. We therefore seek to identify data that can be gathered that measure in some way those contributions. Some of these variables will be relatively easy to gather data for, whilst for others they may be largely absent: if there are substantial gaps in coverage, then there would be a case for investing substantial efforts into designing new measures and collecting them in order to be able to better measure this university contribution to innovation capacity.

This in turn helps us to better specify the overarching research problem, namely the fact that there are many measures available that capture direct transactions, whilst relatively few cover the indirect contributions via the knowledge pool. Whilst knowledge transfer indicators may be a good way to understand the contribution to individual ongoing innovation activities, what they do not provide is a good measure of the 'knowledge pool' from which later activities emerge.

2.1.3 Knowledge transfer and human capital spillovers

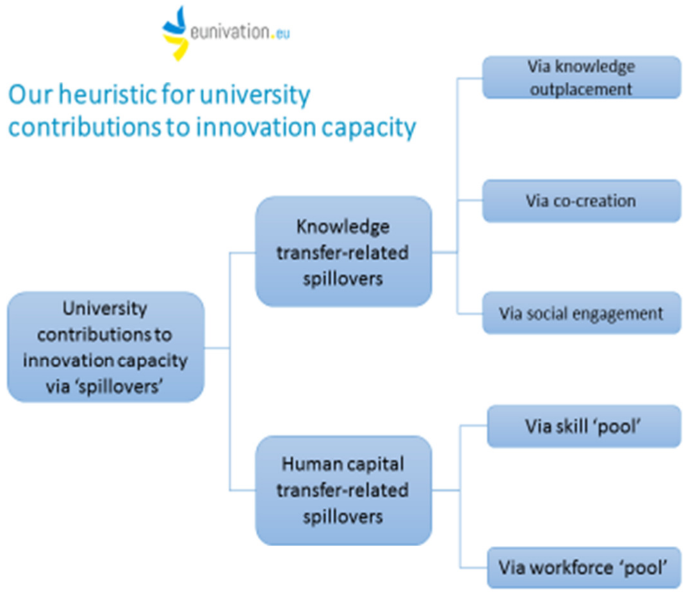
In this literature review, we more systematically conceptualise these innovation assets, and specifically how universities can directly create resources and other externality effects affecting the innovation capacity in entrepreneurial ecosystems. Thus, a second goal of this chapter is to identify appropriate empirical dimensions for each of those assets in order to inform the elaboration of appropriate indicators. The report then explores what constitutes effective measurement of those activities from a policy perspective, arguing that they need to demonstrate three characteristics, namely that they involve research-based knowledge, they involve practical implementation and that firms value the activity (these three characteristics are identified in an empirical analysis of the existing myriad of variables that are used to capture various elements of university contribution to innovation capacity). On that basis, we develop a more balanced approach to measuring university contribution to innovation capacity. The diagram below (Figure 5) highlights the necessary dimensions that have to be covered to provide balance in the suggested indicator set, presented in 3.5. The analysis leading to this is presented in sections 2.2 and 2.3.

Spillovers can be conceptually divided into two sorts.

First, there are those that occur when a piece of knowledge is transferred from within the university into a societal context (e.g. firm, local authority) where it can be used to fill an innovation resource shortage (**knowledge transfer**). Here we distinguish between three varieties of knowledge transfer-related spillovers (a) those spillovers where there is an activity in which the knowledge is specifically transferred through a transaction with a user in which the knowledge is translated (e.g. licensing a patent) (b) those that occur when the university and innovator co-create knowledge and the innovator uses a share of that co-created knowledge as an innovation input (e.g. a shared research project), and (c) those that occur when university knowledge strikes a chord with a non-innovator, and that serves as the antecedent to possible innovation activities (such as media reports of academic activity).

The second class of spillovers are those that happen when students move into the labour market and make use of the knowledge acquired within the university (**human capital**). They embody knowledge capital that is used as a resource that facilitates new innovations, whether in the economic, public or societal sectors. We further distinguish two ways by which universities contribute in this regard, namely (a) the direct education of students who then add to the total stock of human capital as they move into the labour force, and their education becomes an innovation-frontier extending resource, and (b) the other labour market effects that universities may have by enriching the overall human capital in an area that provides innovation-frontier extending effects, such as in attracting highly-skilled graduates, post-qualification education and institutions that improve labour market 'matching'. These two classes of spillovers and their subdivisions are shown in the schematic below and form the basis for the measurement approach that we use.

Figure 5: Overview of the main structure of the literature review



There is a clear geography to individual university contributions. Some universities will create most spillovers at a very local level, when for example they deliver highly-skilled students specifically attuned to particular locally-rooted sectors. Other universities may make their contributions at national or European levels, for example those that are active in providing Ph.D. training and Horizon 2020 research leadership within wider consortia. Spillovers are an emergent property and are not contained by particular territorial boundaries – universities in border regions will create opportunities for benefit across national and EU borders. For this report, we are primarily concerned with contributions to European knowledge pools, and contribution to European innovation capacity, although that might be at a pan-EU level, within member-states, within macro-regions or even within localities, cities and rural areas.

2.2 Spillovers through knowledge exchange mechanisms

2.2.1 Overview

Universities have long been recognized for their important contribution to the long-term economic prosperity and wellbeing of cities and regions. The economic interdependencies between universities and regions are, according to Power and Malmberg (2008), both material, by means of their ability to attract students, business visitors, tourists and funding to regions, and immaterial, associated with reputation effects and regional branding. In terms of innovation capacity, universities are perceived as fulfilling various purposes: to educate and train students; to produce excellent research; to boost productivity through collaborative relations with external partners; to make socio-economic contributions to their localities and businesses in general and to enhance civic value in the public realm. Although it is almost impossible to singularly split these components, this section will mainly discuss the role that research activities generated by universities has on innovation.

Scholarly work dealing with the relation between universities and economic development is extensive and beyond the purview of this report. In this review we focus on empirical studies investigating the impact of universities on the innovation capacity and performance of firms. This literature, mostly within economics, geography and innovation studies, has dealt with different dimensions of the phenomena, namely the economic impacts of universities, on links and processes of interaction, on wider socio-cultural, institutional and political aspects, or on the combination of the three dimensions. Methodologies and measurement approaches adopted are equally diverse, ranging from econometric studies, surveys (both general innovation surveys and dedicated surveys to academics and industry) and case studies, in different national and sectoral contexts and at different times, making the comparability of findings difficult.

One part of this extensive literature has been concerned with the economic impacts of scientific research (for a review see Salter and Martin, 2001). It argues for instance that many innovations would have not occurred without the influence of academic research (or would have occurred much later) (Mansfield, 1991, 1995; Meyer-Krahmer and Schmoch, 1998; Beise and Stahl, 1999) and associates academic research with increased private R&D and patent activity (Aghion et al., 2009; Cincera et al., 2009; Cockburn and Henderson, 2001).

Related studies have explored the spatial dimensions of these academic knowledge flows (for a review see Varga, 2002; Drucker and Gosdstein, 2007). Seminal studies, such as Jaffe (1989) and Audretsch and Feldman (1996) suggested that knowledge spillovers tend to occur within close geographical proximity to the source of that knowledge, displaying a clear distance decay. Universities are also seen to affect high technology location (Varga, 2002; Abramovsky et al., 2007), particularly knowledge based-industries, such as biotechnology. Measuring these knowledge spillovers is inherently difficult and often approached using information from patent citations (Jaffe et al., 1993; Narin et al., 1997; Henderson et al., 1998). While useful to measure knowledge flows, such measures only provide partial information (Roach and Cohen, 2013; Langford et al., 2006; Breschi and Lissoni, 2005). Their accuracy may be limited by differences in firms' citing strategies and motivation and may not sufficiently capture knowledge that is transmitted via other, typically more private channels, such as consulting or cooperative ventures (Roach and Cohen, 2013).

Other contributions have explored, from the point of view of firms, the relative importance of universities as a source of information for innovation (e.g. Cassiman and Veugelers, 2002; Monjon and Waelbroeck, 2003; Abramovsky and Simpson, 2011). They measure spillovers by whether a firm used knowledge emanating from universities. While universities are often the least frequently used knowledge source compared to partners in the vertical production chain (suppliers, customers), they have been found to be of significant importance for certain industries and contributing to more radical types of innovation.

These contributions however do not specify the channels used by universities and firms to exchange knowledge. University and industry are assumed to generally interact using a variety of diverse channels including consultancy, contract research, training, joint research, licensing, research centres, and a variety of other, often informal, means (Cohen et al., 2002; D'Este and Patel, 2007).

The identification and measurement of these various types of channels has attracted intense academic and policy interest (e.g. Molas-Gallart, 2002; Arundel and Bordoy, 2008; Healey et al., 2014). They include a broad spectrum from 'soft' activities (advisory roles, consultancy, industry training, production of highly qualified graduates), closer to the traditional academic paradigm of training and research, to 'hard' or more formal initiatives such as patenting, licensing and spin-off activities (Perkmann and Walsh, 2007; Philpott et al., 2011). Apart from activities aimed at educating people, increasing the stock of 'codified' knowledge through patents and prototypes and problem-solving activities via contract or cooperative research, Cosh et al (2009) argue that universities play also much neglected 'public space' functions, by hosting meetings and conferences, entrepreneurship centers and providing access to networks and personnel exchanges. Finally, greater attention has been paid of late to the contribution of higher education not just to the exploitation of scientific research but also to the social, cultural and environmental development of places (Boucher et al., 2003).

Following this characterisation we distinguish between three main mechanisms contributing to the knowledge pool for innovation. Firstly, these include dedicated efforts on the part of universities to encourage the commercial exploitation of academic research by means of regulatory and other incentives, as well as dedicated training and infrastructure, such as Technology Transfer Offices (TTOs), Science Parks or Incubators. These typically involve transactions devoted to knowledge commercialisation (e.g. licensing a patent, creating a spin-off or technology transfer offices, as well as other incubator structures). Secondly, a variety of channels are pursued by different universities and individual academics to engage in collaborative work with universities. These channels include consultancy, contract research, joint research, use of facilities etc. In these instances, the university and the innovator co-create knowledge and the innovator uses a share of that co-created knowledge as an innovation input, via for instance contract research, or consultancy. Finally, we discuss other forms of wider engagement that go beyond commercialisation and collaborative research, and foster innovation capacity by enforcing social creativity and cultural development, providing the basis for the expansion of the knowledge economy.

Our interest here is to review the evidence and measurement challenges associated with the multiple formal channels for knowledge exchange between firms and universities. In the reminder of this section we discuss the different channels of knowledge exchange. We pay particular attention to the nature and diversity of these channels, the evidence base around their influence on innovation capacity, and the measurement and indicator challenges associated with this evidence base.

2.2.2 Commercialisation and exploitation of research

In the last two decades, efforts to promote the commercializing of public research results have intensified. These have involved the introduction of regulatory and organizational arrangements around intellectual property (IP) exploitation, the promotion of spin-off firms, as well as the setting up of specific administrative bodies and infrastructures, such as Technology transfer offices (TTOs) and Business incubators. This section reviews the evidence base on their influence on innovation capacity and the associated measurement challenges.

The commercial exploitation of university research has become a policy imperative and with it the efforts to quantify the impact of these activities have intensified. Commonly used indicators to measure these commercialisation efforts include patent applications, patents granted, licensing income, number and growth of spin-off companies, and the characteristics of TTOs. They are generally collected by national surveys, or by organizations such as the Association of University Technology Managers (AUTM) in the USA, who gather data at the level of the TTO. The nature and collection of these indicators pose issues in terms of international comparability resulting from lack of common definitions, reliability issues and different target populations (Arundel and Bordoy, 2008).

2.2.2.1 Patenting Activity

Key changes introduced to favour commercialisation have included legislative reforms around IP, most notably the introduction of the Bayh–Dole Act in the USA, which provided the first dedicated legal framework that enabled American universities to own inventions and to be able to exclusively license those inventions. Even though some universities had been involved in exploiting intellectual property through patent ownership since the 1920s, the Act institutionalised IP protection arising from federally funded research. Following the

United States and the Bayh–Dole Act 1980, similar legislative reforms have been introduced in other countries (Mowery and Sampat, 2005)

Some analyses have highlighted the impact of the Bayh-Dole act in USA and the EU equivalent normative as *de facto* incentives helping scientist to disclose their invention and hence increase the number of patents produced (Geuna and Rossi, 2011; Hall et al., 2001; Mowery and Ziedonis, 2002; Mowery and Sampat, 2005). For instance Lach and Schankerman (2008), using panel data and looking at the US landscape, found evidence that when royalty systems are in place, academics generate more inventions, which in turn provide a higher license income to the respective universities. Such findings are corroborated by cross-country studies, such as Valentin and Jensen's (2007) study comparing scientists' propensity to patent in Denmark and Sweden before and after changes in IP regulation. The Baldini et al. (2006) analysis on Italian universities shows that after the introduction of IP regimes, patenting activity has almost tripled. However, other scholars looking at the increase in patent numbers found that incentives to patent affect the quality of the knowledge produced and ultimately its innovation impact. As noted by Fabrizio (2007), an increase in university patenting is associated with a slowdown in the pace of knowledge exploitation, measured as a lengthening of the average time between the creation of patented knowledge and the exploitation of this knowledge by a firm in new patented innovations. This seems close to the study by Henderson et al. (1998) which found evidence that the rate of increase of relevant patents from universities was much less than the overall increase in patenting activity between 1965 and 1988. Baldini (2008) offers a wide overview of the drawbacks university research might suffer from pushing patenting activity over research.

An important caveat is that the real impact of university patents is linked to the degree of direct applicability of the patented invention (Thursby and Thursby, 2002; Link et al., 2003). Thus, a distinction should be made between patents licensed to industry which represent a type of knowledge ready to be exploited and with a commercial value, and other generic patents not yet ready to be exploited but added to the available knowledge stock for future exploitation. In this respect, Thursby et al. (2001), in an original survey of around sixty US universities, find a positive correlation between patent application and disclosures and sponsored research and executed licenses. Similarly, Shane (2002) analyses patents developed between 1980-1996 at the MIT and finds that when patents are effective, there is an increased likelihood of direct commercialisation (by selling to non-inventors) and that patents act in reducing the transaction costs of the technology transfer. Dechenaux et al. (2008) using again a pool of MIT patents show that characteristics, such as patent importance (measured using the total number of citations received); patent radicalness (measured as the number of three-digit patent classes in which citations made are found, but the patent itself is not classified); and patent scope (measured as the number of international patent classes into which the United States Patent and Trademark Office assigns a patent) are positively correlated with the probability that the invention will be commercialized.

Despite being a good proxy of commercialisation of specific types of research activities, scholars have challenged the ability of patents to capture the full extent of knowledge exchange. These arguments concern both how patents are quantified (counts versus content); and how much patents can actually be undertaken as a universal measure of successful commercialisation. In relation to the former argument, Sapsalis and Potterie (2007, 2003) discuss the weakness of using patent counts alone as a measure of the potential contribution to innovation capacity and suggest alternative indicators to capture patent value. These include forward and backward patent citations, non-patent citations, co-assignees and patent family size. Moreover, a crucial distinction should be made between patenting and licensing and their respective capacity to inform our judgement on successful commercialisation of university research. Specifically, the closest element associated to (economic) value creation is licensing rather than patents. However, evidence shows that licensing income is highly skewed – with most HEIs earning little income from their licenses (Heher, 2007). Finally, patents present shortcomings associated to their inability to capture value in all university settings (Andersen and Rossi, 2012) or across different disciplines. For instance, patents serve well in those disciplinary fields where the commercial exploitation of research is very established, but not very well in humanities and social science where the value of research is more intangible to transfer (Abreu and Grinevich, 2013).

2.2.2.2 Spin offs & University Start ups

In the area of exploitation of academic research, entrepreneurship efforts can take to the creation of different types of newly established firms. Particular attention has been given to university spin-off companies, i.e. new entrepreneurial activities usually set up by professors, young researchers or PhD students, and generated within academic contexts or private and state-owned research labs (Chiesa and Piccaluga, 2000). The UK Higher Education Business Community Interaction (HEBCI) survey defines spin-off companies as 'new legal entities and enterprises created by the HEI or its employees to enable the commercial exploitation of knowledge arising from academic research". At the same time, scholars (mostly employing US data) have focused their attention on the entrepreneurial effort and impact of university research, considering also university start-up companies. The table below portrays the differences in terms of proprietary rights, funding and management between spin-offs and start-ups as highlighted by the World Intellectual Property Organisation (WIPO 2011).

Table 1: Differences in terms of proprietary rights, funding and management between spin-offs and start-ups

	Spin-Off	Start-Up
Created by	University	Outside University
Technologies	Owned by University	Licensed to the Start-up by the University
Financed by	University	Outside funder
Managed by	University	Outside University

Source: WIPO 2011

This section will consider studies referring to both categories which equally represent forms of firms' creation spanning from university generated research.

Since the 1990s, the number of university based spin-offs and start-ups has increased significantly, but there is still little systematic evidence about the quality of their performance, the factors associated to their formation and the internal characteristics which determine their success and survival (Djokovic and Souitaris, 2008; Astebro et al., 2012). The lack of historical (longitudinal) data and the institutional differences across countries make it difficult to evaluate the long term impacts of spin-offs and start-ups and the factors affecting their rate of survival (Grimaldi et al., 2011; Lawton Smith and Ho, 2006). Some evidence however points to certain determinants influencing the effectiveness of spin-offs and start-ups as knowledge exchange mechanisms.

Spin-offs tend to perform better in Science, Technology and Engineering (STEM) disciplines (Kenney and Patton, 2011; Lawton Smith and Ho, 2006). This evidence is linked to the characteristics of the invention itself. Shane (2002) studies how technological opportunities relate to new firm creation. He uses event history analysis to examine patents at MIT between 1980 and 1996 and looks at the probability of each patent resulting in the formation of a new firm. His results show that the probability of commercialising an invention by creating a new firm depends on the invention's characteristics, such as importance, radicalness, and patent scope (see also: Dechenaux et al., 2008). O'Shea et al. (2005) looked at the determinants of successful spin-off companies over the period 1980-2001 and found that faculty quality, the size and orientation of science and engineering funding, and commercial capability as well as history (experience) had an impact on successful technology transfer.

This is in line with results from Di Gregorio and Shane (2003) who analyse the determinants of new high tech firm formation and link it to the quality of research but, also, to university policies to retain the new firm's royalties (via equity in the start-up). Such findings align with work by Feldman et al. (2002) on equity versus licensing policies in 125 research intensive universities in the USA. Their results suggest that the use of equity is positively correlated to prior experience with technology transfer, to success in relation to other institutions, and to structural characteristics related to the type of university. Clarysse et al. (2007) look instead at the capacity spin-offs show during and after the start-up phase to raise money, and find that, in the early stages, spin-offs with formal technology transfer start with a larger amount of capital but subsequently do not raise more capital than spin-offs without formal technology transfer.

As pointed out in Veugelers and Del Rey (2014), although significant research efforts have been devoted to trying to measure the formation of university spin-offs, far fewer studies have looked at the growth of university spin-offs. In this respect, work by Klepper and Sleeper (2000) in the US laser industry shows that spin-offs have outperformed other start-ups. While the survival rate of university spin-offs is higher than that of the average start-up, the survival rate of spin-offs from leading universities is even higher. Shane (2004) estimates that 80 percent of the MIT spin-offs started between 1980 and 1996 survived 1997. Of the 153 spin-offs created at ETH Zurich, Switzerland, in the period 1998-2008, 90% survived beyond 5 years. Vincett's (2010) original study is one of the few focusing on the long-term economic impact of spin-off activity. He employs longitudinal data on Canadian spin-off companies (1960-1998) and estimates the cumulative impact (from increased GDP) resulting from the first generation of academic spin-offs and finds that the economic impact of spin-off companies is between three to four times higher than the one that would have been obtained if the same government money had been spent on more typical (non-capital) expenditures.

An emerging topic in the literature concerns the impact of student start-ups. EU policy makers have long emphasized the importance of stimulating entrepreneurial mind-sets among university students (EC 2008). This reflects the growing interest in the effectiveness of entrepreneurship education for students, their career development and in the wider economy in the context of the European policy (European Commission 2008). The recent increase in the number of HEIs using their initiatives to stimulate enterprise and entrepreneurship within their local economies and beyond is driven, at least in part, by the growing number of efforts supporting students' entrepreneurship experiences at HEIs (European Commission, 2015). Among the few examples of studies looking into student entrepreneurship, the most relevant is Astebro et al. (2012). The authors blend quantitative data with in-depth case studies from three American universities. Their results are extremely interesting and highlight how student start-ups outnumber faculty spin-offs - with students being up to three times more likely to start a new firm than HEI staff, and to create firms qualitatively comparable to the ones of faculty.

The studies above employ a vast array of indicators. Nonetheless, the main issues emerging from the literature point to two main issues: the lack of longitudinal data, and the reliance on headcounts of spin-offs and start-ups as proxy of knowledge exchange. In particular, the assessment of causality and medium to long-term impact relies strongly on the capacity to observe historical patterns. Only few studies were able to employ longitudinal data, reflecting the scarcity of such information across different institutional settings. As such, a systematic collection of data on spin-offs and start-ups should be encouraged in order to fully understand the impact of university research on innovation capacity. Moreover, the data available mostly consist of information on headcounts and revenues with little investigation into the 'quality' and characteristics of the entrepreneurial effort. However, literature suggests that organisational attributes play a relevant role in boosting the chances of success and the survival of spin-offs and start-ups, so measures of composition of the human capital should be encouraged.

2.2.3 Structures for Technology transfer: Technology Transfer Offices, Science Parks and Incubators

Apart from the output measures of patenting and spinoff activities, considerable attention has been paid to assessing the effectiveness of specific offices and organizations supporting commercialisation, such as Technology Transfer Offices (TTOs) and Incubators.

2.2.3.1 Technology Transfer Offices (TTOs)

TTOs are tasked with facilitating commercial knowledge transfers of IP that results from university research through patenting technologies and licensing to existing firms or through start-up companies (Siegel et al., 2007). As pointed out by Grimaldi et al. (2011), the contribution of TTOs to the commercialisation of knowledge has not received enough recognition in both theoretical and empirical literature so far.

Coupé (2003), using patent and National Science Foundation data, found that those universities that established a TTO increased their patenting activity. However, several scholars share the idea that TTOs do not have a positive impact and might in fact slow down or not affect the process of knowledge transfer. For instance, results presented by Siegel et al. (2003a) for the US show that TTO involvement delays the commercialization process because of the efforts directed to safeguarding researchers' interests and maximizing university returns. Also Muscio (2009), employing cross-sectional survey data on Italian HEIs, shows only a marginal contribution of TTOs in the process of university-industry collaboration. Using a large panel of UK universities (2000-2009), Clarysse et al. (2011) also concluded that TTOs play only a marginal role in affecting the probability to create a venture, once other environmental and individual level factors are considered.

Other studies have focused on the specific characteristics of TTOs that influence performance. For instance, Chapple et al. (2005) find that HEI size affects TTO effectiveness and particularly that TTOs located in larger HEIs are more inefficient than those in smaller ones. Chapple et al. (2005) also point at the quality of the human capital in TTOs as a determining factor in TTO performance. In line with this, many other studies focus on the role and relevance of the skill set of TTO officers as crucial factors in TTO performance. For example, O'Shea et al. (2005), using panel data on US universities, show that technology transfer success depends on the commercial capabilities of TTO staff. This point is confirmed in findings by Friedman and Silberman (2003) who perform an analysis of US research focused universities. The authors draw data from the Association of University Technology

Transfer Managers Annual Licensing Survey (AUTM: 1997-1999) and find that the capabilities of the management officers are the strongest factor affecting TTO performance. The importance of the skill set in TTOs is mirrored by Markman et al. (2005) which shows how technologies tend to be commercialized faster and earn higher revenues when active collaboration between inventors and TTOs is in place. Lockett and Wright (2005) find that the business development capabilities of TTOs and the royalty regime of the universities are positively associated with spinout formation.

In turn, the best predictors of TTO performance are the skills of TTO employees. A systematic collection of information on management practices (financial incentives; promotions), alignment with university objectives or monitoring systems (tracking performance) could enable having a more nuanced understanding of the differences in TTO performance. This could also shed a light on the costs associated to TTOs, which in some cases outweigh the revenues created (Trune and Goslin, 1998).

2.2.3.2 Incubators and Science parks

Incubators and Science Parks are organizations devoted to knowledge exchange and designed to support the development of new technology-based firms, seeking to link and diffuse talent, capital, technology, and know-how toward the development of new businesses (Mian, 1996). They are property-based organizations with identifiable administrative centres focused on the mission of business acceleration through knowledge agglomeration and resource sharing (Phan et al., 2005). Incubators provide a space where early start-ups and spin-offs develop social ties and build entrepreneurial resources and skills with the mission to facilitate newly established firms activities. The literature refers to various structures that incubate the growth of newly-established firms: science parks, technology parks, accelerators, which all constitute physical spaces to assist a firm's growth (Pahn et al., 2005).

Hackett and Dilts (2004) and Aaboen (2009) offer an extensive overview of the literature on incubators focusing on success factors and evidence of impact on successful entrepreneurial development. The main characteristics of incubators refer to the typology of clients served; revenues; target firms; professional services offered; and incubation time (i.e.: time the new firm can spend in the facility). However, as pointed out by Phan et al. (2005), so far no standard methodology has been developed to measure the performance of incubators.

The extensive literature on the impact of science parks and incubators on company innovation actually shows positive (Monck et al., 1988; Colombo and Delmastro, 2002), negative (Westhead, 1997) or inconclusive results (Udell, 1990). Several studies examine the academic-commercial nexus, in terms of incubation strategies, spin-out companies (Clarysse et al., 2005), licensing (Lach and Schankerman, 2004), team composition and dynamics (Ensley and Hmieleski, 2005). Grimaldi and Grandi (2005) analyse the performance of a series of incubators and define two typologies: one model more closely linked to the traditional economy (focused on cost reduction for the firms and local networking), and another, which they define as *accelerator,* which is instead more focused on high value services, the global market and technology. Lofsten and Lindelof (2002) look at the impact of incubators by comparing a group of firms located in incubators with a control group of outside firms. Their results show that firms in incubators are more likely to have contact with university research; however, the level of R&D output (looked at in terms of patents) between the two groups is not relevant.

University-based incubators are a specific class of incubators that aim to support transfer of research knowledge to industry, commercialize university research, facilitate faculty-industry and university-community collaboration, and more generally support student and graduate start-up initiatives (Allen and McCluskey, 1990; Aernoudt, 2004; Clarysse et al., 2005). Rothaermel and Thursby (2005) focus on how knowledge flows from HEIs to incubators in order to assess incubator firms' performance. Their results are drawn from an original sample of firms from the Georgia Institute of Technology (USA) between 1998 and 2003, and suggest firms' absorptive capacity is the key factor for incubators' effectiveness. Link and Scott, (2005) interlink science parks and spin-offs through the collection of original data on science parks in the USA and survey which companies used to be spin-offs. They find that university spin-off companies are a greater proportion of the companies in older parks; in parks located closer to the university; in parks that are associated with a richer university; and when the technology focus is on biotech industries.

McAdam and McAdam (2008) explore the longitudinal use of the unique resources offered by university incubators to high-technology firms at different stages of growth. It is understood that incubation is not a static process or simply a menu of services. The nature of incubation changes according to the varying resource needs of the tenant firm over the duration of the incubation period; and more importantly, depending on the tenant firm's industrial affiliation. Barbero et al. (2014) develop different types of incubators and different types of innovation. By analysing the incubators in Andalucía in Spain, they find differences in the strategies and knowledge resources provided by each type of incubator to facilitate these different types of innovation (product, technological process and organisational).

The measurement of incubators' performance highlights again the importance of opening up the analysis of impact beyond the headcount (and growth) of number of firms, employees or activities, which are the indicators most commonly used. Interesting insights could be provided by understanding the quality of the human capital which is in charge of the management of the structure, as studies seem to suggest that the interaction between management and incubees increases learning in the newly-established firms (Scillitoe and Chakrabarti, 2010).

2.2.4 Academic engagement

Along with commercialisation, another broad channel of knowledge exchange is more 'relational' or collaborative in nature, involving a variety of bi-directional links and processes for knowledge sharing between firms and universities. These include collaboration in R&D projects and transfer mechanisms, such as consulting agreements, contract research and use of university facilities and equipment by industry.

The next sections provide an overview of the key definitional aspects associated with these activities, available evidence regarding their impact on innovation capacity, as well as considerations of measuring challenges.

2.2.4.1 R&D collaborative projects

Cooperative research partnerships are among the most common forms of university-industry collaboration (Fontana et al., 2006) and are actively promoted via national and international policies. Firms cooperate with research organizations mainly for strategic reasons associated with improving their competitive position and launching new products and services, and for technological motives associated with access to partners' knowledge and technologies (Autio et al., 1996; Bonaccorsi and Piccaluga, 1994; Montoro-Sanchez et al., 2006; Rappert et al., 1999).

Unsurprisingly, academic studies on the determinants of R&D collaboration have found that the likelihood of firms cooperating with universities increases with firm size and R&D investment (Arundel et al., 1995; Cohen et al., 2002; Laursen, 2004; Mohnen and Hoareau, 2003). This is because large and R&D intensive firms and sectors are likely to possess higher technological capability that also allows them to absorb the knowledge developed outside the firm (Cohen and Levinthal, 1990). Cassiman and Veugelers (2006), using data from the Belgium Community Innovation Survey, found evidence of complementarity between internal R&D activities and external sourcing of knowledge.

Different types of innovation are also associated with different propensities to collaborate. For instance, Fritsch and Lukas (2001), using data on manufacturing firms in Germany, and Tether's (2002) analysis of innovating firms in the UK found that firms undertaking product innovation present a higher propensity for cooperation with universities and customers, while process innovation is more likely to involve cooperation with suppliers. Apart from size and R&D intensity, Laursen and Salter (2004) found support linking firms' 'open' search strategies with the number of external channels for innovation. Firms that are 'more open' have a higher probability of considering the knowledge produced by universities as important for their innovation activities (see also Fontana et al., 2006).

While R&D collaboration with universities is associated with positive effects on innovation performance, the literature is only partially conclusive on the specific benefits of collaboration. Empirical studies have sought to measure the influence that engaging in R&D cooperation with universities has on new products and services (Aschhoff and Schmidt, 2008; Belderbos et al., 2004; Faems et al., 2005; Lööf and Broström, 2008; Monjon and Waelbroeck, 2003), patenting (Lööf and Broström, 2008) and productivity growth (Cincera, 2003; Harris et al., 2011). These studies have generally found that cooperating with universities or R&D centres, or using universities as external knowledge sources, has a positive effect on innovation outcomes. For instance, using cross-section data from the Swedish CIS, Lööf and Broström (2008) found that firms collaborating with universities are more likely to apply for a patent and have higher innovative sales per employee. Using a survey of Swiss enterprises, Arvanitis et al. (2008) analysed the effects of different forms of knowledge transfer activities on both innovation performance (in terms of R&D intensity and sales of new products) and labour productivity, and also found a positive influence of these activities on all measures of innovation and productivity. However a study using firm-level data from two surveys (conducted in 1995 and 1998) of Italian manufacturing firms (Medda et al., 2006), did not find evidence that collaborative research with universities enhanced firm productivity.

Using data for the Netherlands from two waves of the Community Innovation Survey, Belderbos et al. (2004) examined the differential performance (measured by labour productivity and improved innovative sales) of innovative firms from R&D collaboration with different actors. They found that R&D collaboration with universities and competitors increased the growth of sales attributed to market novelties, while collaboration with suppliers and competitors was associated to a growth in value added per employee. Aschhoff and Schmidt (2008) conducted a similar study using data from the German innovation survey. They investigated the effects of past R&D cooperation on innovation outcomes based on one year delay, measured not only by sales of innovative products but also by cost reduction due to innovative processes and found that firms that collaborate with universities experienced a higher share from market novelties.

However, the results of these different studies are not completely comparable due to the differences in the sectors covered, the variables used to measure knowledge exchange and the nature of the studies (cross-sectional versus longitudinal approach) (Arvanitis et al., 2007). Many studies are cross-sectional, making it difficult to establish causal links between collaboration and innovation. Longitudinal studies have tried to address this shortcoming, however different studies use different time lags to measure impacts (Belderbos et al., 2004). In terms of measurement issues, studies such as those based on the CIS described above have tended to rely on subjective indicators based on the evaluation of participants about their collaboration activities. Other studies have used different, more objective measures, such as co-authorship or co-patenting (see Calvert and Patel, 2003; also Lundberg et al., 2006 for a methodological discussion), participation in R&D programmes such as FP-funded programmes (Ponds et al., 2010), or counts of the number of collaborative projects and associated income (see Rossi and Rosli, 2014 for a discussion on the adequacy of using income-based indicators). Apart from relying on counts of collaboration, relatively less work has been done to assess the 'network quality' of research collaboration between universities and industry (however, see recent efforts by Sebestyén and Varga, 2012 using social network analysis (SNA) of co- patenting and EU Framework Programme collaboration data for 189 European NUTS 2 regions, as well as Pinheiro et al, 2015 for a methodological discussion on the use of SNA to study university-industry links).

2.2.4.2 Other forms of industry-sponsored R&D: Contract Research and Collaborative R&D centres

Bercovitz and Feldman (2006, p. 177) define sponsored research as a contract that "supports research commissioned through the university and provides resources for infrastructure, graduate students, course releases and summer support for faculty members." Such research sponsoring is generally associated with industry, although recent research by Feldman and Graddy-Reed (2014) has stressed the increasing importance and need for greater understanding of the nature of philanthropic funding from charities and foundations in addition to industry funding.

There is little empirical evidence on the impact of industry-sponsored university research on firms. One early example is the study on biotechnology of Blumenthal et al. (1986), which found that industry support for research in universities had important benefits to firms, particularly in terms of number of patents. Berman (1990) examined the effect of increased industry funding of university research in the USA. Taking a 30-year period, he found that funding increases were associated with subsequent increases in industry R&D expenditure (with a lag of about five years). A number of studies have also found that university departments with a higher level of private financing tend to interact more with industry and support technology transfer to industry more than those university departments that are mainly publicly funded (Lee, 1996; O'Shea et al., 2005; Bozeman and Gaughman, 2007).

The focus of most studies on industry funding has been on the potential costs of such cooperative agreements, in terms of their influence on academic freedom and openness, research productivity and the direction of research towards more 'applied' science (Behrens and Gray, 2001; Blumenthal et al., 1986; Lee, 1996; Thursby and Thursby, 2004; Van Looy, 2004). The literature is however inconclusive about some of these impacts. For instance, Gulbrandsen and Smeby's (2005) survey of university professors in Norway in all fields found that professors with industrial funding are more likely to perceive their research as applied, more likely to publish and patent, and interact more both with industry also universities. By contrast, Hottenrott and Thorwarth (2011) found that higher industry funding reduces the publication output of professors both in terms of quantity and quality in subsequent years, but increases the quality of applied research if measured by patent citations. However, it has been suggested that an increasing reliance on industry funding may have a detrimental unintended effect on innovation in the long term, if it reduces the amount of basic research and increases secrecy in university-industry relations (Behrens and Gray, 2001).

Much sponsored and collaborative research between firms and universities takes place in dedicated R&D centres. Increasingly, firms (particularly large firms) are adopting a more strategic approach to collaborating with universities, through for instance the development of campus-based collaborative research centres, that specialise in particular subject areas and have single or multiple corporate sponsors. One such example are the University-Technology Centres set up by Rolls Royce at multiple universities in the UK (Perkmann et al., 2011). Langford et al. (2006) discuss a few such arrangements in Canada, e.g. industry-sponsored centres on campuses, such as the multi-million dollar University of Windsor/Chrysler Canada Ltd. Automotive Research and Development Centre, as well as other university-industry-government consortia with presence in universities. The reporting of some of these activities is however uneven.

Systematic studies of R&D centres have been mainly carried out in the USA, for instance, in relation to the University-Industry Research Centres (UIRCs) and Engineering Research Centres partially funded by the federal government (Adams et al., 2001; Cohen et al., 1994; Feller et al., 2002). The most commonly reported benefits to firms derived from interaction with Engineering centres are, according to Feller et al. (2002), related to "knowledge generation and transfer", including access to new ideas, know-how, and technology; technical assistance; influence on a company's R&D agenda; increased interaction with other firms; and technical information for customers and suppliers. In a survey of 6000 industrial R&D laboratories owned by firms in the chemical, machinery, electrical equipment and transportation equipment industries, Adams et al. (2001) found that the most important contributions of the centres to firms were in the form of consulting, joint research, and hiring of graduate students. They also found a stronger effect on patents and industrial R&D of those centres that were NSF-funded compared to other centres.

The organisational structures of the centres in relation to the university structure also matter and contribute to shaping different forms of collaborative relationships and engagement. For example, in Australia, the university scientists who collaborate with the industry leave a department and enter a new organization called a centre (Dodgson and Staggs, 2012). In Sweden, the university–industry centres exist in parallel with the university departments and hence the academic researchers do not "move" completely to the new centre, which enables closer collaboration between academia and industry across senior and junior groups of scientists (McKelvey et al., 2015).

Industry funding of academic research can also be channelled via sponsored university research chairs in collaboration with individual firms and industrial consortia. Such chairs "represent a long-term commitment to collaboration that can facilitate 'translation' at the university–industry interface" (Langford et al., 2006). Despite the relative frequency of such sponsorships, the reporting of these activities and the assessment of their influence on innovation capacity is rare.

2.2.4.3 Consultancy

Academic consulting, understood as the "provision of a service by academics to external organizations on commercial terms" (Perkmann and Walsh, 2008; p.1885) has been identified as a widely used form of knowledge exchange, particularly in engineering-related fields (D'Este and Patel, 2007; Klofsten and Jones-Evans, 2000; Rentocchini et al., 2014). The incidence of consulting also varies markedly across countries. For example, Perkmann et al. (2013) suggest that scientists' involvement in private sector consulting ranges from 17% in Germany to 68% in Ireland. Despite their relevance and relative frequency, there is significantly less research on faculty consulting activities compared to other forms of interaction.

Most of the literature on academic consulting has been concerned with its potential negative effect or interference with normal academic duties, stressing the potential trade-offs and tensions between consulting and other activities (D'Este et al., 2013; Landry et al., 2010; Lee and Rhoads, 2004; Mitchell and Rebne, 1995; Rebne, 1989; Rentocchini et al., 2014). For instance, based on data on 5 universities in Spain, Rentocchini et al. (2014) examined the relationship between engagement in consultancy and scientific productivity. They found a negative effect only when the consulting activity was high and particularly for certain fields, such as natural and **exact** sciences and engineering. Their research and other studies, such as the one by Mitchell and Rebne (1995), coincide in suggesting that moderate time spent on consulting is facilitative of research productivity but detrimental if it detracts significant time from research.

Relatively less research exists on the impact of consulting on industrial innovation. Cohen et al. (2002) found that consulting activities score relatively highly among R&D executives, as vehicles through which public research affects industrial R&D. Arvanitis et al. (2008) found that around 15% of Swiss firms consider consultancy activities as important—although they also found that the use of consultancy activities had no noticeable differences on innovation performance compared to the use of other knowledge exchange activities. Consultancy and contract research are perceived as beneficial for innovation, particularly at the latter stages of the innovation cycle, such as product differentiation and improvement, and for SMEs that are less likely to perform formal R&D (Perkmann and Walsh, 2008). Further, consultancy services are more likely to be provided in close proximity (Pinto et al., 2015).

The extent and impact of these activities are often underestimated because they are not consistently disclosed to departments and university administrations, leading in most cases to a significant under-reporting of these activities (Bercovitz and Feldman, 2006; Molas-Gallart et al., 2002; Perkmann and Walsh, 2008). As mentioned earlier, consulting activities taking place in the context of university-industry research centres or other institutional arrangements may also be unaccounted for, particularly when they are funded under different programmes or independently from government programmes (Perkmann and Walsh, 2008). Different arrangements in place in different national higher education systems also influence the extent and type of reporting and measuring of these activities (Molas-Gallart et al., 2002; Perkmann and Walsh, 2008; Rentocchini et al., 2014). For instance, universities in the USA and UK tend to allow, or even provide incentives for consulting services, for instance by specifying a number of days that faculty are free to spend on such activities. In the USA and Canada, universities allow up to 20% of their faculty members' time for these activities.

Along with the problems of measurement and reporting, the heterogeneity of consulting activities and the tendency for consultancy to be delivered in combination with other knowledge exchange activities renders their assessment difficult. For instance, Amara et al. (2012) differentiate between formal and informal consultancy activities, namely those that take the form of formalized contractual arrangements between academics and external organizations and informal arrangements between individuals and external organizations. In a study on academic researchers in Canada, they found that 62% of academics in natural sciences and engineering provided informal advice **in an untraded manner** to companies, and 51% to government agencies. They found considerable differences between paid and unpaid consulting and between consulting with companies and government agencies. While they found a negative relation (substitution effect) between paid consulting and teaching (and no significant effect on publications), unpaid consultancy with government agencies and companies had a positive effect on teaching (and a positive effect on publications).

Heterogeneity in consultancy activities is, according to Perkmann and Walsh (2008), associated with the multiple rationales for engaging in consultancy, namely to raise income (opportunity-driven), commercialize inventions (commercialization-driven) or generate research opportunities (research-driven). The nature of knowledge exchange and the nature of the relationships would vary accordingly. Opportunity-driven consultancy tends to be of lesser academic value, short-term and time-bound, and does not directly contribute to research and teaching. Consulting activities can also go hand in hand with academics' efforts to commercialize technology, for instance in the form of assistance to out-licensed inventions. A third form of consultancy is linked to academics' research and motivated by a desire to "gain insights into industry 'challenges' or access research materials" (Perkmann and Walsh, 2008, p. 1886), which in turn is likely to boost rather than reduce research productivity. Firms would naturally derive different benefits from different types of consultancy; while research-driven consultancy would be attractive to firms in sectors such as aerospace and pharmaceuticals, and particularly large, R&D performing firms, opportunity-driven consulting is likely to be required by smaller firms or new technology based firms, who may hire academics for problem solving and testing concepts.

This heterogeneity in the rationales and nature of consultancy activities calls for a more nuanced classification of consulting activities, and efforts to document these activities in order to understand knowledge-transfer processes. Existing indicators, such as the ones used in the UK Higher Education and the Business and Community interaction survey, measure the income generated as a result of these services, as well as the number, types and location of partners, but they are not able to differentiate between different types of consultancy activities, nor to adequately understand the geography of these relationships.

2.2.4.4 Use of facilities and equipment

Apart from formal technical support in the form of consultancy activities, universities also provide firms access to facilities and equipment to test new ideas and products[4]. Studies have assessed the relevance and perceived value of these services to firms, generally in combination with other forms of university-industry engagement (e.g. Arvanitis et al., 2008). However the use of university facilities and equipment by firms conflate a range of activities that defy easy characterisation. For instance, Rossi and Rosli (2014) note a number of shortcomings associated with measuring the use of university facilities by industry. Firstly, they note that income may not be a good measure of value, as it would be highly dependent on the type of university and the type of service (it may even be let for free). More prestigious or reputable universities may be able to charge more for these services. The cost of knowledge transfer also varies widely across services and disciplines; some services may be very valuable and yet be offered for free or at low cost. Secondly they argue that 'use of facilities' conflates very diverse types of interactions, more value-added activities around production and services such as prototyping or design on the one hand, and more standardised activities such as room and equipment rental activities on the other hand. Finally, the use of specialist facilities often goes hand in hand with other types of interactions, such as consultancy, making it difficult to disentangle them.

2.2.5 Knowledge exchange: Regeneration, Culture and Creativity, Social engagement and Social media

Beyond commercialization activities and other forms of academic engagement, recently several scholars have brought attention to how HEIs foster innovation capacity by enforcing social creativity and cultural development and providing the basis for the expansion of the knowledge economy. A further potential interpretation of the role of universities in developing capacity for a knowledge-based society is engagement and exchange that

[4] This section focuses on the use of facilities and equipment provided by HEIs for industrial purposes, However, it is also acknowledged that a number of HEI staff and students can and do benefit from the use of industry equipment and facilities, above all in STEM subjects, and that such occasions also are forms of engagement and exchange between HEIs and industry.

supports a concern for Responsible Research and Innovation (RRI) and Social Innovation. Universities act as sites of interaction between previously disconnected communities of interest, such as business and corporate responsibility communities, sustainable development, human rights or consumer groups. They can also mediate to avoid the potential exclusion of people and communities from the knowledge economy (Benneworth and Cunha, 2015). However, indicators to measure this impact are still lacking.

In addition to the more 'traditional' notions of the modes in which higher education institutions may contribute to innovation that have been outlined above, university knowledge exchange and engagement activities also influence the cultural and creative milieu within which they are located. It is now accepted that the creative and cultural industries, including new media, are associated with innovation. In this regard, research activities in arts, humanities and some of the social sciences can make a real contribution to the innovation process, although many of these contributions are excluded from measurement with traditional indicators (Abreu and Grinevich, 2013; Olmos-Peñuela et al., 2014; Zukauskaite, 2012). This section endeavours to explore the role of universities within this context.

The creative industry sector is a particular example of a 'non-technological' sector where universities may play a key role. However, as noted by Taylor (2007) and others, models of business engagement advocated by central government are not always appropriate for HEI-creative industry engagement, since the main actors within the creative industries are typically small companies (albeit often comprising knowledge-intensive firms). Quantifying collaborations in this area is problematic and, as a result, measuring the impact of university activities on these 'non-technological' sectors of the economy requires different types of indicators than those used in STEM disciplines. Recently, Zukauskaite (2012) attempted to test the claim that relations with universities affect the innovativeness of new media firms in Scania (region in Sweden) finding that in the case of symbolic industries (value is symbolic not financial) the university primarily supports competence building that influences innovation activities, although a direct impact on product development was evidenced in several companies. The findings suggest that companies that do not exchange knowledge with a university at all perform worse in all five types of innovations addressed in the paper, and especially in the field of product innovation.

Fernández-Esquinas and Pinto (2014) highlight that, in addition to outputs such as patents or contract research, other, broader forms of engagement are important, for instance the role played by social scientists in influencing local and regional policies for health, welfare services and the economy. However, the development of indicators relating to these mechanisms is likely to prove problematic and reliant on anecdotal and highly institution-dependent modes of information gathering.

An alternative way to assess the impact of activities and interactions of universities with the wider regional and national community is by using relational web-based indicators and metrics derived from social media channels, such as Twitter, Facebook, or blogs, known as 'altmetrics'. This represents a more society-focused orientation of traditional citation analysis. Five categories of sources have been defined: Usage (views, downloads); Captures (bookmarks, shares); Mentions (blogged, mentioned in Wikipedia or news sources); Social Media (Facebook likes, shares, tweets); Citations (Web of Science, Scopus) (see: Cave (2012) and Tananbaum (2013)). Tools and services (free and charge-based) are now available and the advantages of using this type of information are: its immediacy, coverage of public sector content and its discipline neutrality. However, several caveats include the potential for gaming; the need for social media literacy; data source instability (Howard, 2013b); and data accuracy (King and Thuna, no date).

The caveats associated with the use of altmetrics seem to preclude attempts to aggregate such indicators to the institutional level or higher. However, given the accepted problems associated with impact measurement within the social sciences, humanities and arts, altmetric approaches may offer the potential for increasing insight relating to engagement and building a knowledge society.

2.3 Spillovers through human capital mechanisms

2.3.1 Introduction

Innovation rests on the capacity to generate and put into practice knowledge and ideas. Different traditions of scholarly literature concur that societies with 'better' human capital (HC) are more likely to enjoy greater fulfilment of their development potential compared to societies with scarce or inadequate human resources. These insights date back to the seminal works of Nelson and Phelps (1966) and Schultz (1972) who first put forth the argument that 'educated people make good innovators', meaning that education enables the transmission of knowledge that is required to facilitate the diffusion and application of innovation itself (Benhabib and Spiegel, 2005). While those early contributions focused on the macro-level, it was Gary Becker (1964) who first analysed human capital investments in the context of microeconomic theory, that is, in terms of strategic choices by both households and firms.

Accordingly, HC is analysed from two, not mutually exclusive, perspectives. The first concerns the returns to individuals who decide to invest in education and training, while the second focuses on the economic value-added, due to more efficient use of production factors, such as financial capital, land and machinery. Both views will be referred to in the following sections. More specifically, we put forward that investments in HC enhance local innovation capacity through two mechanisms, namely: broad societal returns due to the skill pool of highly-educated citizens and the more specific impact due to the workforce pool.

Though the pathways through which education and training generate positive returns are many and diverse, especially if we consider the entire journey in the life-cycle of an individual, universities tend to capture most of the attention (De la Fuente and Ciccone, 2002). Higher Education Institutions (HEIs) are increasingly committed to educating graduates who are not only creative and can develop useful, new or improved products and services, but who are also capable of identifying opportunities, understanding market potential and having the skills and competences to advocate for social challenges (Fastré & Van Gils, 2007). The second approach, HC via the labour force, is usually framed in a production-oriented perspective, whereby human capital relates to the stock of skills and knowledge that is needed to perform work tasks (Sheffin, 2003). Even if the organization and role of universities and HEIs has evolved over time, these institutions have historically been regarded as prime sources of new HC because, through the education of students, universities can have a very real effect on the provision of a skilled labour market.

The remainder of this section will articulate each of these two perspectives, building on the relevant literatures with a view to identifying suitable indicators. Specifically, section 2.3.2 delves into the distinction between the educated citizen pool and workforce pool approaches. Subsequently, in section 2.3.3, we explain how both mechanisms contribute to the innovation capacity, while the last section will focus on specific activities carried out by universities within these two pools.

2.3.2 Universities' contribution to innovation capacity: skill and workforce pools

Though the benefits of knowledge are visible everywhere, there is no doubt that identifying and measuring human capital poses formidable challenges. For this reason scholars have proposed a plethora of measures and proxies. This section analyses how university activities contribute to enhancing innovation capacity through fostering HC via the two mechanisms laid out above, education and labour force.

2.3.2.1 Role of education for the creation of the individual's skill pool

Following the classic work of Gary Becker (1964), we can distinguish between specific human capital, which refers to skills or knowledge that is specific to a set of tasks typically within an establishment or an industry, and general human capital which is instead more amenable to be transferred across jobs. Universities and higher education institutions are expected to provide the latter form of HC, e.g. generic skills that prepare individuals for the labour market beyond the narrow scope of any field of specialisation. This section focuses on general HC because the integration of the 'core competency' of educational programmes has become a central theme addressing turbulent marketplaces and the complex demands of technological and societal changes (Rover, 2005; Gattie et al., 2011; Vanevenhoven, 2013). This, within the educational context, should be conceptualized as a transversal and cross-curricular skill that everyone can develop. Learning to learn – one of the seven competences of the European Key Competences Framework – is fundamental. Efforts need to concentrate on developing transversal skills, or soft skills, such as the ability to think critically, take initiatives, solve problems and work collaboratively, that will prepare individuals for today's varied and unpredictable career path.

The literature highlights the importance of creativity, innovation and entrepreneurship to address economic, environmental and social changes that have been recognized in the policy realm (Baumol, 2004). For example, an ongoing debate at the heart of the Europe 2020 Flagship Initiative Innovation Union and OECD strategies concerns the need to encourage entrepreneurial competences throughout the community (EC, 2010; OECD, 2011). Likewise, recent European policies call for strengthening innovative capacity and the development of a creative and knowledge-intensive economy and society through reinforcing the role of education and training in the knowledge triangle and focusing curricula on creativity, innovation and entrepreneurship (Tether et al., 2005; Cachia et al., 2010).

The goal of fostering entrepreneurship is pursued by means of specialised courses in tertiary institutions (Solomon & Fernald, 1991) and of enterprise education (Donckels, 1991; Gasse, 1985). The specialised literature on enterprise and entrepreneurship education (Dainow, 1986; Gorman, 1997) and of particular entrepreneurship support programmes (McMullan et al., 2002) offers evidence on the effectiveness of these programmes in terms of both higher rates of new business start-ups and enhanced performance of existing businesses, all due to the innovation capacity of individuals. Prior literature focuses on HEIs (at various levels of education) and is clearly centred on a policy perspective. Thereby, although some indicators are aimed at the evaluation of entrepreneurial and innovative cultures within specific countries, the key information comes from specific case studies. For example, Bragg and Henry (2011) propose a set of indicators measuring outputs, outcomes and impacts of an entrepreneurial education, and building on case studies in different countries. As regards the specific indicators, some have relevance with the scope of this report, such as, for example, "% of students receiving entrepreneurial education as part of compulsory studies", "% of teachers receiving entrepreneurial education training" or "% of students considering self-employment as a career". Concerning the last indicator, other studies appear in the scientific literature based on surveys capturing students' self-perception of the entrepreneurial culture they have and have been taught. For example, Edwards-Schachter et al. (2015)

compare students' perceptions in Spain and USA in relation to their vision of creativity, the relationship between creativity, innovation and entrepreneurship and the influence of formal training on developing these particular skills.

2.3.2.2 The workforce pool

More than five decades after the emergence of studies on the importance of HC for economic development, the set of indicators aimed at capturing the human capital generated by universities is extensive. Traditional indicators reflect the output-based approach and thus resort to quantitative measures, such as the ratio of graduates, total years of schooling (Barro, 1997) or total enrolment rates (Gemmell, 1996; Barro and Lee, 2001; Sianesi and Van Reenen, 2003), and project their impact on growth rates (e.g. GDP).

More recent literature focuses on the mobility of individuals. These studies build on the hypothesis that migration is a reflection of a strategy for maximizing expected returns to human capital investments (Faggian and McCann, 2009). Different cases are contemplated under the broad umbrella of mobility.

Though inter-firm mobility of inventors is now regarded as a key source of knowledge spillovers (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003; Corredoira and Rosenkopf, 2010; Song et Al., 2003), empirical studies are still scarce, due to the lack of reliable data on labour mobility of students and academics. The only exceptions are: Lawson et al. (2015); Ejsing et al. (2013); Herrera et al. (2010).

Most studies tend to ignore the effects of student and graduate mobility. Recruitment of graduates and/or student placement prior to graduation are known forms of knowledge flow due to mobility (e.g. Cruz-Castro and Sanz-Menéndez, 2005; Herrera and Nieto, 2013). Faggian and McCann (2009) show that universities have a significant effect on innovation performance through the flows of their high quality graduates. At the same time, mobility can trigger self-reinforcing mechanisms even in spite of expansive policies in education, so that the direction of the spillovers tends to be ambiguous (Moretti, 2003; Bound et al., 2004; Consoli et al., 2013). Within post-educational levels, doctoral level education is seen as one of the key mechanisms in strengthening collaboration between firms and universities and as a key policy target for fostering innovation in the economy (Thune, 2009).

Universities can act as a powerful magnet for attracting talented students and staff from other parts of the country and even further afield (Seeber et al., 2014; Lepori et al., 2015). In addition, through their teaching at undergraduate and postgraduate level, universities have the potential to add to the stock of human capital by means of graduate recruitment into regional businesses, possibly following work placements as part of the students' degree. In particular, graduates can provide the gateway or connectivity for knowledge exchange between researchers and businesses. Unfortunately, all too often teaching programmes respond solely to either student demand or the priorities of the national labour market, especially when there is no clearly articulated business demand linked to regional innovation. As a consequence, graduates emigrate to more dynamic, viz. more attractive, regions. A study on Austria by Schartinger (2002) identifies knowledge transfer from universities to the business sector as a source of positive spillovers. In another work, Faggian and McCann (2009) find that the impact of labour mobility on innovation occurs across, rather than within, regions. This suggests that universities have a significant effect on regional innovation performance, mostly due to the flow of the elite graduates into other regions. As a consequence, limiting measures of UCIC to the surrounding region may miss important effects.

Innovation capacity is understood as requiring the continuous adjustment of knowledge and skills through the entire life cycle of technologies, labour market institutions and of individuals (Vona and Consoli, 2015). Freel (2005) for example identifies training as a key learning and development activity for improving human capital. But only few empirical studies have delved into the impact of training practices on innovation (Santamaría, Nieto and Barge-Gil, 2009; MacDuffie and Kochan, 1995). In sum, it is such bundles of human resource management practices that enhance innovation (Laursen & Foss 2003).

More flexible career paths would also contribute to this trend, since people need re-training and re-skilling at specific junctions in their career. This is where lifelong learning at HEIs is expected to be most beneficial. In fact, the EU has argued for the centrality of lifelong learning as a tool to achieve the Lisbon goals (Souto-Otero, 2011). This has, however, not yet spurred a coordinated response by HEIs and universities.

The level of public involvement in the delivery of re-skilling varies from country to country. In post-graduate training, for example, Austria and Finland are examples of systems in which HEIs have dedicated adult education units, which are deducted from the Master Delivery points. Such an approach is also in place in the UK, where adult students can opt for a "Continuing professional development" (CPD) unit offered by a HEI or a part-time MA unit. In Germany, "lifelong learning" expensive Master courses co-exist along with government-subsidised programmes for full-time students. Indicators on these activities are scarce in the literature and yet most necessary to assess whether adult participation in HE is effective in filling skill gaps. The only exception is a study by Souto-Otero, M. (2011) that uses the ratio between adult new entrants into HE (ISCED level 5A) as a proportion of all new entrants to capture this type of adult training.

The role of intermediary institutions in the process of knowledge transfer from universities to society and to the private sector is another recurrent theme in the literature. The general purpose of these intermediaries is the production and dissemination of different forms of knowledge. By and large, the literature has focused on technology transfer offices (TTOs) that promote and commercialize research outputs (Siegel et al., 2003), but the ecology of knowledge intermediaries is now ample. Bramwell and Wolfe (2008) analyze "Coop and Entrepreneurial" education programmes in the University of Waterloo in Canada aimed at facilitating the transfer of tacit knowledge between students and local and non-local firms. Nelles et al. (2005) report the case of a very successful initiative at Waterloo University (Canada), the Cooperative Education Programme, in which students had to participate in industry activities as part of the basic curriculum. Bagues and Labini (2007) present the case of the online intermediary AlmaLaurea adopted by several Italian universities in the early 2000s. The finding of a 3% wage premium among graduates from universities adjoined to this programme suggests that this type of online labour market intermediary improves the chances of a good match between individual skills and job requirements.

A crucial, and yet neglected, ingredient for the success of these kinds of programmes is the richness and degree of involvement of public institutions (see Filippetti and Guy, 2015). This calls upon a systemic understanding of the knowledge triangle that links together higher education, research and business (Markkula, 2011). Some literature on this presents the case of Knowledge Innovation Communities (KICs), i.e. learning platforms designed to address some of the challenges of the European education system. KICs comprise academic researchers, industry participants, government policymakers and educators, who collaborate on "multifaceted solutions" to address technological, economic, and social issues and the continuous assessment and improvement of such mechanisms (Yusuf, 2008). KICs provide a context in which non-traditional and innovative approaches to teaching and learning are explored and developed. Through these initiatives, universities and HEIs have the opportunity to be further involved in the delivery of entrepreneurial skills.

2.3.3 From a latent capacity to realised innovation

The previous section focused on the activities developed by universities. Here we establish the link between activities and how they contribute to innovation capacity with an explicit account of how these activities influence skills and the workforce pool.

2.3.3.1 From the skill pool to innovation capacity

While the scientific literature is not very specific as to which indicators best capture the activities that contribute to the skill pool of HC innovation capacity, how HC influences innovation capacity is a much clearer issue. Entrepreneurship education, for example, promotes an innovative culture in Europe by changing mind-sets and providing the necessary skills. In a globalized and competitive world, universities are expected to prepare students and citizens to participate in a dynamic, rapidly-changing entrepreneurial global environment. Entrepreneurship education is about developing attitudes, behaviours and capacities at the individual level. These skills and attitudes can take different forms through an individual's career and create a range of long-term benefits for both society and the economy (OECD, 2008). Entrepreneurship education can also mitigate negative attitudes, such as fear of failure or risk aversion that inhibit potential entrepreneurs from pursuing a new venture.

2.3.3.2 From the workforce pool to innovation capacity

Complementary to the pool of highly-skilled individuals with the ability and the potential to envision future innovation, the educated workforce is another pool that can contribute to translating innovation capacity into real innovation. University education triggers positive spillovers by providing a broad spectrum of cognitive skills (Audretsch et al., 2005). Accordingly, some graduates add value to society by applying the notional knowledge and analytical skills acquired through education, while others become proactive leaders in their community by means of critical thinking, problem-solving and interpersonal abilities.

Graduates shape their environment even before entering the labour market, for example, by engaging the productive sector in the context of mobility programmes, such as stages, internships and on-the-job training. Contingent to the absorptive capacity of the firms that host interns, these experiences provide a window of opportunity to tap into recent scientific advances. This is especially the case with firms that either design or intensively use high-tech. Students, on the other hand, are exposed directly to practical research applications and, also, to the challenges of the daily running of a business enterprise. When this tacit knowledge feeds back to university departments, it can both guide the research agenda and create openings for collaborative R&D with non-academic actors (Yusuf, 2008). Similarly, post-graduate students have the potential to provide a large scientific input for enhancing the competitive advantage in R&D, and this can have long-term consequences on economic growth (see Stephan et al., 2004). In addition, promoting exchanges between academic staff and students and firms and other non-academic organizations can be an extremely effective way of not only exposing the benefits of employing graduates, but also helps to build linkages and remove barriers between the university and the private sector that may have stifled other forms of collaboration (e.g. research, consultancy). There is potential for real transformative effects, since the productive sector is exposed to the knowledge assets of the university via its staff and students (Goddard and Kempton, 2011). Universities are also key sources of spillovers, in that they attract or retain talent in the region. The impact of this can be powerful. There is a clear link between the presence of highly skilled people and regional growth; the targeting of people with specific skills can help build up a critical mass, which in turn can act as an attractor of other individuals and businesses (Florida, 2002). The presence of universities in a region, particularly ones with a high profile nationally and internationally, can act as a real ‘magnet’ for talent (Asheim et al., 2007; Florida, 2002). This can be in the form of students, but also academic and research staff who come to work in the institution. Where the research expertise of the university maps onto the sectoral specialisms of local industry, this can create a powerful ‘hub’ for innovation activity.

2.3.4 University activities measuring human capital spillovers

Current indicators are insufficient for capturing the contribution of universities to the innovation capacity of regions and countries. On the one hand, and related to the importance of education for HC development, entrepreneurial behaviour is measured mostly through spin-off and spin-up activities (OECD, 2008). On the other hand, and adopting the vision of HC as flowing through the workforce, traditional indicators focus on the role of graduates in the labour market. In the remainder of the section we propose a set of new indicators that are better suited to capture HEI contribution to innovation capacity, based on the literature review.

Activities for increasing the HC skill pool

We consider four main activities through which HEIs can enhance the HC skill pool: **leadership and governance, curricula, teaching and learning, internationalization of culture.**

Leadership and governance: the availability of an internal entrepreneurial culture contributes to maintaining a dynamic and successful organisation, particularly in times of uncertainty, unpredictability and complexity. Leadership and governance can stimulate innovation of all kinds in an organisation that is held together by a shared vision and culture that is not overloaded with managerial systems or constantly striving for autonomy from stakeholders. For example, the involvement of external stakeholders in the leadership and governance of the HEI can create and nurture synergies between teaching, research and university societal engagement, promote entrepreneurship through education and provide support for start-ups and knowledge exchange that enhance the innovation capacity of existing firms.

Curricula: While there is a claim about the importance of entrepreneurship education across disciplines, it is usually offered in the form of stand-alone courses and mainly in business schools. It is therefore important that entrepreneurial education be integrated across disciplines. This would influence the development of attitudes, behaviours and capacities at the individual level but also skills that can be further developed and tailored over the course of an individual’s career. These, in turn, can create long-term benefits to society and to the economy, for example by stimulating creativity, by supporting and enhancing self-learning, learning to learn and lifelong learning skills and competences. In addition, the design and provision of training programmes in direct response to society’s needs can have a significant impact on the local economy. This however requires moving beyond traditional delivery models and the development of tools such as distance learning, on-site teaching, modular programme design, new approaches to accreditation and better use of the private sector in the design and delivery of training programmes (OECD, 2008). The effective delivery of workforce development requires detailed labour market intelligence including the forecast of new and emerging skills needs.

Teaching and learning: The introduction of entrepreneurship teaching in education is fraught with difficulties and often fragmented due to ad-hoc involvement of external actors rather than systematic efforts to revise curricula. The delivery of entrepreneurship teaching by academic staff of management departments is also deemed insufficient (EC, 2002). In order to develop creative and entrepreneurial learning approaches, it is crucial that teachers be trained to become reflective practitioners who are able to discern whether a particular didactic method triggers or stifles creativity among students (Cachia et al., 2010). To facilitate the process of learning, universities should include both short-term and long-term programmes and workshops, including educators as well as entrepreneurs and practitioners. This requires the adaptation of material used in entrepreneurship courses in Europe with emphasis on experiential and action learning (practitioners and entrepreneurs) in order to engage students more deeply in the learning process.

Internationalization: There is a general consensus that, as part of a broader strategy, internationalisation can offer valuable benefits to students, faculty and the institution as a whole (Altbach and Knight, 2007). It can spur strategic thinking that leads to modernizing pedagogy, stimulating greater student and faculty collaboration, and opening up new avenues for research collaboration. International mobility of scientists and students can also enhance academic entrepreneurship through exposure to new research environments and application opportunities (Krabel, 2009). Embedding internationalization into university strategy benefits students and academic staff in terms of the skill acquired along their careers. A widely practiced approach to internationalization are partnerships with higher education institutions abroad that facilitate staff and student exchanges, collaboration in research and development, international joint degree programmes and the opening of campuses abroad. Opening up wider links through distance learning approaches, globalization of curricula, building stronger linkages with local international businesses and closer engagement with alumni abroad are also growing practices (OECD, 2012).

Activities for increasing the workforce pool

Graduates: the total number of graduates is a crude measure of the human capital stock that does not take into account the diversity of know-how, and of how labour markets impinge upon it. Employability rates are a better measure to link the supply workforce with the available demand jobs. Due to the co-existence of various forms of skill mismatch among graduates employed in occupations that are below their actual potential (Flisi et al., 2014), indicators aimed at capturing the fit between available skills and knowledge and jobs developed are better suited to assess the effectiveness of learning within HEIs.

Mobility: the benefit of mobility programmes is two-fold. On the one hand students and academics bring into firms the latest thinking stemming from research labs, as well as the tacit knowledge they carry. This helps non-academic partners to solve and face short- and long-term difficulties in their current innovation. Students, in turn, gain a first-hand understanding of practical research applications and also of the challenges firms face. This tacit knowledge, circulated back to the university department though academics, can both guide the research agenda and create openings for collaborative R&D with industry. Mobility influences the exchange of experience at both short and long-term levels in order to go beyond the cross-border faculty and research collaboration.

Lifelong learning: Entrepreneurship is considered as one of the eight basic key competences and should be instilled at all stages of education and training. Through the career path, it is necessary to continuously update one's knowledge and skills in order to adapt to the changing demands of a dynamic competitive environment. This is especially important for workers who need to upgrade their skill set but also for the unemployed who need to keep up in order to face better prospects of labour market reintegration.

Intermediary institutions: The role of intermediary institutions in the HC approach mainly relates to putting in touch the available resources at the university. It consists of networks and specific units and departments within the HEIs that facilitate linkages between graduates and other non-academic agents –firms, public organizations, practitioners, etc.

Talent attraction and retention: The availability of large pools of creative talent facilitates innovation. Companies are attracted to those places where high-skilled people are accumulating. The process of talent attraction starts with new students arriving in particular locals and regions to study, and continues after they finish their degrees and remain in the same place to work and develop their careers. Both talent attraction and retention are key contributions of the universities to the available workforce.

2.4 Potential measures for university contribution of knowledge exchange and human capital to innovation capacity

The previous two sections have been structured around existing indicators; it is possible to identify in the literature a number of sub-dimensions that can potentially be reflected in the indicators that are chosen. Although the choice of indicators is not purely a measurement question (see chapter 3), it is possible from a range of literature sources to identify measures that have been used to capture these sub-dimensions of university contribution. Clearly some of these measures are not optimal, but rather reflect what it is currently feasible to gather in an attempt to provide insights into the magnitude of the underlying variable. Therefore this does not necessarily provide us with a full range of potential indicators – as it may be feasible or desirable to develop other indicators that capture the same dimension more fully in line with the policy intention. The table below provides an overview of all the variables the literature review identified as being suitable for measuring the desired dimensions.

Table 2: Potential indicators to measure the key elements of knowledge exchange and human capital to innovation capacity

HC stock	University activities	Indicators	References
Commercialisation	IP Activities	Number of disclosures/ new patent applications filed/ applications granted in year/ total patent portfolio	(Aernoudt, 2004; Agrawal and Henderson, 2002; Andersen and Rossi, 2012; Azagra-Caro et al., 2003; Baldini, 2006; Barbero et al., 2013; Chiesa and Piccaluga, 2000; Clarysse et al., 2007; Colombo and Delmastro, 2002; Djokovic and Souitaris, 2008; Fabrizio, 2007; Geuna and Rossi, 2011; Grimaldi and Grandi, 2005; Henderson et al., 1998; Jain and George, 2007; McAdam and McAdam, 2008; Roach and Cohen, 2013; Rogers et al., 2000; Siegel et al., 2007, 2003; Smith et al., 2014; Vincett, 2010)
	Patent quality	Forward and backward patent citations/ Non-patent citations/ #/ type co-assignees, # international patent classes	
	License numbers	Number of licenses for non-software and software (by: SMEs, non-SME commercial and non-commercial) Partner type: SMEs, Other (non-commercial) businesses and other non-commercial organisations.	
	IP Income	IP revenues Total cost of IP	
	Other forms of IP	Number of design rights Number of trademarks	
	Non-proprietary IP	Number of open source software, blogs, wikis, open source media, open source pharmaceuticals	
	Spin-off activity	Number of spin-offs, staff start-ups, graduate start-ups, HEI-owned, non HEI-owned, survival rates Estimated employment and turnover of active spin-offs % of spin-offs located in campus incubator or university premises Total private equity funding raised in spin-offs and start-ups Spin-off links to university (e.g. student projects, collaborative/ contract research, staff secondment)	
	Incentives for staff	Financial/ other incentives for staff for the IP they generate Y/N Requirement within the HEI to report or disclose (internally) IP Y/N (by type)	
	Infrastructure for commercialisation	Presence in the university of any of the following Y/N: On-campus incubators; Small office areas; Other incubators in the locality; Science park accommodation; Entrepreneurship training; Seed corn investment; Venture capital; Business advice FTE staff employed for the purposes of driving or supporting commercialisation	
	TTOs	TTO: Y/N, staff FTEs, annual budget, revenues, services offered e.g. Evaluation of Invention Disclosures, Management of IP portfolio including patent applications, Marketing of knowledge and technology offers for commercialisation, Licensing of IP rights and knowhow, Active involvement in spinoff development/business planning, Management of equity stakes in spinoff companies, Management of proof of concept/technology incubation funds or projects, Management of incubator facilities	
	Incubating facilities	Tenant firms' sales growth (%), employment growth (%), profit growth (%), finance raised, S&T employment, R&D expenditure, # patents, # copyrights, new product launches, consultancies with university, entrepreneurs from	

HC stock	University activities	Indicators	References
		university, entrepreneurs with PT positions	
Academic engagement	Collaboration for R&D	Sectors the university is working with Income, total value, number of collaborative R&D projects (by: SME , Non SME commercial, non-commercial) Length of collaborative projects, number of partners New products/processes successfully created as a result of collaborative research No of publications between academic researchers and industry Joint supervision of theses with industry Joint student projects with industry No of industry-sponsored research centres Number of industry-sponsored academic chairs University research funded by industry (total value and % of total) University research funded by charities/foundations (total value and % of total)	Adams et al., 2001; Agrawal, 2001; Arvanitis et al., 2007; Bercovitz and Feldman, 2006; Calvert and Patel, 2003; Clark, 2012; D'Este et al., 2013; Feller et al., 2002; Fontana et al., 2006; Hewitt-Dundas, 2012; Lee, 2000; Mitchell and Rebne, 1995, 1995; Perkmann et al., n.d.; Perkmann and Walsh, 2008, 2007; Ponds et al., n.d.; Rentocchini et al., 2011; Santoro and Bierly, 2006)
	Contract research/ Consultancy contract	Income, total value, number of contracts (by: SME , Non SME commercial, non-commercial) Length of contracts, number of partners, long/short term benefits of interactions	
	CPD/ CE courses for externals	Revenue, total learner days delivered (by: SME , Non SME commercial, non-commercial, individual)	
	Facilities and related services	Income, total value, total number of services (by: SME , Non SME commercial, non-commercial, individual)	
Social, community and cultural engagement	Media engagement	Number of media appearances by staff Social media mentions, cites, appearances	(Abreu and Grinevich, 2013; Benneworth, 2013; Comunian et al., 2014; Fernández-Esquinas and Pinto, 2014; Olmos-Peñuela et al., 2014; Paul Benneworth and Jorge Cunha, 2015; Zukauskaite, 2012)
	Societal engagement/ education	Third mission/societal engagement objectives included in HE policy or strategies Specific internal budgetary allocations to TM/SE activities Numbers of academics engaged/volunteering for TM/SE activities (Numbers of) Events/facilities open to TM/SE activities Numbers of research initiatives with direct impact on community Staff student resources (time/cost) allocated to delivery of community services and facilities Attendance figures for facilities/events	

HC stock	University activities	Indicators	References
	Educational outreach	Staff/student numbers dedicated to educational outreach HEI budget allocated to educational outreach activities Numbers of community participants	
	Community outreach	No of community representatives on HEI Committees/Boards Value of income from community partnership agreements, etc.	
	Interaction with third mission stakeholders	HEFCE: Research Excellence Framework impact cases (aggregate data) - potential indicator	
Skill pool	Leadership & Governance	Availability of specific strategies for entrepreneurial education Availability of activities fostering an entrepreneurial behaviour within the institution (courses, training, programmes,…) Involvement of external stakeholders (from outside academia) in the leadership and governance of the HEI	Bragg and Henry (2011); OECD, 2008; EC, 2011; Krabel, 2009
	Curricula	Participation of non-academic agents in the definition of curriculum development Intra-curricular: % of students receiving entrepreneurial education as part of compulsory studies % of degrees including specific subjects related to creativity, innovation and/or entrepreneurship Extra-curricular Number of extra-curricular courses related to creativity, innovation and/or entrepreneurship % of academics teaching entrepreneurial courses	
	Teaching & Learning	Number of courses for the creation of a critical mass of entrepreneurship teachers Number of practitioners and/or entrepreneurs teaching entrepreneurial courses	
	Internationalization	Availability of international campus Number of students participating in international exchange programmes Number of academics participating international exchange programmes for academics	
Work force pool	Graduates	Number of employed students after one year leaving the university Number of students working in an occupation directly linked to their degree after one year leaving the university Number of students in S&T occupations after one year leaving the university	Flisi et al., 2014; Barro, 1997; Gemmell, 1996; Barro and Lee, 2001; Sianesi and Van Reenen, 2003; Thune, 2009;

HC stock	University activities	Indicators	References
	Mobility	Number of students (undergraduate, postgraduate, PhD) doing training in the private sector Number of researchers working in the private sector Number of projects (degree thesis, master thesis, thesis,…) done in collaboration with the private sector	Schartinger (2002): Faggian and McCann (2009); Souto-Otero, M. (2011)
	Lifelong learning	Number of courses required by non-academic agents (firms, public institutions, NGOs,…) % academics teaching in courses required by non-academic agents (firms, public institutions, NGOs,…) Number of students over 25 years old	
	Intermediary institutions	Availability of intermediary institutions facilitating employment and training (student network offices, employment offices,…) University member of networks and platforms facilitating linkages between graduates and other non-academic agents –firms, public organizations, practitioners,… (e.g. AlmaLaurea, KIC)	
	Talent attraction & retention	Number of students moving to the region to study at the university Number of students that after finishing their degree remain in the same region (one year after).	

2.5 Conclusions: Tensions and Shortcomings

HEIs are the product of social, economic and intellectual developments: they encompass teaching, research, and a wide spectrum of third mission activities that define their context-specific identity. Most often, the latter is a result of a balancing process between these activities. A vast literature looks at differences within higher education systems, especially concerning the development of HEIs' internal characteristics and the changing relation with their environment.

Although embedded in the macro system just outlined, this review has focused more on the meso and micro level and, specifically, on the pathways through which knowledge develops, diffuses and transforms. It looked at the mechanisms that universities adopt to engage and contribute to innovation capacity; and at how such mechanisms can combine and transform internal and external factors into available knowledge *pools* which involve the valorisation of both knowledge exchange and human capital.

A first, and common, limitation that emerges from the literature review is the dominance of knowledge-transfer mechanisms. Despite teaching being widely known as the first mission of HEIs, the capacity of universities to generate entrepreneurial and other innovation specific skills remains arguably an under-studied contribution of HEIs to innovation capacity. In particular, despite positive assessments of individual initiatives, the measurement of the outputs, outcomes and value added generated by this first mission as a whole is seriously underdeveloped. As such, our first recommendation is to fill this gap by collecting more indicators on human capital both in terms of transfer (from HEIs to society) and composition (e.g. workers in science and technology occupations with tertiary education).

A second key limitation concerns the lack of systematic collection of historical data (both on knowledge exchange and human capital). This is a serious limit to the ability to measure impact across different institutional settings and across countries. From this it follows that to establish the *extent* of the contribution of HEI activities to innovation capacity, it is necessary to develop a standard set of measures that enable cross-country comparisons of the relative importance of KE and HC to innovation capacity.

2.2.6 Knowledge Exchange – Main Critiques to existing indicators

Knowledge Exchange activities are extensively covered by prior literature, and their contribution to innovation capacity has been analysed in detail. The composition of knowledge exchange however is complex in that it encompasses a wide range of activities including knowledge creation (patents; R&D collaboration), transfer (spin–offs; TTOs) and diffusion (science park and incubators but also, the societal engagement which HEIs can generate in their communities). The importance of each of these mechanisms is widely acknowledged – as testified by the diffusion of such activities across universities. There is a bias however towards data counts (of patents; TTOs; Spin offs etc.) rather than on their content. This is a significant weakness because it yields an unbalanced view of the quantity of outcomes produced in the process of knowledge exchange rather to the detriment of a full appreciation of the underlying qualitative differences between the key mechanisms at work. The choice of indicators (data counts, income derived from activities) therefore carries with it potential biases towards certain types of institutions and activities, potentially overlooking diversity of engagement and institutional diversity (Rossi and Rosli, 2014; Huisman et al., 2015).

A desirable set of KE indicators should put emphasis on the resources that allow HEIs to generate, transfer or transform knowledge into socio-economic values. The capacity to impact on value generation via the exchange of knowledge is mediated by the quality of the mechanism activated at the HEI level. Thus, it is the difference in the capacity HEI mechanisms have to promote entrepreneurship and knowledge exchange that determines the outcome. This in turn depends on the way universities organize the content of these activities – i.e. the quality of the structure aimed at the process of transfer and the characteristics of its staff. Arguably, the focus of impact indicators should rest not on quantifying KE outcomes, but on a full qualification of the factors that determine successful generation of knowledge exchange between HEIs and society.

2.2.7 Human Capital – Main Critiques to existing indicators

The role of HEIs in fostering an entrepreneurial mind-set and in generating the relevant skills has been a policy issue for years (for example: Lisbon Agenda 2000; European Charter for Small Enterprises 2000; European agenda for Entrepreneurship 2004). At the same time, however, the measurement of human capital rests on different proxies and theoretical approaches that do not capture the full potential of universities.

From the vision of HC as an enabling force for individuals to contribute to innovation and entrepreneurship, the extant literature focuses on start-up creation as a proxy of entrepreneurial culture within the university. But the capacity of individuals to spur innovation capacity is an essentially intangible, and thus difficult to measure, asset. While there is no doubt that education provides technical competences and mastery of available analytical tools to potential future innovators, entrepreneurs and other stakeholders, it is important to account for different aspects and dimensions of HEIs. In Europe, entrepreneurial education is still trying to find its place within the existing range of learning opportunities. Initiatives to counter this shortcoming are in place across several European countries but these efforts are fragmented and often driven by external actors rather than the education system itself (European Commission, 2002).

On the other hand, when HC is considered as a characteristic embodied in the labour force, the contribution of universities is narrowly assessed on the basis of indicators such as the ratio of graduate workers. There is scope to look beyond educational to proxy individuals' competences, and to focus on the set of skills that individuals use in the context of their work activity. Such an approach has the potential of offering a more nuanced understanding of what individuals do on the basis of their capabilities, and it is therefore a more direct approach to measure how knowledge generated in the context of HEIs, but combined with working experience, fuels innovation capacity. Under this perspective, it is necessary to match the workers' level of education achieved and occupation carried out because education and training increase workers' productivity and a strong economy ultimately relies upon the cognitive skills of its workers (EENEE, 2011).

Building on these suggestions, the next sections will propose a new set of indicators which links theoretical underpinnings of knowledge exchange and human capital literature to innovation capacity and which aims to capture knowledge impact and quality from HEIs to the wider society.

3 The prototype set of indicators: the draft version

3.1 From measurements to indicators

In Chapter 2 we identified a set of measures by which it is it possible to assess the contribution of higher education institutions to innovative capacity. There is a very wide literature on how universities contribute to innovation capacity, and we have identified a range of the measures by which this contribution can be enumerated. However, it is a non-trivial task to move from defining a characteristic in theoretical terms as a measurement, and then to operationally measure it. In making any kind of measurement, there are always issues in that everything but the very simplest characteristics are not directly observable. In an ideal case, a measurement protocol is able to define a precise methodology by which an observation can be converted into a measure.

In measuring length, for example, all lengths can be defined (and the lengths of any objects can be compared) in terms of how long light takes to travel that length (the metre is the length of the path travelled by light in vacuum during a time interval of 1/299792458 of a second). For most common uses however, the definition of light is not used but rather an indirect version of it – such as a ruler or tape measures based on a measuring protocol to gain a representation of the desired characteristic. For highly complex characteristics that do not directly correspond to physical properties, where there are subjective elements that become embedded into the definitions, this issue of converting measurements into measuring protocols becomes correspondingly more difficult.

The standard answer to this problem is in the use of proxies for precise measurements, which capture some element of what is important about the characteristic under consideration. For any given characteristic, there are a range of indicators which will capture some element of it, and therefore provide a proxy for 'measurement'. Some indicators will provide better proxy measurements than others for particular characteristics – they are more technically suitable than others. Any indicator set has three dimensions which determine whether it is more or less suitable as a proxy– firstly the extent to which it is successful in capturing the **magnitude** of a characteristic in a particular situation, secondly in capturing the **variability** between situations, and thirdly, the extent to which it provides **sufficient breadth** of coverage and is demonstrably closely linked to the underlying characteristic for which the user seeks measurement.

The previous applies to indicators of all forms, where the art of constructing a good indicator set is to select indicators which provide the best possible proxies for the issue under consideration. However, in this project is it also necessary to acknowledge that indicators are 'political' objects in providing someone with knowledge about a situation in order to take action in respect of this situation. Therefore, an additional dimension is the legitimacy of indicators, which is quite different to their statistical suitability as proxies for measures. In selecting indicators, we therefore choose them to optimise two dimensions, their **technical suitability** as indicators (see 3.3) as well as their **policy legitimacy** (see 3.2).

In EUniVation, the task is to measure a complex and multi-dimensional process that provides policy-makers with information useful for decision-making. This takes place within the context of education as a policy domain reliant upon the Open Method of Co-ordination (OMC), in which measurements and indicators play a key role in co-generating legitimacy for co-ordinated action (Drachenberg, 2011). Despite a number of prior attempts to pick indicators that might be useful for these policy purposes (Healy et al., 2014), none of the previous attempts to deal with university contributions to innovative capacity have produced a framework that in terms of legitimacy was as successful as the indicators which fed into the Community Innovation Survey (see 3.2).

From section 2, we define universities contributing to innovative capacity via spill-over effects that make knowledge resources more readily available to innovators. Although universities themselves undertake innovation, witness for example the rise of massive on-line open courses (so-called MOOCs), new learning environments and new publishing environments, universities mainly create knowledge that is then exploited elsewhere. As innovators operate typically under resource scarcity, university contributions expand the overall envelope of what those innovators could achieve (the 'better innovation' in figure 2). Hence the university spillovers – in whatever form - represent the university's contribution to innovative capacity. But at the same time

> "*Knowledge flows, by contrast, are invisible; they leave no paper trail by which they may be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that she likes*"(Krugman, 1991, p. 53).

But attempts to operationalise these have proven extremely difficult and tend to produce a reversion to standard – limited – proxies, such as patents (see Nelson, 2009 for a comprehensive review) or to the sources of knowledge given in the Community Innovation Survey. We have specifically identified a number of shortcomings in the current variables used to measure university contribution to innovation capacity in 2.2.5 and 2.3.4 and these form the basis for proposing a *better* set of indicators. As well as being an extremely restrictive vision of how knowledge flows to innovators, they have a particular issue in covering university contributions effectively, because of the many indirect ways in which universities contribute to innovative capacity, which are not always captured within particular transactions between universities and firms. As section 2 shows, this process may be relatively long-term, such as when scientific knowledge builds to enable technological breakthroughs, or it may be immediate, for example when students go to work in corporate R&D laboratories.

The wide range of spillovers that we are concerned with (across knowledge transfer and human capital), the long-term pathways into influence, and the reliance of absorptive agents to exploit that capacity are all conceptual challenges for measuring UIC. From this we deduce that the problem of indicators for measuring UIC is not a simplistic challenge, and to avoid replicating the challenges of previous indicator-led efforts, in this chapter we seek to understand what an adequate set of proxies would look like in terms of technical suitability and policy legitimacy (section 3.2).

That then allows us to sift the potential long list of variables, related to the measurement dimensions and propose a final indicator set. We decompose 'reasonable proxy measures' between two dimensions (a) technical suitability and (b) legitimacy. Although technical suitability is relatively explicit and easy to define, policy legitimacy is more complicated, and therefore we infer its central characteristics through an analysis of one particular variable area, namely entrepreneurship education (see Section 2.3.4 above).

3.2 The technical suitability of indicators for UIC

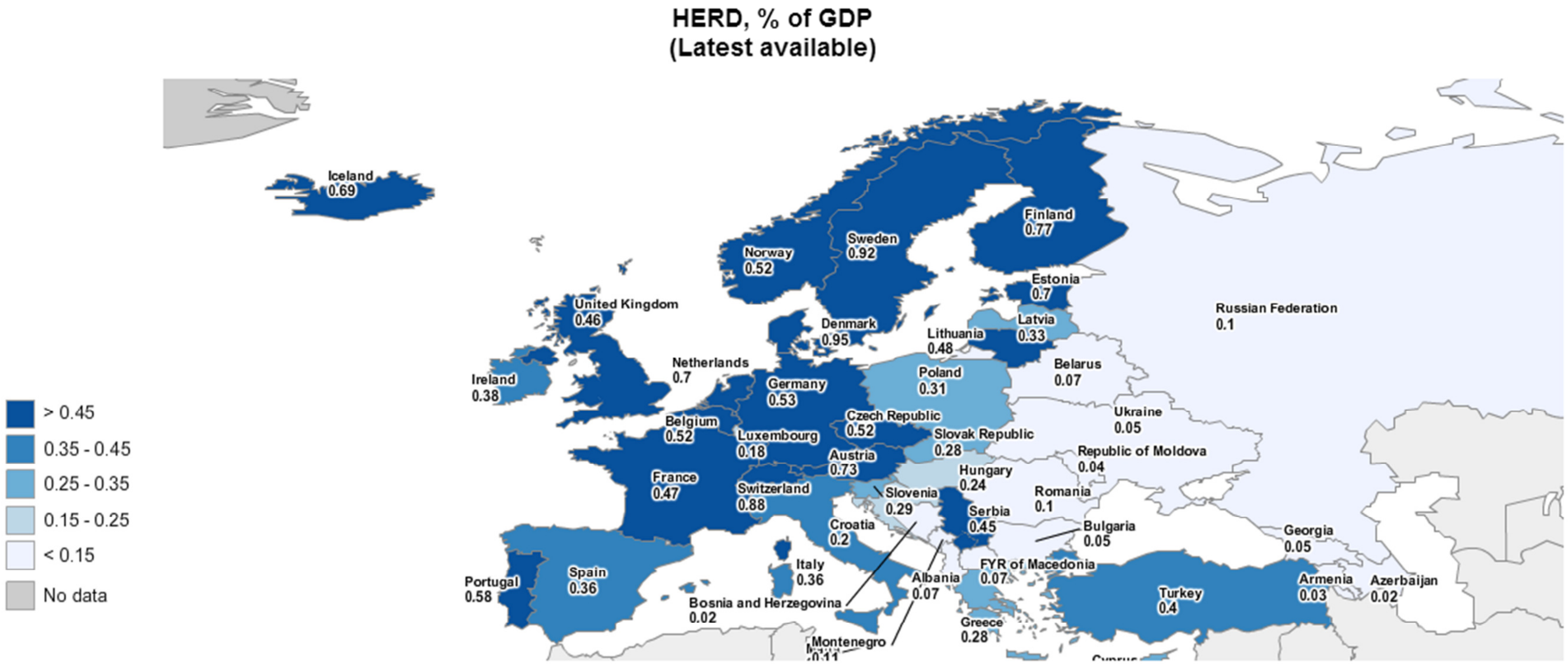
The ideal is to have one indicator that captures all performance at the level of the system as a whole; such an indicator typically carries very high policy legitimacy. In innovation terms, measuring gross expenditure in R&D as a percentage of GDP (GERD in GDP) has become a widely accepted proxy measure of innovative performance at the macro-scale. Although it does not capture all innovation activity, and is biased against certain sectors where innovation is not closely linked to formal R&D activity, it is reasonably widely used. Is there a comparable figure which might measure universities' contribution to innovative capacity in an aggregate way? The Innovation Policy Platform (IPP), which is a joint venture between the World Bank and OECD, provides simple and clear indicators for policymakers in terms of innovative performance, and a number of countries, such as Finland, have made use of these indicators for decision-making. The IPP proposes a number of indicators proposed to measure the contributions of universities and other public research laboratories to overall innovative effort, which is similar to our own efforts to measure university contributions to innovation capacity. The headline indicators chosen are:

- % of Higher Education Expenditure on R&D in Gross Expenditure on R&D
- Total research employment in HE per 1000 employees
- The impact of domestic scientific collaboration by institutions on research output
- Employment rate of doctorate holders by gender
- The quantity and quality of scientific production, 2009
- % innovative firms citing university/ government as "highly important" knowledge source for innovation

It is possible to use this data to generate some kind of proxy for university capacity to innovative capacity, as shown in the table overleaf. This information has some policy value, in indicating which countries (and potentially regions) perform best in terms of higher education expenditure of research and development (HERD) in gross domestic product (GDP) (for example). But there is the issue about the extent to which HERD expenditures contribute directly to innovative activities. Business research and development (R&D) is undertaken for the specific purpose of adding business value, through creating and exploiting new knowledge. By contrast, the knowledge that is created in higher education R&D is not always created with an idea for external exploitation in mind[5]. Therefore although this indicator *could* be used because it is system-wide, we argue that it is necessary to select more indicators and combine them in a smart way to gain a proxy measurement of what matters here.

[5] Although clearly great technology breakthroughs leading to substantial changes in society often draw on academic knowledge not deliberately created to be immediately exploited http://www.researchtrends.com/wp-content/uploads/2013/05/Traces_vol01_withPreface.zip

Figure 6: One potential headline indicator measure for UIC (HERD as % in GDP)



Source: Innovation Policy Platform (2015)

These various variables capture in the Innovation Policy Platform and Innovation Union Scoreboard, partly and incompletely, different kinds of spill-over effects that provide resources that can allow innovators to achieve better innovation. The Innovation Union Scoreboard provides very clear measures but is calculated in a very composite way (aggregating normalised indicators quite arbitrarily) to generate a 'score'. It has policy value in terms of differentiating between magnitudes (performance) and highlighting different dimensions (allowing low performers). The question would then be what kind of indicators would be necessary to properly capture these spillovers:

> ***A good indicator is one which is strongly related to the mechanisms by which spill-over effects see knowledge flow from universities into the knowledge pool.***

3.3 Indicator policy legitimacy: the Open Method of Coordination context

Although research is a European policy area, the European Commission does not have any formal competency in the field of higher education, it being a matter for member states. At the same time, there have been considerable developments at a European level in higher education policy, most notably the creation of the European Higher Education Area, the so-called Bologna process. This functions through an open method of co-ordination (OMC), within which member states and other key actors (e.g. sub-national higher education systems) co-ordinate and improve their performance in a common direction of travel. The role of the European Commission is in providing transparency and communications between these prime actors; in the specific example of the case of Bologna, in benchmarking progress towards compliance, identifying good performance and weak performance, and sharing best practice from these good performers to help those performing more weakly.

The OMC method also applies here in the case of universities contributing to innovative capacity. University third mission policy is something reserved to national legislative competence (and occasionally sub-national, for example in Belgium). The political purpose of measuring UIC is therefore to assist with this co-ordination of national higher education policy-makers towards a situation where the legislation and frameworks to optimise the aggregate contribution is maximised across European higher education as a whole.

The purpose of an indicator set is therefore to differentiate between performance levels, as well as the balance of performance levels: to say that higher education (university) system A contributes more to innovative capacity than system B. It also provides an insight into potential reasons why system A contributes more than system B. This provides an antecedent for governments responsible for systems A and B respectively to structure the inter-governmental dialogue that forms the core of an OMC. In aggregate, these indicators are useful in identifying which HE systems function well in this regard, and helping to use knowledge in those systems to raise performance across Europe as a whole.

The key issue for an indicator set of an OMC is to allow a comparison between different systems, analysing what particular systems do well or not, and identifying bottlenecks within systems. We have seen in the previous chapter that measuring UIC has to take place in terms of the measures of useful outputs from universities. It is clear that these can then be aggregated to the level of the system to allow this comparison (much as the Innovation Scoreboard distinguishes between four classes of *innovation* system on the basis of aggregated statistics). Therefore, the issue of the quality of indicators in capturing variability relates to the question of the extent to which these indicators are able to differentiate between performances in national systems. This raises the question of what constitutes performance and how it relates to the particular observable activity carried out by a university. Unfortunately, there is no one-to-one correspondence between an activity by a university and the desirable characteristic (contribution to innovative capacity).

Consider for example the fact that universities may, through their entrepreneurial education programmes, contribute to innovative capacity by endowing individuals with generic skills that make their specific skills more usable. That entrepreneurial education may also make it easier for firms to access that graduate human capital in a variety of ways that extends leads to more/ better innovation in the Figure 2 sense. The issue here is the question of what to measure. It is possible to measure the total amount of entrepreneurship education undertaken by HEIs. It is likewise possible (at least theoretically) to measure the total labour market in research, development, technology and innovation jobs that have undertaken a qualification in entrepreneurship education.

Both of these measures are problematic as indicators: not all entrepreneurship education will make it easier for graduates to use their human capital for innovation, and secondly, in measuring university contribution some of that capacity contribution will be latent and unrealised (and still offering future innovation gains). A policy-maker assumption that a big increase in entrepreneurship education also corresponds with a big increase in UIC is therefore a false assumption about who is performing ‘well’ or not, in terms of the goal of raising UIC.

> ***A good indicator is suitable: there is a stable proportionality between the activity being measured and the overall characteristic being measured (UIC).***

3.4 Developing a robust framework for assessing UIC indicator policy legitimacy

The overall utility and effect UIC indicators also depends on the extent to which they are capable of inspiring others to action. One of the reasons that an extremely limited number of knowledge transfer indicators have achieved such widespread support as indicators – as proxies of university innovation contributions (patents, licenses, spin-offs) – is that they are widely <u>believed</u> to be good proxies. They are thus ‘legitimate’, and others are willing to take action based on them within the wider OMC framework (benchmarking, comparison, best practice sharing).

At least part of the problem to date with developing indicators that measure UCIC via human capital effects has been in failing to develop a widely accepted set of indicators; we attribute this to a failure to identify what makes indicators ‘legitimate’ in this context. Just as in 3.2 we offer a definition of indicator merit based on the extent to which it ‘measures’ university spill-over effects, we also argue that indicator merit is based on the extent to which they are believed by the key stakeholders within the OMC arrangements to be legitimate[6].

To do this, we look at one particular area where key OMC stakeholders (the Commission, national governments, national university representative associations/ Rectors’ conferences) have attempted to develop indicators to measure university contributions. Looking at these various attempts provides a means to understand the kinds of ways in which these key OMC stakeholders define **indicator legitimacy**.

[6] Believed is used here to refer to a shorthand meaning that an actor is prepared to take action based on the interpretation of the indicators. This may be for extrinsic reasons, such as achieving particular scores, may be related to *ex ante* conditionality, or because the actor does believe that the indicator helps to diagnose the situation adequately.

We specifically consider the question mentioned above of university contributions via a short case study of entrepreneurship education and indicator legitimacy. We have chosen entrepreneurship education because there have been extensive efforts to measure university contributions in this area resulting in the publication of a number of reports where extensive lists of indicators are proposed. On the basis of the reports we compiled relatively long lists of potential indicators for measuring how entrepreneurship education contributes to UIC (ICF GFK, 2014; EC, 2008; Ecorys, 2012; Welsh Government, 2010; HEQCO, 2013): see table below. We stress here that we are not proposing these indicators, rather they provide a means to observe the process by which policy-makers consider the legitimacy of indicators, and from which we infer a wider typology for legitimacy.

Table 3: An overview of the range of indicators proposed elsewhere by which UIC could be measured

1. Expert Group on Indicators on Entrepreneurial Learning and Competence: Final Report (ICF GHK, 2014)
There is a specific national (regional) strategy for the implementation of entrepreneurship education and/or objectives related to entrepreneurship education as part of a broader education strategy
Learning outcomes (attitudes, skills, knowledge) related to entrepreneurship education are explicitly stated in the national (regional) curriculum
% of population aged 15 and over who have taken part, at school or university, in any course or activity about entrepreneurship (defined as turning ideas into action, developing your own projects)
% of the population 18 - 64 who believe they have the necessary skills or knowledge to start a business
% of population aged 15 and over who “strongly/totally agree” that their school education helped to develop a sense of initiative/ sort of entrepreneurial attitude
2. Report of Expert Group “Entrepreneurship in higher education, especially within non-business studies” (European Commission, 2008).
The programmes have clearly defined objectives and a well-defined expected set of outcomes
There is a balance between the theoretical and practical aspects
Activities and events are organized to improve students’ ability to work in a group and build a team spirit, and to develop networks and spot opportunities
Different guest lecturers are involved (e.g. experts on patent law, company financing, etc.)
Young entrepreneurs (for instance, alumni who have started a company) and experienced business people are involved in courses and activities, and contribute to their design
Courses and activities are part of a wider entrepreneurial programme, with support mechanisms for students’ start-ups in place and actively utilized
Exchanges of ideas and experience between teachers and students from different countries are sought and promoted
3. Entrepreneurship in education: second follow-up measurement (Ecorys, 2012)
The educational programmes are always guided by questions from the environment/business in the area of

entrepreneurship and enterprising behaviour
Teachers have influence in the development of activities in the field of entrepreneurship and enterprising behaviour
Degree of embedding entrepreneurship or enterprising behaviour in the curriculum/education of intermediate vocational education and higher education
Teachers receive (additional) course(s)/training in the area of entrepreneurship
The percentage of vocational education and universities that have specific activities aimed at entrepreneurship or entrepreneurial behaviour
The frequency of using entrepreneurs as guest lecturers
Opportunity for students to set up a firm or to participate in a company
The HEI has specific activities aimed at entrepreneurship or entrepreneurial behaviour
The percentage of educational institutions where teachers do an internship in business
Assessment of skills/talents/performances on entrepreneurship or enterprising behaviour during school career
Activities are developed in cooperation between different disciplines
Involvement of parents in classes where entrepreneurship or entrepreneurial behaviour is contained
4. Youth Entrepreneurship Strategy: an Action Plan for Wales 2010-2015 Welsh
Number of businesses engaged with Higher Education
Number of young people involved in entrepreneurial activity as part of the curriculum
Number of young people involved in entrepreneurial practical experiences in colleges & Universities
Mentoring opportunities for young people (e.g. Enterprise clubs)
5. Student entrepreneurship, Sa, Kretz & Sigurdson, 2014
Number of Entrepreneurship Courses in Ontario Colleges and Universities
Most Frequent Sub-Topics of University Entrepreneurship Courses
Numbers of Entrepreneurship Courses Offered in Colleges by Programme Topic
Most Frequent Sub-Topics of College Entrepreneurship Courses
University Entrepreneurship Credentials Offered
Entrepreneurship Centres and Hubs at Universities and Colleges
Entrepreneurship Personnel at Colleges and Universities

Mean Importance Ratings of Programme Goals by Programme Type
Mean Importance of Evaluation Criteria by Programme Type
Dutch Association of Universities of Applied Science (2012)
Number of HBO graduates employed in business/public sector
Income from practical education in contracts
Number of adults following lifelong learning programmes
Number of teachers primarily engaged in business activities
Positive attitude to entrepreneurship by students
Number of students in entrepreneurial education
Contribution of the Associate Professors/ Research Centres to professionalising teachers
Applying research results in curricula (e.g. minors, course variants)
Number of students involved in research (both regular and graduating projects)
Number of training and workshops for business activities
Number of students doing placements in business activities

Source: Compiled from cited reports.

On this basis, it is possible to reflect on this question of **legitimacy of indicators** for measuring how entrepreneurship education is part of universities' contributions to innovation capacity. In each of the reports, they are attempting to demonstrate three qualities that a particular kind of entrepreneurship education has – entrepreneurship education that contributes to UIC, to avoid the volume fallacy where more activity does not correspond with increases in the contribution the universities make to innovative capacity. The issue with entrepreneurship education is that a particular kind of entrepreneurship education can have a kind of activation effect for innovation in organisations facing serious innovation resource constraints. That entrepreneurship education increases the overall volume of university knowledge being applied in different kinds of innovation processes and therefore represents a contribution to innovation capacity. But at the same time, it is clear that not all entrepreneurship education fulfils this criterion.

In the indicators proposed above, we see an opportunistic selection of indicators (based on what is readily available or easily gathered) in an attempt to provide balanced coverage with these three qualities. This is perhaps most explicitly stated in the monitoring framework of the Welsh Assembly Government, the Youth Entrepreneurship Scheme, in which they seek to monitor three discrete dimensions, equipping, engaging and empowering. **Equipping** we see here as being analogous to the university activities, providing the entrepreneurs with the skills, tools and understanding to be entrepreneurial in a more general (if not explicitly theoretical) framework. **Empowering** is the implementation of tools in a particular context, and therefore having the opportunity to experience the challenge of being confronted with a real-world problem and having to take a synoptic decision of which theoretically-possible pathways to pursue. **Engaging** is ensuring that these experiences take place not only under the tutelage of academics but also entrepreneurs, who are able to bring their own know-how and context specific knowledge to the situation.

We contend that these three variables capture quite neatly three more general characteristics that policy-makers are seeking – implicitly – in their selection of variables that cover university contribution to innovation capacity. They are seeking to know that there is a **university** (or HEI) making a contribution, that there is contribution to **innovation** in terms of an interested user, and that there is **capacity** built via a (student) learning experience. We therefore suggest that our three dimensions of validity for entrepreneurship education can be represented as:

(a) The entrepreneurship education is more than purely practical in its nature, and is embedded within structures that assure the quality of that education as a form of higher education.
(b) There is genuine exposure of the students to real world business examples of entrepreneurship, so although it is conceptual, it is not exclusively conceptual, and so the students will later have the capacity to be actively involved in innovative entrepreneurship.
(c) There is business involvement and investment in the activity, suggesting that the businesses see that there is some value in the activity that is taking place, and therefore, as well as being both conceptually oriented and involving business contacts, it also has a relevance for those participating businesses.

Extrapolating from the specific situation of entrepreneurship education to university contribution to innovation capacity more generally, it is possible to develop three characteristics which contribute to **indicator legitimacy** (summarised below). These three characteristics correspond to the model of university spillovers that we set out in the introduction, involving a knowledge creation activity, which is activated in students (it does not remain purely academic) and the presence of an external stakeholder. The three dimensions necessary for legitimacy in the indicator framework are namely:

- they are related to university human capital **formation processes**, i.e. they are rooted in theory (rather than being purely experiential).
- they are experientially grounded through **practical implementation and experience**, in which there is transfer of the know-how of innovation, as well as the know-why to the innovator
- they involve a **connection, network or interaction with business** that signals that they have a relevance or wider utility for business innovation.

This provides a means to identify what kind of indicator set will be regarded as legitimate to cover spill-over effects in the dimensions set out in 2.2 and 2.3, even if they are not completely able to 'measure' spillovers.

3.5 The proposed indicator set

Eunivation seeks to develop an improved set of indicators for measuring university contribution to innovative capacity, and therefore, in proposing a novel indicator set, to be able to identify where the improvement here arises. In section 2.4, we have set out a range of measures that could potentially be used to give an indication of the extent to which universities are contributing to innovative capacity, whilst in 2.5 we set out the existing critiques of indicator sets. In Eunivation, therefore, we wish to make a selection of indicators to measure UIC which optimises their conceptual merit and their policy legitimacy. But it is equally important to address the critiques of existing indicator sets. In 2.5, we noted that good knowledge exchange indicators are those that allow us to measure the mechanisms that HEIs have in place to generate, transfer or transform knowledge into socio-economic values.

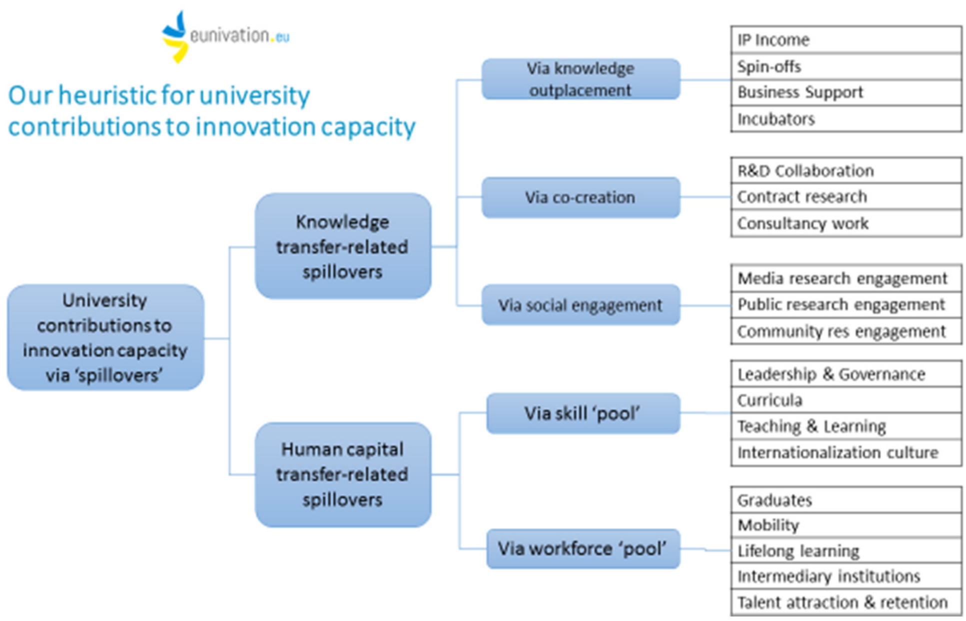
Indicators should therefore be sought to reflect the quality and scope of those structures and their staff involved, as well as the total volume of activity they create. Indicators for human capital conversely need to encompass the added human capital that education brings to individuals in their own innovation processes. These indicators therefore also need to capture the full breadth of where activity leads to innovation, and not fall foul of an assumption that employment in knowledge-intensive sectors is the only, or indeed, must represent a legitimate, means by which human capital contributes to innovation capacity.

The indicator challenge is therefore in picking a set of measures which are suitable to use as the basis for those indicators and then in operationalising the characteristics into a set of proxy indicators which can be gathered. The challenge here lies in the operationalisation, in ensuring that the choice of proxies is such that they maximise the indicators' technical validity and political legitimacy. We must also fulfil the criteria identified above, namely that they are conceptually 'good' and legitimate and address current critiques.

(a) they must be proxies that are measuring something in which a rise can conceptually be considered to be associated with 'increased spill-over benefits',
(b) they must suggest that there is a university stock that flows and creates an impact, namely they are a university output, suggestive of real world activity, and in which innovators are signalling their interest, and
(c) they must be improvements on the current state-of-the-art, capturing university mechanisms and behaviours for knowledge exchange, and a broad scope of human capital contributions to innovation capacity.

On that basis, we have made a selection of the variables proposed in sections 2.2 and 2.3 to present a first indicator selection for measuring university contribution to innovative capacity. In this, we have firstly sought to ensure that the indicators represent a fair balance of measures by ensuring that they cover a broad spectrum of the dimensions identified in the literature review. To recall, that analysis suggests 19 possible facets by which we can measure elements of university contribution, set out in the figure below.

Figure 7: Possible facets of the proposed variables



In the table below, we make a selection of the suitable variables for measuring UIC according to our three criteria above. All indicators have been selected from those found in the literature (see 2.4), sometimes technically modified to provide a better comparative situation. We have then sought to balance them across dimensions, and we have sought to maximise the total performance against our two functional dimensions, their technical suitability and their policy legitimacy (see 3.1 and below):

- Technical suitability: the **magnitude** of a characteristic in a particular situation, secondly the extent to which it is successful in capturing the **variability** between situations, and thirdly, the extent to which it provides sufficient **breadth** of coverage
- Policy legitimacy: related to university knowledge capital **formation processes**, experientially grounded through **transferring know how**, and involving a **connection, network or interaction with business** that signals that the indicators have a relevance or wider utility for business innovation.

Thus building on the literature review (Chapter 2) and the policy analysis (Chapter 3), it is possible to state that the indicator set presented below represents a clear improvement in indicators for measuring UIC in comparison to the state-of-the-art. We therefore propose to use this indicator set (Table 5) as the basis for Phase 3 of the project.

Three criteria dimensions for optimising UIC indicators

1. The three dimensions necessary for **technical suitability** are:

- the magnitude of a characteristic in a particular situation,
- capturing the variability between situations, and
- the extent to which it provides sufficient breadth of coverage

2. The three dimensions necessary for **policy legitimacy** are namely that:

- they are related to university human capital formation processes, that is that they are rooted in theory (rather than being purely experiential).
- they are experientially grounded through practical implementation and experience, in which there is transfer of the know-how of innovation as well as the know-why to the innovator
- they involve a connection, network or interaction with business that signals that they have a relevance or wider utility for business innovation.

3. The changes necessary to make an improvement on the current state-of-the-art involve:

- capturing university mechanisms and behaviours for **knowledge exchange**, and
- capturing a broad scope of **human capital contributions** to innovation capacity.

Table 4: Proposed indicator set to measure how universities contribute to innovation capacity via spill-overs

	University activities	Proposed indicators	Technical Suitability	Policy legitimacy
Skill pool	Leadership/ Governance	1. % extl members on university bodies (senate/ council/ court), Oversight/ faculty/ consultative Board	✓✓	✓✓✓
	Curricula	2. Participation of non-academic agents in the definition of curriculum development (level measure)	✓✓	✓✓
		3. % of academics teaching extra-curricular courses on creativity, innovation and/or entrepreneurship	✓✓	✓✓
	Teaching & Learning	4. % of non-academic staff with validated qualification or experience in entrepreneurship training	✓✓	✓
		5. % of staff teaching entrepreneurship courses	✓✓	✓✓
	Internationalization	6. Number of ECTS awarded to international exchange students	✓✓	✓
Workforce pool	Graduates	7. % of former students (by cohort) who are employed within one year of graduation	✓✓	✓✓
		8. % of former students (by cohort) employed in an occupation that matches their degree within one year of graduation	✓✓	✓✓
	Mobility	9. % of students taking ECTS in external settings (i.e. private sector)	✓	✓✓✓
		10. % of Ph.D. training time spent in the non-academic sector	✓✓	✓✓✓
	Lifelong learning	11. % of academics teaching in courses required by non-academic agents (firms, sector, NGOs,…)	✓✓✓	✓✓
	Talent retention	12. % of students (by cohort) who moved to the region (travel-to-study area) of the university	✓✓	✓
		13. % of students (by cohort) who stay in the region (travel-to-study area) of study within one year of graduation	✓✓	✓✓
Commercialisation	IP Income	14. IP revenues (licenses)	✓✓	✓✓
	Spin-off activity	15. Estimated employment and turnover of active HEI spin-offs	✓✓	✓✓
		16. Estimated employment and turnover of Student start-ups – including founders' academic background	✓✓	✓✓
		17. Industry involvement in Student start-ups: estimated funding; licencing of the invention to industry		
		18. Number of STEM grads; Number of Total grads; Number of total staff with postgrad degrees		
	Infrastructure for commercialisation	19. Presence of (Y/N) or Number (N) in university: On-campus incubators (N); Small office areas (Y/N); Other incubators locally (N); Science parks (N); Entrepreneurship training (Y/N); Seed corn investment(Y/N); Venture capital (Y/N); Business advice	✓✓	✓✓✓
	Incubating facilities	20. Tenant firms finance raised	✓	✓
Academic	Collaborative R&D	21. Income, total value, number of collaborative research involving public funding (SME, large firm, non-commercial)	✓✓	
		22. No of publications between academic researchers and industry	✓✓✓	✓✓
		23. University research funded by industry and by charities/foundations (number of projects, total value and % of total)	✓✓✓	✓✓

	Consultancy	24. Income, total value, number of contracts (by: SMEs , Non SME commercial, non-commercial)	✓✓	✓✓✓
Public Engagement	Media engagement	25. Number of media appearances by staff and by students	✓	✓✓
	Societal engagement	26. Third mission/societal engagement objectives included in HE policy or strategies	✓	-
		27. Numbers of academics engaged in Charities/Boards of Foundations/Schools	✓	✓
	Education outreach	28. HEI budget allocated to educational outreach activities	✓✓	✓✓

Part B: Fieldwork and feedback on the draft indicator set

4 Insights from the fieldwork to the draft set of indicators

4.1 Introduction

In the framework of the study, a significant number of interviews have been carried out with HEI representatives, policy makers and industry representatives across Europe aiming at capturing their personal opinion on the draft set of indicators. In fact, interviewees were asked to provide feedback based on their perspective, experience and national context, as well as suggestions that could be potentially utilised for the refinement of the draft set of indicators.

With the above in mind, this chapter summarises the feedback and suggestions collected by the team during the interview-based fieldwork of the study (see Annex 1 for more details on the methodology of the fieldwork). In the following sections, we present the main insights derived from the interviewees employing the overall structure proposed for the draft list of indicators, as follows:

- Section 4.2: Increasing the capital skill pool.
- Section 4.3: Increasing the workforce pool.
- Section 4.4: Commercialisation.
- Section 4.5: Research reach-out.
- Section 4.6: Public engagement.

Within each of the abovementioned sections, the team has summarised the main points of the interviewees' subjective input on each of the different proposed indicators. In particular, the conceptual appropriateness (i.e. the relevance of the proposed indicator to the concept it is aimed at capturing), as well as the technical feasibility (i.e. the degree to which the data required to operationalise the proposed indicator are already available or easy to access and collect) of each proposed indicator are discussed based on the comments provided by the interviewees and specific suggestions towards their improvement are presented along with alternative and/or complementary measures which could be employed to this end.

Overall, the purpose of this summary chapter in the context of the study was to provide the feedback required by the team in order to refine the draft list of indicators and produce the final set of indicators that follows in the next chapter (i.e. Chapter 5).

In this respect, the key comment that the fieldwork passed over to the team is that there is a **need for better defining all the indicators proposed** so as to ensure consistent and reliable data collection and measurements in the future.

More specific information (including suggestions derived from interviewees' personal feedback) about each of the different indicators proposed is provided in the sections that follow.

4.2 Increasing human capital skill pool indicators

4.2.1 Percentage of external members on university bodies (senate/ council/ government body/ oversight/ faculty/ consultative board)

Relevant type of spillover: Ensuring diversity and openness towards society in the style of and the set of capabilities for governance.

The participation of external members in HEI bodies may not only have a considerable impact on their strategic orientation but also help them develop stronger connections to industry, gain a better understanding of the external environment, and align with societal needs and challenges. In fact, across several EU countries, relevant legislation encompasses provisions that pertain to the composition of HEI governing bodies, imposing a minimum number of external members. With that in mind, in general, the indicator received positive feedback in terms of conceptual appropriateness during the fieldwork of the study. Its technical feasibility was also confirmed given that information on the composition of HEI bodies is typically available to the public (e.g. on the web sites of HEIs).

Still, the feedback received from the interviewees suggests that the particular university bodies to be included in the scope of the proposed indicator should be specified since the HEIs' governance structures often vary across countries (or even regions). Moreover, according to their opinion, the emphasis would be more appropriately placed on **bodies that have decision-making authorities at the lower level of HEI governance**, as the impact of external members on such bodies is more direct.

To this end, the national legislative framework is an important parameter that needs to be considered, since it may make it compulsory (even define the exact percentage/ type) or prevent the participation of externals on different types of university bodies.

Furthermore, the different background of university bodies' external members should be carefully considered as well (e.g. politics, social organizations or industry), since it may be indicative of the diverse ways in which they impact the entrepreneurial culture within a HEI.

In this respect, many interviewees highlighted that it would be meaningful to focus the scope of this indicator on **externals who are working outside of the HE system and especially those within the business sector**. The participation of externals with a business background and/or activity would hint towards University - Business Collaboration (UBC), which can play an important role in developing an entrepreneurial culture within a HEI.

An indicator that was suggested in this respect by interviewees is the number (or percentage) of external members in HEI bodies with a business background and/or an entrepreneurial track record.

Moreover, although the presence of external members in HEI governing bodies was considered by the vast majority of the interviewees as quite important in terms of fostering innovation, the role and degree of their involvement was considered as an important focal point to be considered as well. Indeed, many interviewees stressed that the role of external members who participate in HEI bodies, the extent of their involvement, and by extension, their impact on the leadership and governance of a HEI would be more indicative of the effect that they have on stimulating an internal entrepreneurial culture.

A qualitative assessment would be more appropriate to capture the abovementioned aspects. At the same time, however, it would require substantial effort and resources, a fact which may hinder its actual implementation on a large scale.

Consequently, it appears that, according to the interviewees, the proposed indicator would be more conceptually complete if it also included **qualitative aspects of the contribution** of the external members to the governance of the HEI.

The existence of strategic partnerships with the industry and/or public authorities (e.g. municipalities) was mentioned as an additional indicator that could be employed in this context. However, a clear definition of what is considered as a strategic partnership and how this may be evidenced would have to be developed in order to ensure the reliability of the indicator. Incentives provided by the HEI leadership for collaboration with the industry and entrepreneurship activities may also be an appropriate indicator in this respect. Another alternative perspective to monitor for capturing the entrepreneurial culture of the HEIs is the existence of measures that promote the engagement of professors in activities within the private sector. Finally, other important business culture aspects which may be indicative of the HEIs' entrepreneurial culture are related to teaching activities and indicators, such as the number of teachers coming from the industry or the number of entrepreneurial courses provided may help capture them, thus complementing the proposed indicator.

4.2.2 Participation of non-academic agents in the definition of curriculum development (level measure)

Relevant type of spillover: *Increasing the variety of knowledge sources; including the experience of practitioners in curriculum development; aligning education outcomes to industry skill requirements; reducing on the job training costs -> improve productivity*

The proposed indicator was favourably assessed in terms of conceptual appropriateness and was widely considered as an overall good signal of the availability of courses that nurture an entrepreneurial mind-set. The process of defining curricula, however, is far from being standardised across different contexts at national or even institutional level and, therefore, it may be difficult to reliably operationalise the proposed indicator.

More specifically, based on the feedback collected, it appears that non-academic agents can participate and provide feedback on the definition of curricula not only in many different ways but also with varying degrees of involvement, which would be quite difficult to quantify (both in terms of level and quality) so as to produce a level measure.

With that in mind, interviewees suggested that the different **types** of non-academic agent participation included in the scope of this indicator, as well as the way to determine the **degree** of their participation, should be clearly specified.

In fact, many interviewees suggested that the scope of the indicator should be made broad enough to include different types of non-academic agent participation and in this way account for the great diversity that exists across different EU Member States. However, it appears that the broader the scope of the indicator, the more difficult it would be to quantify the degree of involvement and by extension to actually operationalise the indicator.

The **backgrounds of non-academic agents** included in the scope of the indicator (e.g. politics, industry, social stakeholders, etc.) should be specified as well, as they may have a different impact on the curricula development process. In this respect, the insights from the interviews suggest that the focus could be placed on non-academic agents who have **business experience** or even better on those who are **entrepreneurs**.

Along these lines, the participation of non-academic agents with business experience or entrepreneurs in the definition of curriculum development may be an appropriate indicator to be employed.

Still, it is important to note that there are opponents to the idea of involving external people in the curricula design, who believe that curricula should be developed by the academic community and external people could only act as consultants. As such, it appears that although the proposed indicator seems to be generally accepted, the idea has not penetrated at the same level among the studied countries. In Bulgaria for example it is not a common practice to involve external people in the development of curricula, whereas in Poland this practice has already become part of the national HEIs' established processes.

Furthermore, the legislative framework in many countries makes it impossible for externals to be involved in curriculum development.

In this context, based on the feedback received during the fieldwork of the study, it appears that additional indicators could be employed to complement the proposed one with a view to capturing relevant aspects of the actual **teaching activities** of HEIs, as well as the **content of the curricula** with emphasis on **courses relevant to entrepreneurship**.

In fact, relevant indicators that were suggested by interviewees for measuring the aforementioned aspects are the existence (or the number) of entrepreneurial courses (often required by the HEIs' funding policies), the number of courses provided by industry representatives, as well as the integration of internships or on-the-job training into curricula. What is also important according to interviewees and may serve as a meaningful indicator, in this respect, is the existence of interfaculty-multidisciplinary study programmes, since innovation is often achieved at the intersection of different scientific disciplines. An indicator aimed at capturing the degree to which curricula address societal needs are accordingly updated and are close to the "state-of-the-art" may also be relevant according to interviewees, but at the same time rather difficult to measure as well.

4.2.3 Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS

Relevant type of spillover: *Creating a culture of enterprise which in turn alters the perception of risk - people educated in being less risk averse are more likely to catch opportunities and innovate.*

The interviews conducted during the fieldwork of the study confirmed that the teaching and learning activities of HEIs can have a major impact in terms of promoting an entrepreneurial mind-set and enhancing innovation capacity. In this context, the proposed indicator was perceived as technically feasible, as information would be relatively easy to collect at institutional level (if not already available). Still, its appropriateness in terms of fully capturing the aforementioned impact was challenged by the majority of the interviewees.

In particular, much of the feedback received revolved around the definition of entrepreneurship courses. It was perceived that the terms "entrepreneurship courses" may be seen as ambiguous and could be often confused with standard business degree courses. Indeed, several interviewees highlighted that the proposed indicator may be favourably biased towards HEIs that focus on business-oriented academic disciplines, in which entrepreneurship courses tend to be relatively more popular. Employing a complementary indicator such as the number of entrepreneurship courses in non-business study programmes may help account for this potential bias. Still, many HEIs integrate entrepreneurship elements into their study programmes (business orientated or not) which may not be easy to discern and include in the measurements made for the proposed indicator.

With this in mind, it appears that the proposed indicator can be improved by broadening its scope to include **courses which are not strictly focused on entrepreneurship but still involve relevant topics** (including innovation-related ones). The types of courses to be included within this scope should be specified, while the focus on ECTS may be omitted.

Another aspect brought up quite frequently during the interviews is that the proposed indicator mainly aims at capturing the business knowledge and skills acquired by the students and not the entrepreneurial culture developed through the teaching and learning activities of the HEI in general. In this respect, interviewees highlighted that it would be meaningful to also capture the "soft skills" required by the market (such as for example creativity, communication of ideas, flexibility etc.); however, entrepreneurship courses may prove to be too conceptually narrow to effectively capture them. There is also a recognised risk that entrepreneurial orientation might be equated with training or formal learning, when in reality entrepreneurship does not necessarily require formal training or learning as part of the academic curriculum. By the same token, enterprise education is not a guarantee of innovation and other mechanisms may be more conducive to improving innovation capacity.

Along these lines, some interviewees suggested that perhaps a better option would be to employ an indicator that would measure the **extent to which entrepreneurship is embedded in the curricula** rather than try to measure the number of dedicated modules[7].

The presence of project-based learning in courses, during which students learn through projects carried out with businesses was an interesting indicator proposed by interviewees in this respect, along with the number (or percentage of total) students who are engaged in such learning activities. In addition, several interviewees suggested focusing on more practical training, such as internships/placements, which may be more relevant to the aspect that the proposed indicator is designed to capture.

Given the above, it appears that the **actual interaction of students with innovative businesses,** as well as individual entrepreneurs, was perceived as being more crucial and influential rather than theoretical entrepreneurship courses, and thus may serve as a better indicator.

Other indicators that were proposed by interviewees as more relevant to entrepreneurial culture and industry interaction are: the number of courses where companies are involved, the percentage of students involved in collaboration with the industry. Given that apprenticeship programmes are also very important in this respect, the share of the time students spend in a company can be measured as well, with a view to capturing this effect and this information is relatively feasible to collect.

[7] An example of embedding entrepreneurship in curricula can be found in a pilot project conducted by the Quality Assurance Agency for Higher Education, Scotland (QAA). For more information: http://www.universities-scotland.ac.uk/wp-content/uploads/2016/03/US_MIH2_FINAL_16MAR16.pdf

Moreover, according to the insights collected from the interviewees, it seems that the proposed indicator does not provide any information about the educators' training on entrepreneurship.

In this respect, the team should consider utilising complementary indicators that will focus on the **entrepreneurial and/or overall business activity of HEI teaching staff**.

The percentage of HEI teaching staff, who currently work for the industry and/or have a business/entrepreneurial background, as well as the number of teachers who have received training in entrepreneurship and/or commercialisation of research results, were suggested as perhaps being more appropriate indicators of teaching and learning activities that foster an entrepreneurial culture. Finally, interviewees suggested looking into other relevant training activities provided by HEIs, such as workshops which are aimed at students and/or HEI staff and address entrepreneurship as well as innovation-related topics.

4.2.4 Number of ECTS awarded to international exchange students (ERASMUS students) as a percentage of ECTS

Relevant type of spillover: Internationalisation involving incoming students brings about opportunities related to diversity of culture and backgrounds. As such, spillovers of an international community could provide the increased variety in the knowledge generated.

The proposed indicator was perceived as conceptually appropriate and technically feasible, since the data required for its operationalisation would be relatively easy to generate and collect at university-faculty level, if not already available[8]. Still, it appears that there is some room for further improvement, especially with respect to better capturing the different dimensions of the internationalisation culture of HEIs.

In particular, the majority of the interviewees suggested to further disaggregate the proposed indicator based on different internationalisation dimensions, so as to provide a more comprehensive picture for policy and decision makers. For instance, many interviewees proposed to clearly distinguish between inward and outward flows of international exchange students and provide information about their geographic origin. In this respect, it is important to note that the way in which the indicator is currently described caused confusion to interviewees, who could not understand whether it refers to incoming or outgoing ERASMUS students.

Moreover, many interviewees highlighted that although the proposed indicator seems to be relevant to the internationalization culture, it is not conceptually broad enough, particularly because of its restriction to measuring just ERASMUS students. In addition, they also highlighted that the number of international exchange students may be easier to collect instead of the credits awarded to them. This would also allow for better comparability (and potentially benchmarking) across countries which do not employ the ECTS.

With the above in mind, it becomes evident that the focus of the proposed indicator on ERASMUS students may end up greatly limiting its scope (and thus its usefulness), which could in fact be broadened so as to include **other programmes** as well, taking explicitly into account both **incoming and outgoing exchange students**. A **distinction between EU and non-EU** countries may also be meaningful information for policy and decision makers.

[8] For instance, data for the proposed indicator are collected in the UK by HESA. For more information: https://www.hesa.ac.uk/

In addition to international student mobility, interviewees highlighted that what is also crucial and perhaps even more important in terms of building innovation capacity, is the international mobility of HEI staff (i.e. both inward and outward flows of e.g. academics, researchers, scientists and teachers, etc.). A complementary indicator that was suggested by interviewees in this respect is the number of HEI staff with a Ph.D. from a foreign HEI. In this respect, it is important to mention that according to the majority of the interviewees, HEI staff mobility is expected to be relatively harder to measure than the proposed indicator.

Other indicators suggested by interviewees under this category include: the number of students and scientists with different nationalities, the number of international internships provided, the presence of interfaculty courses offered in collaboration with international partners, the number of students and researchers in all exchange programmes, the number of courses provided in international languages, level of international activity of the professors, all international activity of students and staff, as well as the number of different countries represented in the total pool of international exchange students.

Finally, interviewees stressed that differences in national legislation will need to be taken into account before operationalising any of the different indicators proposed under this category. In the case of Slovenia, for example, HEIs encourage students to participate in exchange programmes, but the legislation that imposes the local language to be exclusively used in the courses provided by the universities creates barriers to attracting students from abroad (although measures have recently been taken towards removing this restriction).

4.3 Increasing the workforce pool indicators

4.3.1 Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation

Relevant type of spillover: Enhancing the fitness of local human capital creation with the local industrial setting.

The feedback received on this indicator through the interviews suggests that it is conceptually relevant. At the same time, however, interviewees highlighted that it is based on the assumptions that all job positions relative to the studies of students (and all educational levels) are potentially innovative and the matching between studies and occupations supports innovation and creativity. These assumptions can be challenged, given that not all job positions are related to innovation and that interdisciplinary occupation could also bear substantial capacity for innovation (for example, an engineer could be innovative working in a different profession/ work environment as well). Besides, the extent to which the occupation of people matches their human capital level cannot be easily defined objectively and innovation or creativity is often found in career paths where employees work in a completely different sector from their original qualification.

Furthermore, the proposed indicator appears to be highly dependent on the labour market characteristics of each country according to the opinions of the interviewees, many of whom expressed concerns that it may be influenced by fluctuating market conditions and field-specific characteristics. In Belgium, for instance, people typically tend to find occupations that are related to their studies, especially in the field of applied sciences. However, this might not be the case in every country, where employment rates may also vary significantly. On a similar note, in the UK one year after graduation is too soon to obtain an accurate picture for the proposed indicator, because of the very large job mobility occurring during the first years after graduation. Early-career jobs tend to be a poor indicator of later-career jobs. Soon after graduation a big proportion of graduates are employed in non-graduate level jobs, but these differences tend to even out and around 90% would be employed in graduate level jobs after 18 months. Thus, depending on when you perform the measurement, the outcome of the proposed indicator will differ significantly.

At the same time, the feedback received hints that although the proposed indicator can prove useful for specific purposes, such as for adapting HEIs' curricula to labour market requirements, it may overall serve more as a signal of graduate employability and their ability to find a job rather than of the contribution of HEIs to innovation capacity.

In this context, the insights collected through the interviews suggest that the proposed indicator should be complemented with a clear and objective definition of **what is considered as "human capital level"** within its scope (e.g. number of years in education, focus of studies, educational level, etc.) as well as **how its match with the occupation of graduates is to be determined** (e.g. through the use of perceptual measures collected by surveying the graduates). Furthermore, a definition of "**cohort**" should be included in the indicator along with the specific time after the graduation of the cohort of students that the measurement should be implemented (e.g. 1 year).

Some interviewees also suggested that it may be meaningful to distinguish the indicator by academic discipline, since in some disciplines job seeking results more easily and faster in finding a job than in others.

On another note, the feedback received with respect to the technical feasibility of the proposed indicator, suggests that data availability varies among the different countries. For example, data related to indicators that focus on the employment of HEI graduates seem to be used in Scandinavian countries and are already available either through statistical registries or surveys. In other countries, however, the data required for the operationalisation of the proposed indicator may be more difficult to find, particularly regarding the matching between studies and occupation. Relevant information could be provided by alumni networks, HEI data collection programmes and career advice offices, as well as labour authorities or other reliable sources of statistics[9].

Overall, the use of the International Standard Classification of Occupations to match occupations with qualifications acquired through higher education has been proposed. This is considered essential for ensuring the consistency and comparability of the proposed indicator.

4.3.2 Number of STEM graduates; Number of total graduates; Number of total HEI staff with Postgraduate Degrees

Relevant type of spillover: *Maintaining an adequate overall level of human capital in the region*.

"Number of STEM graduates" and "Number of total graduates"

The proposed indicator "Number of STEM graduates" received mixed assessments during the interviews. On the one hand, it was perceived to be relevant in terms of enhancing the innovation capacity of an economy and even more so for certain regional contexts characterised by specific business needs (e.g. regions where there is a high demand for engineers, etc.). On the other, the focus on STEM graduates does not take into account a

[9] For instance, in the UK, HESA's DLHE survey of graduates collects data on occupation, industry, salary and location 6 months after the completion of their studies.

quite substantial part of HEI activity and contribution to innovation capacity, as graduates from disciplines such as Social Science and Humanities have a great involvement in innovation and entrepreneurial activities as well.

With the aforementioned in mind, it appears that it would be meaningful to widen the scope of the indicator to include **graduates of non-STEM disciplines**. Their number would be better expressed as a percentage of the total number of graduates. Furthermore, the indicator could include the number of graduates disaggregated by **academic discipline** as well as **educational level** (e.g. Bachelor's, Master's, PhD, etc.). In this respect, the educational level to which the term "graduates" refers to will have to be clearly specified, since it may not refer to the same education level in all European countries.

At the same time, adopting a wider scope for the proposed indicator would also be aligned with the EU agenda to get innovation activity into non-STEM disciplines in Horizon 2020. Relevant indicators that were proposed by interviewees in this respect include the share of graduates by academic discipline in the total population of graduates, the share of graduates per level of education (i.e. Bachelor's, Master's, PhD, etc.), again in the total population of graduates, as well as the total number of interdisciplinary graduates.

Still, it is important to mention at this point that some interviewees highlighted that the number of graduates may not be adequate enough to effectively indicate their innovation potential without any assessment of the quality of their studies and forcing an increase in their numbers could lead to a decrease in the quality of education. With this in mind, an additional indicator that was proposed is the number of interdisciplinary study programmes, assuming that interdisciplinary studies promote innovation potential through the combination of scientific knowledge.

All in all, the necessary data for measuring the aforementioned indicators were found relatively feasible to access at institutional level. It appears that these data are already being collected centrally in specialized education databases (e.g. the Higher Education database in Belgium) or by ministries of education and national statistical offices.

"Number of total HEI staff with Postgraduate Degrees"

The feedback received on the "Number of total HEI staff with Postgraduate Degrees" hints that this proposed indicator is also relevant to the quality of teaching to some extent. However, during the fieldwork, a large number of interviewees expressed the opinion that it is not clear what kind of staff is included within the scope of the indicator.

As such, based on the comments of interviewees, the definition of this indicator should clearly specify the **type of HEI staff** to be included within its scope (for example professors, researchers, administration etc.).

In this respect, the insights collected via the interviews suggest that it is very common across EU Member States for post graduate studies (even doctoral studies) to be mandatory for teaching staff in HEIs and, in any case, having a post graduate degree does not necessarily mean an increase of innovation potential.

It appears that the scope of the indicator could be purposely kept wide enough to include the **total staff of HEIs**.

In fact, the number of total staff with a post graduate degree is a performance indicator already used to assess colleges and universities in some countries (e.g. in the Netherlands).

In cases where the indicator is not already in use, however, it may imply additional effort to collect the required data at HEI level, since they will probably not be recorded centrally.

4.3.3 Percentage of PhDs undertaken jointly with a private (non- academic) partner

Relevant type of spillover: *Providing a stable pathway for combining theoretical and practical know-how; – permits engagement of research relevant to firms' objectives, lowers transaction costs of future recruitment (lowers skill mismatch).*

Mobility was perceived by interviewees as a very important channel through which HEIs contribute to innovation capacity. In fact, the activity addressed by the proposed indicator was considered not only conceptually relevant but also crucial and quite widespread between HEIs and businesses. Still, many interviewees suggested that the current scope of the indicator should be broadened so as to take into account all types and facets of inter-sectoral mobility.

Indeed, insights from the interviews indicate that it would be meaningful to expand the scope of the indicator to also include **similar activities at Bachelor's as well as Master's level**. For example, the team could consider including the interaction between students and industry through internships, apprenticeships or other forms of formal placements at undergraduate and postgraduate levels.

Moreover, some interviewees suggested that it would be useful, mainly from a policy perspective, to disaggregate the proposed indicator by type of private non-academic partners (e.g. SMEs vs. larger enterprises) or even by their country of establishment (e.g. domestic vs. foreign businesses). Complementary information on similar collaborative activities with organisations of the public sector may be quite useful as well. The percent of students volunteering and collaborating with the industry and/or non-academic public organisations at undergraduate and postgraduate level was proposed as a meaningful indicator in this respect.

In general, however, some interviewees highlighted that the concept that the proposed indicator is aimed at capturing may be more applicable to technology-oriented studies. Moreover, according to them, the team should note that there may be differences amongst universities due to internal research regulations or different organisational cultures. In Slovenia for example, collaboration with the industry is not common in the course of a Ph.D. and there is significant research orientation towards basic science, while researchers and professors are mainly evaluated based on papers' production. In some cases, companies may also not be interested in such collaborations in order to safeguard their intellectual property, but in general they get involved to solve research problems and find potential talents to hire.

In any case, when looking into the types of collaboration that are to be addressed by the indicator (e.g. having a mentor from the industry), the team needs to provide clear definitions in order to be able to collect data efficiently and reliably, as many interviewees highlighted.

In this respect, it appears that the proposed indicator ought to be accompanied with a precise definition of the term "**jointly undertaken"** so as to allow for reliable measurements across different contexts.

In terms of technical feasibility, the indicator appears to be highly dependent on national/regional particularities. In Germany, for instance, there is a long tradition of collaboration between HEIs and companies in the frame of Ph.D. programmes and the majority of PhD students would meet the criterion of the proposed indicator. However, there is no comprehensive registry in this respect and consequently it would be rather difficult to collect reliable data on whether the Ph.D. has been actually undertaken jointly with a private non-academic partner. A relatively similar situation applies to Denmark as well, where there are plenty of informal collaborations between Ph.D. students and private companies during Ph.D. programmes, with no centrally available statistics. Still, in Denmark there is also the possibility to enrol in an Industrial Ph.D. programme where the time is split between the HEI/public research institution and a private company. Information on these Ph.D. programmes would be possible to collect reliably.

All in all, it appears that the data required to operationalise this proposed indicator are most probably not collected centrally in many countries (e.g. in Belgium) at the moment, thus making their collection relatively challenging at EU level.

Finally, the feedback received from the interviewees highlights the importance of also considering **teachers' mobility** under this indicator category. A potentially appropriate indicator that was suggested by interviewees in this respect is the **number of HEI staff that also hold (part-time) positions in the industry** or other non-academic public organisations.

4.3.4 Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs etc.)

Relevant type of spillover: By systematising practical experience to facilitate application across contexts, further training can equip workers with the skills to be more efficient, driving up productivity.

The lifelong learning activities of HEIs were perceived as highly relevant for increasing the knowledge and skills of the workforce in an economy. The indicator proposed was found conceptually relevant by interviewees in this respect and especially in terms of capturing some aspects of the degree to which academics interact with the market, serving as a marker of academics who are connected with the industry and understand the needs of businesses. At the same time, however, the fieldwork revealed that the proposed indicator alone does not appear to be sufficient for capturing all aspects of lifelong learning activities, as the percentage of academics teaching in courses required by non-academic agents may not necessarily reflect the level and quality of their involvement in this respect.

In this sense, it would be meaningful according to some interviewees, to shift the focus of the indicator in order to capture the **proportion of the total time** that academics allocate to teaching in courses required by non-academic agents rather than simply their number (or percentage). The **types of courses** to be included within the scope of the indicator should be clearly specified so as to safeguard the reliability of the measuring process.

Even so, however, insights from the interviews suggest that the focus of the proposed indicator on the supply side of lifelong learning may hamper its effectiveness in capturing the degree to which this type of HEI activities contribute to innovation capacity.

In particular, many interviewees suggested focusing on the **demand side** as well, utilising additional relevant indicators, such as the number of non-academic participants in lifelong learning activities, as well as the revenues that HEIs generate through the provision of lifelong learning.

This kind of demand side indicators would serve as a better signal of the value that lifelong learning activities offer to non-academic agents, and by extension of the contribution of HEIs to innovation capacity.

Other indicators proposed under this category include the following: number of employees attending courses of the HEI; number of lectures and study days organized for the public (alumni networks, companies); availability and/or number of courses designed and available for employees of non-academic agents (especially part-time study programmes for employees); the revenues which HEIs generate through these activities; number of lifelong learning courses offered regularly by the university; number of seminars and ad-hoc events organised and attendance numbers; and finally, the number of employees working outside the HE sector who participate in relevant programmes provided by HEIs.

With respect to the technical feasibility of the proposed indicator, it appears that in some countries (e.g. Belgium) it is currently quite hard to find the necessary information, since it is not reported or collected centrally at the HEI level. In fact, many interviewees expressed concerns with respect to the collection of statistics on lifelong learning activities of academics, as they tend to offer this kind of trainings outside the framework of their HEI and thus have no reporting obligations. In many cases, interviewees even mentioned that academics may be reluctant to provide this information to their HEIs, as these activities are considered to be outside the scope of their academic duties.

4.3.5 Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university

Relevant type of spillover: Capturing new talent that has potential to minimize the risk of inertia in the local skill base.

The insights collected during the fieldwork of the study revealed that there is, in fact, a quite diverse array of determinants that influence the decision of a student to attend a specific HEI, other than the particularities of the HEI itself. This great diversity implies an inherent difficulty in determining the true reasons which lead students to study at a certain HEI. For example, it might be a choice made unwillingly rather than intentionally (e.g. the available spaces in a student's first HEI of choice were all occupied in the year of application) or even for other non-educational reasons (e.g. overall popularity of the region or the HEI, individual preference of studying at a city rather than in a rural town, etc.). With this in mind, it appears that the proposed indicator, albeit relevant to talent attraction and retention, may present relatively diluted results which ought to be interpreted with caution, while taking into account the specific context of HEIs (e.g. geographic position and socio-economic characteristics of the region, language, cost of living, etc.).

In this light, the conceptual appropriateness of the proposed indicator was challenged by the interviewees during the fieldwork of the study. More specifically, some interviewees highlighted that the indicator may be more reflective of the overall attractiveness of HEIs rather than of the talent of the people who they attract. Furthermore, it seems that it does not adequately capture the retention level of graduates in the area/country in which they complete their studies, an aspect which may be more essential in terms of measuring the contribution of HEIs towards enhancing the innovation capacity of the regional economy.

In this respect, several interviewees stressed the importance of focusing the scope of the indicator on **graduates (and not undergraduates) who moved to the region of the HEI and actually chose to stay there after the completion of their studies** in order to find a job.

Moreover, the current definition of the indicator does not differentiate between students who moved from a neighbouring region and students who moved from abroad, and thus is not sensitive enough to identify the relative weight of people attracted from other countries. Furthermore, the actual operationalisation of the indicator, as many interviewees highlighted, may prove to be problematic due to difficulties in terms of defining the region (travel-to-study-area) of HEIs.

Along these lines, many interviewees suggested that it may be more meaningful to track **students that come from abroad and stay in the country (and not necessarily the region)** of the HEI, especially in the context of relatively smaller EU Member States.

An interesting indicator proposed by interviewees in this respect is the number of foreign students who choose to remain in the region/country of the HEI after their graduation and actually manage to find a job after a given period of time (e.g. 1 year after graduation).

In terms of technical feasibility, it is important for the team to keep in mind that the data needed for the operationalisation of the proposed indicator appear to be rather difficult to collect, especially in cases where they should also measure retention levels. For instance, in some member states (e.g. in Germany), the collection of reliable and comparable data for the proposed indicator would be relatively challenging to realise at national level due to the diversity of the statistics collected (or not collected) across the different regions and their regional HEIs. On the contrary, in Denmark and the UK relevant data seem to be already collected. In any case, this data collection would be feasible only while students are affiliated with the HEI; otherwise, access to these data is subject to legal barriers (e.g. personal data regulations).

Finally, the **attraction of talented researchers** appears to be an important aspect that could be taken into account in the proposed set of indicators as well. The number of foreign faculty members could be employed as an indicator in this respect.

4.4 Commercialisation indicators

4.4.1 IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)

Relevant type of spillover: *Valorisation of knowledge and bringing academic knowledge closer to commercial application*.

An indicator which focuses on the knowledge transfer activities of HEIs was perceived as highly appropriate to gauge their contribution to innovation capacity. The proposed indicator along with its focus on the commercialisation of Intellectual Property Rights (IPR) was, overall, well-received by most of the interviewees. In fact, indicators on IPR commercialisation are already in use not only at institutional but also at policy level.

The emphasis of the proposed indicator on IPR, however, also has several implications which were highlighted during the interviews. In particular, the focus on IPR revenues (instead of, for instance, the actual number of licenses/patents or the percentage of patents that have somehow been commercially exploited) may induce an inherent favourable bias towards HEIs which have produced a few "blockbuster", potentially innovative patents, underestimating at the same time, the impact of the number of patents produced by another HEI. Subsequently, HEIs which may have not produced such highly successful patents yet but are quite active in patenting and licensing may not fare as well in the proposed indicator.

Moreover and perhaps more importantly as well, many HEIs do not base their knowledge transfer activities on patenting and licensing. However, this by no means implies that they do not collaborate with businesses and exchange valuable knowledge with them (e.g. through consultancy). Indeed, insights derived from the interviews indicate that IP figures are skewed towards certain types of universities and activities, and can potentially lead to distortions when used to inform funding decisions. While IP revenues may be seen as a standard and natural measure for research-intensive universities, the same measure may not be very meaningful for teaching-focused universities or universities not specialising in Medicine and STEM subjects.

Along these lines, concerns were also expressed with respect to the applicability of the proposed indicator in certain national contexts. For instance, it does not appear to fit well within the context of Finland and perhaps even less so in Sweden. On the one hand, according to the interviewees, HEIs in Finland typically tend to commercialise their IPR through start-ups or even existing businesses and in result may not fare as well in this proposed indicator. In Sweden, on the other hand, the “professor's privilege” entitles researchers, instead of institutions, to patent (and by extension license) their inventions and, as such, Swedish HEIs are not usually oriented towards commercialising IPR through licenses. In addition, some interviewees expressed their concern with respect to developing an inflated sense of the actual business impact of IPR, given that sometimes the costs of protecting IPR can outstrip any revenues, when a lot of innovative knowledge is openly available to the public nowadays.

With the above in mind and as many interviewees highlighted, an indicator focusing solely on IPR, albeit a meaningful measure, may not be sufficient to capture the diverse knowledge transfer activities of HEIs. It ought to be complemented with **additional measures that represent different paths of Knowledge Transfer (KT) and are treated separately**, providing a more complete picture of this aspect of HEI contribution to innovation capacity. As an alternative, the proposed indicator could focus on the **total revenues generated from KT activities,** following a more generic approach and capturing all the different activities that create revenue through knowledge transfer.

In this respect, given the proposition of interviewees to focus on the total revenues generated from KT activities, it is important to note that the constituents of total KT income, as defined by the proposed indicator were not found to be exhaustive by the interviewees (e.g. the revenues generated from contract research provided to businesses appear to be missing). Moreover, according to interviewees, the different components of total KT income (including IPR revenues) may be more meaningful if measured over the total funding for research or as a percentage of the total HEI income. The difficulty of measuring them (and especially consultancy), however, was frequently stressed during the fieldwork, indicating that the operationalisation of an indicator that would encompass all KT activities may encounter problems in terms of technical feasibility.

All in all, based on the fieldwork, it appears that information on IPR commercialisation required to operationalise the proposed indicator may become increasingly accessible in the future, as governments become more and more interested in this activity of HEIs and encourage the collection of this kind of data. However, the total KT income may prove rather harder to measure, especially if a process for aggregating the data required is not established.

4.4.2 Student start-ups (total active start-ups, turnover, private funding raised)

Relevant type of spillover: Entrepreneurial activities associated to starting up a business involve: employment growth, potential exports etc.

During the fieldwork of the study, the spin-off activity of HEIs was generally recognized by interviewees as a very important factor contributing to innovation capacity. In particular, start-up companies linked to a HEI appear to be a very good proxy for capturing this contribution based on interviewees' feedback, but the link should be clearly specified within the definition of the indicator by focusing on **spin-off activity**, since start-up companies are not necessarily spin-offs (particularly in the case of graduate start-ups).

Indeed, several interviewees stressed that the emphasis on start-ups may be more indicative of the entrepreneurial culture of the HEI rather than the extent of its actual spin-off activity and the number of research-fuelled spin-offs appears to be more relevant to the concept which the proposed indicator is aimed at capturing.

With the above in mind, it appears that an indicator **focusing explicitly on spin-offs established by students utilising knowledge produced within HEIs** (and not start-ups in general) would be more appropriate for the proposed indicator set, as many interviewees highlighted. This indicator would be more interesting from a policy perspective as well, since spin-offs may be considered as more relevant outputs of public investments in HEI research.

Still, it is important to note that other views suggested that, while many student start-ups end up not being viable as businesses in the long run, they can help to enhance the students' employability regardless of their business results and thus, they can serve as a platform to move into employment. Therefore, the proposed indicator needs to be seen in a broader context despite its constraints and problems (e.g. it may be more applicable to applied science and business faculties than to humanistic sciences or it may be dependent on national regulatory frameworks that might limit or hinder such activities). According to interviewees, university managers tend to regard student start-ups as a much broader concept than commercialisation; they perceive them as an indicator of contribution to innovation capacity and not just in a direct commercial/economic sense.

Along these lines, a **separate indicator for student start-ups**, especially in innovative sectors, could be used along with spin-offs.

However, measuring the number of start-ups would be particularly hard and data would hardly be reliable and comparable, because it seems that there is not a common understanding of the definition of a start-up company.

Furthermore, and perhaps more importantly, spin-offs and start-ups founded by faculty members were considered by the majority of the interviewees as a more appropriate focal point for the proposed indicator.

In this light, the indicator should also take into account the **spin-offs and start-ups established by HEI staff members, professors and researchers and not only by students** (or graduates). To this end, the indicator should include a clear definition of the terms "**spin-off**" and "**start-up**" as well as of the term "**student**" (i.e. it should specify if graduates are also included in its scope and, if so, until how many years after their graduation they should be included in the measurements).

In this context, several interviewees suggested that a more comprehensive approach should be followed to define and monitor spin-offs and start-ups of HEIs. More specifically, according to insights from the fieldwork, the indicator to be utilised in this framework should be approached over a longer period of time, in order to study the sustainability as well as the growth of the companies (a 3- or 5-year time frame was suggested as suitable).

In this respect, the long-term survival rate of the companies was perceived as a rather crucial metric for the indicator (i.e. the percentage of companies still active 5 years after establishment), along with the number of jobs created, as both are quite important when measuring their impact on innovation capacity and the economy in general. Still, this would make the operationalisation of the indicator more challenging in terms of data collection.

In addition, the private financing raised by start-ups and spin-offs was also considered, albeit more often than not as sector-dependent, as a relatively more appropriate metric for the proposed indicator, especially throughout their initial development stages, during which their turnover may not be significant and thus not a meaningful metric.

Still, based on the insights collected from the interviews, it appears that information on the turnover, profitability, and private funding of start-ups and spin-offs, although relevant and meaningful metrics for the proposed indicator, is harder to collect and thus measure, than simply their number, especially in the long term.

Finally, other indicators suggested as relevant by interviewees include the number of start-ups and/or spin-offs funded against their total number (even though it may be dependent on the particularities of regional funding ecosystems,) as well as the number of start-ups and/or spin-offs hosted in the incubators, science parks and/or business accelerator programmes of HEIs.

4.4.3 Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership

Relevant type of spillover: *Creating support for Research into novel businesses (pre-development phase); Cluster effects: social capital and trust.*

The conceptual relevance of the proposed indicator was perceived as excellent by the vast majority of the interviewees, who particularly stressed the importance of the infrastructure within its scope for taking new ventures successfully off the ground. Still, concerns were expressed with respect to the terminology employed by the proposed indicator, which may hinder its seamless operationalisation.

More specifically, the term “**active involvement**” should be accompanied by a clear definition in order to enable the collection of reliable measures. “**Small office areas**” was also perceived as a vague term and should be further elaborated[10].

Additional infrastructure that could be integrated within the scope of the proposed indicator, according to the interviews, includes any joint or shared infrastructure with the industry, technical facilities available for rent or use in the frame of technological services (e.g. laboratories, prototyping facilities and equipment, etc.) as well as technology transfer offices, innovation hubs and networks with entrepreneurs, co-working spaces and pre-incubators.

On another note, some interviewees suggested that simply measuring the presence and number of the commercialisation infrastructure of HEIs does not take into account the

[10] For instance, the difference between incubators and small office areas was not obvious to the interviewees and should be clarified.

extent to which these are used (e.g. what if a university has plenty of office areas but they are not in use) or the effectiveness of their activities and, by extension, their actual impact on innovation capacity. Technically feasible proxy indicators that may be used in this respect are the number of people or companies that use the infrastructure and its services, as well as the amount of revenues generated by these infrastructures and their allocated budget.

In this respect, the significant role of the employees working in the research commercialisation field was frequently highlighted during the interviews, given that they are the ones who can determine how the infrastructure is exploited and how much value it can offer. Indeed, interviewees stressed the importance of monitoring the number of employees (FTEs) occupied with research commercialisation, as well as their profiles and qualifications on knowledge transfer, in order to capture their actual effect on innovation capabilities.

Overall, the technical feasibility of the indicators under this category has not raised many concerns during the fieldwork, indicating that the data required for their operationalisation would be feasible to access and collect.

4.4.4 Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)

Relevant type of spillover: *Creating support for the Development of novel businesses (post-research phase); scouting of new business opportunities.*

The proposed indicator was perceived by interviewees as highly appropriate and complementary to the indicator on the presence/number of commercial infrastructures. Moreover, according to the fieldwork, the different measures of the proposed indicator appear to have adequately captured the typical service offers of such infrastructures. Still, several interviewees highlighted that when it comes to business advice, not all support provided is potentially linked with innovation. In this respect, some interviewees suggested that the indicator should not exclude advice provided to the public sector, while the provision of networking and matchmaking services could also be included within its scope**.**

With that in mind, it appears that the proposed indicator should be supplemented with a definition of **what is considered as business advice** within its context, ensuring a common understanding of this service and thus safeguarding the reliability of the measurements. In fact, **all services included in its scope should be better clarified** to avoid misinterpretations of the indicator (e.g. participation in seed investment and venture capital may not be allowed by national regulations for HEIs in some countries, whereas providing services aimed at facilitating the access of companies to such funding sources may be possible). Moreover, **networking and matchmaking services** provided by the infrastructure may also be included as an appropriate metric within the scope of the indicator.

The data required to operationalise the proposed indicator appear to be relatively feasible to collect based on the feedback received from the interviewees. In some countries they might even be already available (e.g. in the UK, data on commercialisation infrastructure and services are already captured by the HE-BCI survey). Still, in EU Member States where they are not, they would need to be collected at the institution level.

At the same time, however, the insights derived from the interviews suggest that the quality of the services provided by commercialisation infrastructures, the degree they are being utilised, as well as their impact, may be a far more important indicator for policy and decision makers. In fact, many interviewees suggested that a qualitative assessment of the services would be necessary in this respect. The collection of the information required for this qualitative assessment may, however, have a considerable negative impact on the technical feasibility and thus, the actual operationalisation of the indicator.

Alternative indicators which may be employed in this context are the number of firms served (even disaggregated by type of company such as large firms, SMEs, etc.) and the revenues generated by the provided services, with a view to capturing more information on their added value.

4.5 Research 'reach-out' indicators

4.5.1 Number of publications between academic researchers and industry

Relevant type of spillover: *Co-authorships signal collaborative activity that may provide market insights and catalyse the commercialisation interest and entrepreneurship of university researchers*.

The proposed indicator was widely regarded by interviewees as a simple yet clear and relatively good indicator of collaborative R&D between HEIs and businesses. In fact, based on the fieldwork carried out in the frame of the study, it appears that its use is quite widespread (at least in Scandinavia), providing further evidence of its conceptual appropriateness.

Still, many interviewees highlighted that the proposed indicator can exhibit a lot of variability across different disciplines/sectors and may be distorted by the existing use of publication incentives and rewarding schemes that influence the careers of academics. In other words, the high motivation of academics for publications ("publish or perish") may lead to an increase in their number without necessarily meaning an analogous increase in the generation of innovative outcomes.

Moreover and given that in some countries (e.g. Slovenia) publications with partners from the industry are not recognised as highly as the ones made with other academics, some interviewees suggested that academics may not be interested in producing publications with the industry. At the same time, companies are also often not particularly interested in producing publications, as they can be time-consuming and may involve the risk of exposing sensitive information about their research results and intellectual property.

In this context and in order to be more widely applicable and comprehensive, the proposed indicator could incorporate **peer-reviewed publications**, **professional publications** (where university colleges also publish), as well as **conference proceedings**. A distinction between domestic and international publications could be meaningful as well.

In terms of technical feasibility, information for the proposed indicator is already available at national as well as international level (e.g. at university rakings, EU statistics, OECD statistics, etc.). Additionally, there are widely used scientific publication databases that can provide the necessary information (e.g. Scopus, Google Scholar and Web of Science). A typical problem, however, associated with reliably measuring the number of co-publications is the difficulty in determining the affiliations of the authors, as mentioned by the majority of interviewees.

All in all, however, the insights collected from the field work clearly indicate that not all collaborative R&D activities lead to scientific publications.

Indeed, several interviewees stressed that the proposed indicator should also be

complemented with other indicators in order to more accurately capture the breadth of collaborative R&D activities.

Going beyond bibliographic measures of collaborative R&D outputs, alternative indicators that were proposed by interviewees as potentially conceptually relevant encompass jointly-created clusters, networks, centres of excellence, etc. Co-patenting may also serve as an indication of collaborative R&D, as well as the provision of scientific/technology services (e.g. use of equipment or laboratory facilities) and contract research. An additional relevant indicator that was proposed in this respect is the number of projects/PhDs undertaken in collaboration with companies and also with the public sector (e.g. EU-funded projects in the framework of Horizon 2020).

4.5.2 University research funded by industry and by charities/ foundations (number of projects, total value and percentage of total)

Relevant type of spillover: Collaboration can generate complementarity effects in terms of knowledge sharing and transfer. Also, collaborations enhance trust among partners and favour the creation of social capital.

The insights collected from interviewees during the fieldwork of the study suggest that, even though this proposed indicator appears to be relevant, it may not be effective in capturing collaborative R&D activity. Indeed, interviewees highlighted that university research funded by the industry and/or by charities/foundations (also referred to as contract research) does not necessarily imply actual interaction and knowledge-sharing amongst them in the framework of collaborative R&D activities.

With this in mind, it appears that the team needs to carefully clarify the kind of collaboration that the indicator is aimed at capturing and by extension, the projects which are to be included within its scope.

In this respect, some interviewees suggested **focusing on research activities conducted with external non-academic partners** (e.g. from industry, public authorities, NGOs, etc.) and not on those that are simply funded by them. In fact, it would be meaningful to **separate university research funded by industry from the research conducted with financial resources from charities/foundations** or from public sector organisations, as the goals of each may greatly differ (e.g. business problems vs. societal challenges). It would also be interesting (at least from a policy perspective) to distinguish between research funded by SMEs and larger enterprises. Moreover, based on the interviewees' feedback, the proposed indicator could be improved by expanding its scope so as to take into account **publicly-funded collaborative R&D project and activities** (both at national and EU level, such as Horizon 2020 projects).

The feedback received with respect to the metrics of the proposed indicator suggests that the number of projects, especially of collaborative innovation projects (e.g. EU-funded projects), appears to be more useful compared to the (percentage of) total value of research funded from external sources. Still, the total value may be easier to find in the book-keeping records of HEIs and thus operationalise, provided that further clarifications are elaborated for calculating the percentage of total value (i.e. define what the total value to be measured here is exactly and what the specific projects and activities, which are to be considered as funded research in this context). Even so, however, the actual figures will be very dependent on the size of the companies with which the HEIs are engaged. An alternative indicator that was suggested by interviewees in this respect is the number of joint applications made with industry partners in order to acquire research funding.

Overall, in terms of data collection, the proposed indicator was viewed by interviewees as not presenting challenges, since the data required for its operationalisation appear to be possible to collect by HEIs. In fact, information on HEI research funded by external sources is already being collected in some countries. However, in many cases the available data are mainly collected on an aggregate level without a detailed distinction amongst the various sources of research funding. Thus, a greater level of disaggregation may adversely affect the technical feasibility of the proposed indicator.

4.5.3 Income, total value, number of contracts (by: SME, large firms, commercial, non-commercial)

Relevant type of spillover: *Close to demand pull logics via the direct provision of knowledge services to firms. Responding to needs of a greater variety of stakeholders (without structured industrial R&D units) most notably SMEs. Can create bridges between SMEs and HEIs: successful engagement leads further positive externalities.*

The fieldwork revealed that the proposed indicator appears to be relevant to enhancing innovation capacity and is particularly important for firms or public organisations that have not developed strong in-house R&D capabilities. Still, its phrasing appears to have created some confusion amongst interviewees in terms of the type of consultancy to which it refers.

With this in mind, the indicator should be rephrased to clearly indicate whether its scope includes only **consulting contracts of the HEI signed at an organisational level** (e.g. in the frame of contract research or subcontracting) **or** also includes **advisory services provided to firms by professors and researchers at an individual level**.

In this respect, interviewees highlighted that it may be difficult to distinguish between consultancy contracts and collaborative projects or R&D contracts of HEIs. Therefore, the definition of consultancy in the context of the indicator should be very clear to guide reliable measurements. Moreover, the insights collected from the interviews attested to the fact that consultancy services provided by academics at an individual level are not only a crucial way in which HEI staff contribute to innovation capacity, but also quite widespread in many countries, and thus a great indicator in this context. Still, from a technical perspective, individual private contracts of staff members of HEIs are not publicly available and are often not reported internally to the HEIs, which would make their measurement rather difficult. On the other hand, relevant data on consultancy contracts of HEIs are relatively easier to find (e.g. in the book-keeping records of HEIs), but the differentiation between SMEs, large companies, commercial and non-commercial contracts might prove difficult to trace.

All in all, based on the feedback received from the interviews, it appears that it might prove challenging to operationalise the proposed indicator with reliable measurements.

4.6 Public engagement indicators

4.6.1 Presence in traditional and social media by staff and by students relating their knowledge

Relevant type of spillover: *Wider engagement involves the public early in debates, decisions and policies about the acceptability of new technologies/innovation; or, helps in shaping* *public knowledge, trust attitudes about the perception of risks and benefits associated with new technologies.*

This proposed indicator was met with the most scepticism during the fieldwork of the study. In particular, the concern that many interviewees expressed was that the presence in social media (e.g. via a LinkedIn profile), especially of students, is not directly contributing towards enhancing innovation capacity. To the contrary, engagement in traditional media was perceived as more relevant to the contribution of HEIs to innovation capacity, albeit only to a relatively small degree. In fact, presence in traditional media was considered by interviewees as more relevant to creating awareness and disseminating research. However, this kind of activities involve the interaction of academics with the economy as well as the society that may in turn trigger collaborations that could lead to innovation. In this context, the majority of interviewees assessed the proposed indicator as conceptually relevant and meaningful from a policy perspective, serving as a signal of the interactions between science and society.

Along these lines, interviewees' suggestions for the improvement of the indicator include narrowing its scope to include only **media engagement activities of HEI staff (and not students) relevant to research dissemination**. According to their feedback this would not only be more meaningful but also more technically feasible.

In this respect, it appears that it would be relatively difficult to reliably measure the proposed indicator as the way this type of information is reported across HEIs varies greatly. Moreover, interviewees highlighted that the phrasing of the indicator is too generic at the moment (i.e. in terms of what exactly needs to be counted) and therefore the collection of relevant data could prove to be problematic. Still, the communication and dissemination departments of HEIs may keep some relevant records for official communication activity, which could be utilised for collecting relevant data.

In general, however, a **standardised process** (including the definition of a measuring system as well as units) to produce data for the indicator, along with the various activities that should be included within its scope, would have to be elaborated in order to safeguard its reliability and validity. To this end a **qualitative approach** may be more suitable in order to be able to effectively discern media engagement activities relevant to research dissemination.

Alternatively, the number of communication events organised by HEIs was proposed as a potentially suitable metric for the indicator which, according to interviewees, would be easier to operationalise.

4.6.2 Third Mission/ Societal Engagement objectives included in HE policy or strategies

Relevant type of spillover: Strengthens links with local communities adds to problem solving of local issues leading to greater local economic development.

The third mission of HEIs was regarded as vital in terms of building the innovation capacity of the economy and society as whole. In this context and with the proposed indicator in mind, the majority of the interviewees highlighted the gap that may exist between the stated societal engagement objectives and the activities, as well as the impact of HEIs in this respect. Nevertheless, many interviewees also stressed that such objectives ought to be embedded in the strategy and policies of HEIs and in this sense, given its technical feasibility as well, the inclusion of the proposed indicator in the set appears to be justified.

From a technical perspective, the information for the proposed indicator needs to be investigated at the HEI level. The data required can be traced from the mission statements of HEIs. However, the comparability of data may prove challenging due to the diverse definitions of societal engagement followed by different HEIs.

Alternative measures suggested for this indicator by interviewees include the budget allocated by HEIs to societal engagement activities and the number of academics involved in such activities, any incentives or rewards provided to academics (or students) to this end and the number of relevant events organised. The number of contracts or projects carried out (or currently underway) for the public sector, the region or NGOs, were also proposed as more tangible measures, which can potentially reflect the level of HEI participation in shaping regional/national strategies. Finally, some interviewees suggested that separate measures should be developed for (i) the engagement activity of HEIs with their local communities and (ii) their participation in the formulation of social policies and strategies at local, regional and/or national level.

4.6.3 HEI budget allocated to educational outreach activities

Relevant type of spillover: Opening up opportunities to scout, capture and retain talent in the region.

The concept of educational outreach, which the proposed indicator is aimed at capturing, can indeed contribute towards enhancing innovation capacity based on the feedback received from interviewees. However, the budget dedicated to educational outreach activities of HEIs does not seem to necessarily reflect the extent, quality or impact of such activities. In this respect, interviewees highlighted that educational outreach activities are undertaken by the staff of HEIs more often than not on an informal basis with limited financial support from their HEIs and no reporting obligations. In fact, some of these activities may even be private initiatives of HEI staff or even funded by non-academic agents (e.g. businesses, NGOs, etc.) and may not be reflected in the budget of HEIs at all.

In this context, interviewees suggested employing **alternative measures** in order to capture the educational outreach of HEIs, such as the number of events organised to this end as well as the number of participants (who are not academics) in such events. Other proxies suggested including the number of HEI staff engaged in such activities or the time and effort allocated by them. In addition, several interviewees stressed that a more precise definition of the activities to monitor should be provided along with the indicator (indicatively including, for instance, activities targeted to attract students, to support alumni networks etc.).

Finally, it is important to note that the number of events with an educational outreach character may be the most technically feasible to operationalise as the data required may be already available in some EU Member States. In the UK, for instance, the necessary data are already collected by the Higher Education Statistical Agency (HESA) and are part of HE-BCI survey data.

Part C: Feasibility study and final indicator set

5 Introduction to the final indicator set

Phase 3 of the project considered 19 potential indicators for inclusion in the prototype indicator set as set out in 3.5. On the basis of the evidence presented in chapters 3 and 4, this indicator set has been reduced to 10 indicators. From this point onward, consideration will only be given to those selected 10 indicators. The indicator selection process was developed through a feasibility study which sought to eliminate the least useful indicators whilst maintaining the breadth of coverage proposed in the theoretical framework and arising in the original potential indicator selection. More information on this indicator selection process is presented in 6.1, and it is this that is referred to as the indicator prototype set. This short chapter provides an introduction to the remainder of the report, to make clear the steps that are taken towards arriving at the recommendations presented in 7.3 and 7.4.

The existence and purpose of a prototype presupposes that efforts are being made to work towards a final product, which in this case we assume to be the development of a European-wide index or scoreboard of university contribution to university capacity. The purpose of a prototype is therefore to provide insights and learning opportunities into the desirable end-goal without the necessary resource commitments to realise that final product. In 6.2, we therefore present a synthesis summary of the learning messages arising from the information gathered in the course of phases 2 and 3 for the remaining ten indicators, relating to the quality and suitability of the indicators as judged by a desk review and our peer experts, as well as the fieldwork via the national case studies.

In 6.3, we make a recommendation on the next steps for the progress towards the UCIC scoreboard. Section 6.2 demonstrates that the indicator set is convergent, namely that it produces a set of measures that capture what is important conceptually, intuitively and also to stakeholders in UCIC. We therefore recommend that the next step of this process is a ‘go’, to the development of a pilot indicator framework. We then test the readiness of the prototype set to progress to a full indicator status by examining the availability of data sources to populate the prototype indicator set. We conclude that the indicator availability is limited, and therefore the next step is to develop appropriate measures that can populate the indicator set and produce a UCIC Scoreboard.

In chapter 7, we set in more detail our proposals for progressing from the current state-of-the-art (in this report) to a putative Pilot phase (our primary overall conclusion from the study). To provide more certainty on the form and function of the Indicator Scoreboard, in 7.1 we analyse the potential uses to which a scoreboard can be put. We note that this research project has been undertaken to deal with a suboptimal equilibrium in current indicator availability and in particular the reduction of UCIC to commercialisation activities. We therefore note that the purpose of the indicator scoreboard has therefore been to provide more detailed and extensive evidence on how universities are contributing to innovation capacity.

In providing that information, it is important to avoid falling into the trap of mistaking indicators (what needs to be measured) with measures (what others have to date used to measure those indicators). In section 7.2, we therefore present an overview for each of the indicators of what it is precisely that needs to be measured, and the ways that that could be captured in practice with a particular measure. We present both the measures that were identified in the literature review, as well as the suggestions made by stakeholders in the course of the Field Study and the questionnaires. This provides the basis for the first stage of any pilot study, namely building a consensus amongst pilot participants of what must be counted in order to generate data to populate the measure.

The last two sections of the report set out our recommendations for the next steps both in terms of progressing on to a pilot project and identifying specific groups in order to facilitate the pilot project. In section 7.3, we propose that what is needed in a pilot is a five-step process:

- a consensus regarding measures is developed,
- methodologies for counting those measures are developed,
- they are implemented by lead users,
- the collected data is reported back to a central operational team, and
- the reported data is standardised into a scoreboard pilot and pilot handbook for measuring those variables.

In section 7.4, we make a series of specific recommendations to the client and to other stakeholders about the necessary steps in order to deliver a successful pilot indicator set and Scoreboard building on the highlighted learning points and insights.

The success of the next step depends on the emergence of a clear problem owner, and we recommend that DG EAC play this role, and attempt to identify other potential partners and co-sponsors to provide a broader support base.

There are a range of other European bodies for which the Scoreboard could provide additional useful information and support their own policy development processes, notably DG RESEARCH, DG REGIO and the Committee of the Regions.

The value of the Scoreboard ultimately depends on the extent to which national higher education and innovation policymakers accept this wider perspective on innovation and are willing to support universities and their partners in these processes.

We also argue for an ongoing dialogue with stakeholders at a European level as being necessary to successfully deliver any pilot activity, involving both university representative groups as well as social partners representing the beneficiaries of university contributions, including firms, public sector organisations, NGOs and civil society organisations.

Finally we note that the success of the pilot phase depends on the substantive involvement of higher education institutions in various ways by

- their leaders being open to understanding their wider societal contributions,
- their institutional research activities generating data on societal contributions, and
- university researchers contributing to the wider conceptual debate towards a wider perspective of innovation and the roles of universities in building smart, social and sustainable societies.

6 Evaluation of the prototype indicator set

6.1 Final prototype indicator selection process

The final prototype indicator set is presented in table 1 below. This indicator set was arrived at through a multi-stage optimisation process which sought to choose the best indicators on the basis of a synoptic analysis of their characteristics, the results of the expert feedback consultations, as well as the results of the Field Studies and the questionnaires. This information was presented in summary in chapter 4, and more detail is available on this in Annexes 3 and 7. The result of this optimisation process was to reduce the overall indicator set numbering 19 indicators to 10 indicators. We note in making this optimisation that there is one of the dimensions that is inadequately covered, but for which there are as yet no appropriate indicators: that is the contribution of universities to innovation capacity through the work their academics take through public engagement, informal interactions with societal partners and other forms of informal outreach. More detail is provided on the optimization process in Annex 7 of this report.

Table 5: Final indicator set

Category	University activity	Indicators
Human capital	Lifelong learning	Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)
Human capital	Mobility	Percentage of PhDs undertaken jointly with a private (non-academic) partner
Human capital	Curricula	Participation of non-academic agents in the definition of curriculum development (level measure)
Knowledge transfer	Collaborative R&D	University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)
Knowledge transfer	Consultancy	Income, total value, number of contracts (by: SME, large firms, commercial, non-commercial)
Human capital	Teaching & Learning	Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS)
Knowledge transfer	Infrastructure for commercialisation	Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)
Knowledge transfer	Education outreach	HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)
Human capital	Internationalization	Number of ECTS awarded to international exchange students (ERASMUS student) as a percentage of total ECTS
Knowledge transfer	Student start up activity	Student start-ups (total active start-ups, turnover, private funding raised)

***** NOTE The shading separates out the three indicator coverage spans proposed in Chapter 6 corresponding to core (5), optimal (3) and extensive (2) coverages.***

This final indicator set has been the result of an optimization process involving various procedures. The aim has been to retrieve an indicator set that is the most legitimate, most technically suitable, most limited in number and has a large extent of university activity coverage. These various elements have been brought together to propose a final indicator set optimised in terms of the following considerations:

- Providing the broadest possible coverage of the full range of dimensions of UCIC
- Includes indicators that are technically the most suitable for measuring these dimensions and are regarded by policymakers as having sufficient legitimacy
- Includes indicators that have a degree of external validity (expert validity and arguments put forward by stakeholders)

The first step in the optimisation process was to eliminate the indicators that have been weak in one of the three dimensions against which they have been evaluated: (1) being closely associated with 'UCIC', (2) being intrinsically good and (3) being positively evaluated by the stakeholders. On the basis of these evaluation criteria, we deleted 9 indicators from the indicator set. The 9 indicators have been deleted for the following reasons:

- 4 carry almost no relevant information because what can be measured does not readily correspond to the scale along which a characteristic can be measured (IP income, media engagement, community engagement, leadership & governance).

- 3 carry some useful information at a relatively small scale and are associated with UCIC despite not being particularly significant in the creation of innovation capacity (incubators, intermediary institutions and talent attraction/ retention).

- 2 are reasonable indicators but are excluded because they duplicate other, better indicators that have already been chosen (contract research and graduate numbers – both are indicative of innovation but not as closely associated with innovation capacity as the ultimately selected variables).

The second step in the optimisation process was to assess the remaining 10 indicators on the basis of the three considerations listed above. The indicators have been divided into three indicator sets: a core indicator set, an additional indicator set and an extensive indicator set.

The indicators analysed best were included in the core indicator set. The first consideration in choosing a core indicator set has been to balance the important university activities that contribute to innovation capacity. The most important activities to cover have been the human capital contribution via skills and knowledge, and the knowledge transfer contribution via collaborative research activities with external users. Three human capital indicators have been selected, with one of them (mobility) reflecting both human capital and knowledge transfer. The other two indicators facilitate the uptake of skills by non-academic agents and the involvement of these agents in defining the curriculum. The two knowledge transfer indicators selected on collaborative R&D and consultancy are activities that demonstrate the interest of an external actor in the knowledge that emerges from universities. In addition, the indicators received the strong support of the stakeholders and experts.

The first consideration in choosing the indicators for the additional indicator set has been to sustain the balance between the university activities and to include the activities missing in the core set. For the human capital indicators the student throughput was missing and therefore the indicator covering teaching and learning has been included. Concerning knowledge transfer activities, public engagement and commercialisation have not been covered and these two activities received most support during the optimisation process. The infrastructure for commercialisation provided an indicator of clear commitment to transfer knowledge and the education outreach activity demonstrates the commitment of universities to make research publicly available.

The consideration of the extensive indicator set has been to determine whether some dimensions have not been sufficiently covered and whether there are indicators that can provide added information proportional to the overall further effort to retrieve the data. The internationalization activity has been included because it provides an additional example of how skills can be activated and used within society. The information for this indicator is already available and/or easy to collect. The indicator for student start-up activity demonstrates the extent to which universities are creating raw material that can be used for innovation and the extent to which they support the use of this raw material for generating new businesses. This university activity shows an informal innovation contribution and therefore covers an element not yet taken into account. Moreover, the information for this indicator is easy to collect.

6.2 Overview of individual indicators in the final indicator set

This research project has developed a prototype indicator set for measuring the contribution of universities to innovation capacity. It is a prototype: it is not intended to be implemented in unaltered form. It presents a mock-up of how that indicator framework could be implemented in order to provide the opportunity for appropriate learning to inform a subsequent pilot phase. We incorporate those learning outcomes in chapter 7 where we present our recommendations for the next steps, and in particular how to deal with the shortcomings and lack of readiness in data sources for generating a putative University Innovation Contribution scoreboard. In 6.2, we bring together all of the information gathered in this research project relating to the ten selected indicators in order to identify what remains to be done to produce workable and useful indicators for this scoreboard.

In the following sub-sections we therefore summarize the information gathered in Phases 2 and 3 of this research project under four headings:

- Indicator rationale: an overview of the process to which the indicator corresponds and the practical university activities, outputs and outcomes through which that process operates.
- Expert feedback: a summary of the analysis made through the desk-based indicator analysis and the peer expert feedback from phases 2 and 4.
- Indicator feasibility: a summary of the readiness of the indicator to be immediately gathered on the basis of existing data sources, based on the indicator fiches (see Annex 6).
- Alternative measures: an overview of other potential measures proposed in the field research and questionnaires, with the identification of the most plausible alternatives.

6.2.1 Lifelong learning courses upgrading the skill set of students and the (un)employed

Indicator rationale

In a rapidly changing economy, it is important that students, as well as employed and unemployed people continually update their knowledge, competences and skills. A dynamic competitive environment requires from people to respond adequately to the unstable demands of employers. HEIs providing lifelong learning courses and training are expected to be the most valuable for re-training and re-skilling in order to prepare people for flexible career journeys. There have been multiple measures in the literature that try to capture the element of lifelong learning, including courses in teaching focusing on continuous professional development, and the participation of adults in higher education to address their skill gap. The most interesting measures found in the literature have been the provision of training and learning courses that directly answer the needs of society. These courses can then have a significant influence on local economies. Non-academic actors such as firms and the public sector have the labour market insights to know to some extent what is needed in terms of new skills.

Expert feedback (*from us and peers)

By using this lifelong learning measure, we focused on a learning activity of HEIs that moves beyond the traditional way of teaching by involving non-academics. This might explain the relatively low understanding of this indicator. The measure has a low legitimacy, which demonstrates that it is not strongly connected to a core university activity and that it is only to a small extent associated with being a relevant mean to update the skills of people.

The experts have been positive about this indicator, albeit they put forward that the indicator is rather downstream. They suggested focusing on students or ECTS, but agreed that it would be difficult to retrieve the data. In addition, they put forward that it is important to differentiate between the kinds of non-academic agents and to try to focus on courses that are professionally accredited. The latter would demonstrate that these are required by non-academic agents.

Box 1: expert feedback on the lifelong courses required by non-academic agents for UCIC
• Differentiate between different agent
• The courses have to be accredited, thus required by non-academic agents

Stakeholder feedback (interviewees and questionnaires)

Stakeholders have a similar extent of support for this measure. From the questionnaire, we can find that the indicator was relatively strongly appropriate as an impact measure. The variable has also been regarded as being useful. However, considering the perceived feasibility of the indicator, we can see that the ease of collecting the data for this measure is somewhere in the middle. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)	2.02	1.97	1.77

Interviewees provided a number of qualitative rationales for the appropriateness and feasibility of this measure. Lifelong learning activities of HEIs are perceived as highly relevant for updating the skills and knowledge of the workforce. The measure shows the interaction of academics with their surroundings. It signals the connection of academics with industry and academics trying to understand the needs of the economy. Nevertheless, it was noted that the indicator does not capture the level and quality of academics involved in teaching external courses. Moreover, the indicator stresses only the supply side, whereas the demand side is equally important. Only focusing on the supply side may not effectively capture the extent to which these activities of HEIs actually contribute to innovation capacity. A focus on the demand side might provide meaningful insights into the value that these courses will offer to non-academic agents. To conclude, many interviewees were concerned about collecting information about this measure, because similar courses and training like these are offered outside the framework of HEIs.

Box 2: stakeholder interviewee feedback on the lifelong courses required by non-academic agents for UCIC

- The percentage of academics would not reflect the level and quality of their involvement in external courses
- Private activity also exists in this field and its reporting may be problematic
- Maybe focus on the courses more relevant to innovation
- Developing indicators measuring the demand for such courses may be more appropriate

Indicator feasibility

No data or immediately available information on academic teaching in courses required by non-academic agents have been found. As previously, the indicator must be created collecting ad hoc information. According to the availability scale, this indicator is very difficult (4) to build. A survey should be organized so as to collect information from EU universities on curricula definition. Universities should be sampled ensuring representativeness and trying to cover the largest possible number of member states. The set of information needed to build the indicator should be collected by national experts in each member state. National experts are almost a necessity for studies where original data need to be collected for a large number of countries. National experts have better access to institutions in their countries and are able to interpret the data collected in the light of the national context, institutions and practices. No reliable proxies have been found (see Annex 6).

In general, this measure focuses on a relevant university activity that could contribute to innovation capacity. The experts, the interviewees and the stakeholders agreed that this university activity could potentially contribute to innovation capacity. However, they suggested that the indicator should be more differentiated. Concerning the feasibility of the measure, the results of the field study and the indicator fiche show that the information for this indicator is difficult to collect. A number of these kind of courses are not offered within the formal HEI structure and no immediately available information is accessible.

Other potential indicators

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- *Number and age of people attending the lifelong learning courses of the HEI*
- *The proportion of students (and time/credits) spent in courses required by non-academic agents.*
- Number of lifelong learning courses offered regularly by the university
- Revenues generated by courses provided to non-academic agents

The two indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.2.2 Mobility programmes activating knowledge flows

Indicator rationale

Universities can contribute to innovation capacity through activating knowledge flows by stimulating mobility programmes. These mobility programmes for students allow them to shape their environment even before they enter the labour market. By providing students with the opportunity to engage with private partners, knowledge will flow in two ways. On the one hand, students provide firms with tacit knowledge and recent scientific advances. On the other hand, private partners expose students to the daily practises of running a business and possible research problems. The latter could influence the research agenda of HEIs and might lead to future collaborations between the university and the firm. Mobility in this way builds linkages between academic and non-academic partners and the knowledge that flows between the two actors can be an input for innovation.

Expert feedback (*from us and peers)

Our focus on doctoral candidates fits well with our understanding of stimulating knowledge flows through mobility programmes. Doctoral candidates have the potential to provide businesses with scientific input that can be used for R&D activities that can have a future impact on the economy. This seems to be a good understanding, as the measure has a strong legitimacy. The legitimacy demonstrates that it relates to an important and relevant channel of HEIs that contribute to innovation capacity. It demonstrates clearly a link between universities and business, which is crucial for exchanging ideas and skills.

The experts were positive about the use of this indicator. They agree it is a useful measure to capture linkages between universities and non-academic partners. However, they stressed that knowledge flows do not only occur at the doctoral level, but also at lower levels of education. For example, master's students that do an internship within a company. In relation to this, it is necessary to understand that knowledge flows are directed mainly from the firm to the student rather than the other way around.

Box 1: expert feedback on mobility programmes activating knowledge flows for UCIC

- Include lower level of degrees: might also ask about masters courses or about placements at different stages
- Internships and apprenticeships – knowledge flow is more from the firm to the student than vice-versa

Stakeholder feedback (interviewees and questionnaires)

Not only the experts, but also the stakeholders who responded to the questionnaire have been positive and supportive of this variable. From the questionnaire, it was reported that the indicator in terms of appropriateness and usefulness has been rated higher than average. The perceived feasibility of the measure has been rated as being average. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Percentage of PhDs undertaken jointly with a private (non- academic) partner	2.17	2.14	1.99

Alongside these quantitative responses from the survey, interviewees provided a number of arguments on the relevance and feasibility of this measure. The interviewees agreed that the indicator is a compelling variable emphasizing a necessary university action to share knowledge with private actors. At the same time, the interviewees agreed that to increase the relevance of this university activity, other elements should be taken into account. Similarly to the experts, the interviewees suggested that not only doctoral education, but also other post graduate education (e.g. master's) and even undergraduate education should be included. Related to this, the indicator is too restricted and should also entail internships and apprenticeships. In addition, the indicator also focuses on the mobility of teachers. In general, it would not be difficult to measure mobility and to retrieve the needed data, although the ease of gathering the information seems to depend on national and/or regional particularities.

Box 2: stakeholder interviewee feedback on mobility programmes activating knowledge flows for UCIC

• It is applicable to specific fields and may not capture all mobility across the higher education sector

•HEIs research regulation may affect it

•Define the applicable types of collaboration

•Reliable measurements are dependent on the availability of official Industrial PhD programmes

•The indicator ought to be accompanied with a precise definition of the term 'jointly undertaken'

•Mobility of academics is also important

Indicator feasibility

We found no data or immediately available information on the percentage of PhD programmes undertaken jointly with private non-academic partners. This mobility indicator should be created collecting new and ad hoc information. At present, an amount of useful information could be held by the institutions managing the Erasmus+ programme. The latter, in fact, includes funding of joint projects (at both the advanced tertiary and at Doctoral education level) between universities, public research centres and private corporations across EU members states. These joint programmes, however, require intra-EU mobility of the PhD students which are involved. That is, no information on joint projects or PhD programmes carried out by universities and private (non-academic) partners located in the same country are provided. According to the availability scale, this indicator is very difficult (4) to build. Also in this case, a survey should be organized so as to collect information from EU universities on the number of PhD programmes characterized by a collaboration with non-academic partners (see Annex 6).

This measure is a compelling and relevant indicator for focusing on the activity of mobility. The qualitative and quantitative comments we received demonstrate that the measure focuses on an important university activity seen to contribute to innovation capacity. It captures the link between universities and external partners and enables universities to share knowledge with private actors. The general feedback we received is that the indicator is too narrow and should try to also include other post graduate students. Regarding the ease of gathering the data for this indicator, the HEIs should be able to retrieve the needed data. At the moment, no immediately available data is accessible.

Other potential indicators

As a proxy for the percentage of PhDs undertaken jointly with a private (non-academic) partner, the indicator fiche provides an indicator reporting the number of former PhD students employed as researchers in private organizations. This proxy provides information on the amount of PhD students continuing to do research as employees in private corporations. This may partially capture the linkages between universities and the private sector regarding PhD programmes. The indicator is drawn from the Eurostat database:

- *Employed doctorate holders working as researchers in the private sector.*

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- % of students volunteering and collaborating with industry at undergraduate and postgraduate level

- All types of inter-sectoral mobility, including teachers' mobility
- *Number of HEI staff who hold part-time positions in the industry or other non-academic public organisations*
- Internships and apprenticeships

The two indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.2.3 University curricula activating students' innovative capacities

Indicator rationale

One of the important elements of university contributions to innovation capacity is that they 'activate' the theoretical/ conceptual skills they transfer to individuals, so that when individuals move into the labour market from university, their skills are of immediate relevance. This is reflected in the curricula that universities offer, and the extent to which they seek to activate their students in different ways and expose them to external pressures. There were various measures proposed in the literature for capturing that element, including measures of entrepreneurship education, and teaching/ education in innovation and creativity. The most compelling of these was the involvement of non-academic agents in curriculum development, as a broad measure of this activation of students within the mainstream teaching they receive, as related by the OECD (2008).

Expert feedback (*from us and peers)

Using a curriculum measure corresponds well to our core interest, which is having a good understanding of 'activated teaching'. The measure also has a strong legitimacy – demonstrating that it relates to a core university knowledge activity (teaching), it demonstrates external interest in that activity (external agents signal interest through their involvement), and it is associated with making a practical difference in the way that the knowledge activity is organised.

The experts were positive about the use of the indicator, although they noted that unless it was very specifically defined, there were risks of rewarding an overspecialisation in training specific to particular companies, that made it easier for single firms instead of creating a wider societal innovation overspill.

Box 1: expert feedback on the activated curriculum measure for UCIC

• Industry may want to develop HEI curricula just to have a pool of employees to hire in the medium term (once the first batch of students finish) to adjust to business cycle fluctuations, while hampering the improvement of innovation capability which is a long term capability-building process

• The mechanisms through which the potential benefits can materialise are quite indirect and informal

Stakeholder feedback (interviewees and questionnaires)

There was reasonably strong support amongst stakeholders for this variable. From the questionnaire, it was reported that the indicator was relatively strongly appropriate as an impact measure. It was also seen as being useful, but at the same time, the perceived feasibility of the indicator was seen as being 'in the middle' of the scale. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	Usefulness	Ease of Data Gathering
Participation of non-academic agents in the definition of curriculum development (level measure)	1.96	2.03	1.67

Alongside these quantitative responses from the survey, interviewees provided a number of qualitative rationales justifying why they found it a compelling variable, although it was noted that there were some within HE that marked a wider involvement, and that there was mixed acceptance of the idea across the EU (with a slight east/ west split). There needs to be a better specification of what kind of non-academic agent was meant here, and opinions were mixed on whether it should include business agents or even be restricted to entrepreneurs, as against including a broader selection of the social partners who may also be able to activate students towards more social kinds of entrepreneurship. The main shortcoming of the indicator was that the level of participation was a difficult thing to measure, although there were no proposals for other indicators.

Box 2: stakeholder interviewee feedback on the activated curriculum measure for UCIC

• Consider also the actual content of curricula and the teaching activity

• Non-academic agents can participate and provide feedback on the definition of curricula not only in many different ways but also with varying degrees of involvement

• Define how exactly the measurement of participation will be achieved

• This concept is not equally spread among EU countries

• There are opponents to this idea

• Define background of non-academics

• Focusing only on non-academic agents who have business experience or even better on those who are entrepreneurs may be more appropriate

• Time requirements for involving non-academics are seen as a barrier

Indicator feasibility

No information has been found regarding the participation of non-academic agents in curricula definition. Therefore, this mobility indicator should be created collecting new ad hoc information. According to the availability scale, this indicator is very difficult (4) to build. In fact, no immediately available (as well as limited-access) micro data providing useful information have been found. A survey should be organized so as to collect information from EU universities on curricula definition. Universities should be sampled ensuring representativeness and trying to cover the largest possible number of member states. The set of information needed to build the indicator should be collected by national experts in each member state. National experts are almost a necessity for studies where original data need to be collected for a large number of countries. National experts have better access to institutions in their countries and are able to interpret the data collected in the light of the national context, institutions and practices (see Annex 6).

The measure on the activated curriculum should be updated to some extent to increase its relevance and legitimacy. This university activity has legitimacy and demonstrates that activated teaching should be a core activity of HEIs. However, to increase the relevance, the fieldwork part of the study demonstrates that the indicator needs to better specify the kind of non-academic agent. Regarding the technical feasibility of this measure, the fieldwork and the questionnaire demonstrate that it will be rather difficult to collect the information for this measure. At the moment, no database includes information on this indicator and the indicator fiche shows that no readily available alternative indicator is present.

Other potential indicators

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- Number of courses provided by industry representatives
- *Integration of internships or on-the-job training within the curriculum design (ECTS/ study hrs)*
- Existence of interfaculty-multidisciplinary study programmes
- Participation of non-academic agents with business experience or entrepreneurs in the definition of curriculum development
- *The number of hours provided by externals to engage in curriculum development*

The two indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.2.4 Contract research supporting collaborative R&D between universities and external partners

Indicator rationale

One of the most common ways in which universities can contribute to innovation capacity is by collaborating in R&D activities with external organizations. R&D collaboration can support firms in obtaining the necessary knowledge and technologies to improve their services and products. Their access to new knowledge and technologies can have a positive effect on innovation performance. Various measures have been proposed to capture collaborative R&D including the number of publications between academic researchers and industry and the number of industry-sponsored research centres. The most compelling measure found in the literature has been the one on collaborative R&D in the form of contract research. Universities can contribute to innovation by engaging in contract research to support collaborative R&D with external partners. Contract research can generate interaction between universities and external partners, such as industry. This interaction supports technology transfer to firms which has the potential to generate innovation. Moreover, research that is being funded by external organizations has the potential to benefit industry when it results in patents. Various measures have been proposed to capture collaborative R&D.

Expert feedback (*from us and peers)

By using this contract research measure we focused on collaborative R&D by not only taking into account industry research sponsoring, which receives traditionally the most attention, but also including the more philanthropic research funding by charities and foundations. This provides a good understanding of collaborative R&D as is shown by the strong relevance and legitimacy of the measure. This demonstrates that it is an important activity that universities should engage in and a relevant channel for HEIs to contribute to innovation capacity.

The experts have been positive about the use of this indicator and consider collaborative R&D in the form of contract research to be able to improve innovation capacity. Nevertheless, we need to understand that funded research does not always involve active collaboration and that the impact of this kind of collaboration is likely to depend on the size of the companies that are involved. We should therefore differentiate between small and large firms that are engaged. In addition, they put forward that the indicator should also take into account public funding and that the measure clearly specifies what kind of projects are applicable.

Box 1: expert feedback on contract research supporting collaborative R&D for UCIC
• Amount of money seems to be more relevant than the number of projects

• The figures will be dependent on the size of the companies that the university is engaged with
•A unilateral direction in the flow of knowledge could suffice if the contribution to the ability to improve innovation capability is important

Stakeholder feedback (interviewees and questionnaires)

The stakeholders who have responded to the questionnaire have a similar view to the experts. There was strong support amongst the stakeholders. The high scores of the indicator based on the data from the questionnaire demonstrate the support for this measure. The indicator is strongly appropriate and useful and also received an above average score for perceived feasibility. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	Usefulness	Ease of Data Gathering
University research funded by industry and by charities/ foundations (number of projects, total value and percentage of total)	2.37	2.37	2.06

Apart from quantitative feedback, we also received qualitative rationale for the relevance and feasibility of this measure. The interviewees considered contract research to be relevant but not sufficient enough to apprehend collaborative R&D. Contract research does not necessarily imply active R&D collaboration or even actual interaction. It is therefore necessary to be clear about the kind of collaboration that is implied and about the projects that are applicable for contract research. Moreover, it would be necessary to distinguish between the size of the firm that is involved in the contract research because size is most likely to influence the value and the number of projects. The interviewees suggested, in addition to expanding the score of the indicator, to include publicly-funded collaborative R&D and to address peer to peer collaboration. In general, it would be possible to collect the data for this indicator as no challenges are reported. Several HEIs already collect this kind of data at the aggregate level. If the indicator would entail separate measures for funding sources, then the technical feasibility would be lower, because the HEIs reported that no detailed distinction amongst the various sources of funding is available.

Box 2: stakeholder interviewee feedback on contract research supporting collaborative R&D for UCIC
• Funded research does not necessary involve active collaboration
• Better conclusions could be drawn if separate measures were used per funding source
• Clarify what projects are applicable
• What is the total in 'percentage of total'
• Public funding to be included
• Participation in peer to peer collaboration (e.g. Horizon 2020 projects)
• The figures will be dependent on the size of the companies the university is engaged with. Consider distinguishing between small and large firm engagement.

Indicator feasibility

No information has been found on university research funded by industry and by charities/foundations. New data should be collected. According to the availability scale, this indicator is hard (3) to build. In order to build this indicator, balance sheet information should be collected from universities. Such collection requires a survey similar to the one described above. Universities should provide information on the source and composition of their funding. However, the disclosure of the universities' balance sheet information could be hindered by specific privacy policies of EU member states (see Annex 6).

Contract research is a very legitimate measure to capture the university activity of collaborative R&D. The experts, stakeholders and interviewees have been positive about this measure and agreed that this measure could be used to determine the contribution to innovation capacity. To increase the legitimacy of this indicator, the fieldwork part of the study proposed to also include public funding and to consider the size of the firms/industry the HEI is engaged with. Concerning the readiness of this indicator, some HEIs are already collecting this information. Currently, no database has the information available on HEI research funded by industry and by charities/foundations. To gather the information for this indicator, a new survey should be developed.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the variable collaborative R&D. As an alternative proxy, we report the Eurostat indicator on the share of private funding of tertiary education. This proxy does not provide any specific information on the composition of universities' research project funding. Nevertheless, it allows us to assessthe relative importance of private funding of HE across EU member states. The suggested indicator is:

- Total tertiary educational expenditure by non –educational private sector bodies

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- Number or value of total collaborative projects/collaborative projects of competitive grants/long-term collaborative projects
- Collaborative university research funded by industry (SME vs larger enterprises)
- Contract research provided to the industry
- *Joint applications for funding with the industry*

The indicator that we believe might offer a reasonable alternative to the overarching indicator is shown in italics.

6.2.5 Consultancy activities stimulating knowledge exchange to external organizations

Indicator rationale

Firms sometimes do not have the innovative capacity to rapidly address and solve problems that require their immediate attention. To be able to address these problems, they look beyond their own organisation and contact universities to retrieve the relevant knowledge needed to develop further. Firms engage in collaborative research projects with universities to increase their internal knowledge base. Our literature review suggests several channels through which universities and firms can stimulate knowledge exchange that can increase the innovation capacity of firms. These include joint research, use of facilities and contract research. The latter has been included in the previous section as a relevant channel for collaborative R&D. The most interesting university activity we have found that relates to firms contacting universities to provide the necessary knowledge are consultancy activities.

Consultancy activities are provided in close proximity, can have a positive effect on innovation at later stages of the process and are also interesting for SMEs that are less involved in R&D structures.

Expert feedback (*from us and peers)

Our focus on consultancy activities corresponds well to our core interest of having a good understanding of universities engaging in collaborative research activities. This is demonstrated by the strong legitimacy of the measure. The strong relevance of the measure indicates that it is related to innovation capacity. It demonstrates collaboration between universities and firms, which is important for knowledge exchange.

The experts have been supportive about the use of this indicator. They agreed that it is a good indicator to measure the local and regional effect of consultancy and that it is a relevant form of cooperation between universities and business that contributes to innovation. They also stressed that it is important to take into account that most large scale collaboration is international, because universities need the best people to work on specific projects where solutions need to be found for large scale problems. There should therefore be a clear focus on regional development and collaboration.

Box 1: expert feedback on consultancy activities stimulating knowledge exchange for UCIC

• Focus should be on regional development and collaboration

Stakeholder feedback (interviewees and questionnaires)

Not only the experts, but also the stakeholders who responded to the questionnaire have been positive and supportive of this variable. From the questionnaire it was reported that the indicator in terms of appropriateness and usefulness has been rated higher than average. The perceived feasibility of the measure has been rated as being 'in the middle'. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Income, total value, number of contracts (by: SME, large firms, commercial, non-commercial)	2.26	2.28	1.89

We also received qualitative feedback from the interviewees on the relevance and feasibility of this measure. The interviewees have been supportive of this measure because it is to some extent important for innovation and specifically for firms not focused on R&D. However, they suggested to better clarify the type of consultancy. For example, whether it includes only consulting contracts of the HEI or whether there are also consultancy activities of professors and researchers included in this measure. Some of the interviewees put forward that consultancy activities and contract research are not easily distinguishable, which again stresses the need to be clear about what is meant by consultancy. Overall, it is feasible to collect the information for this indicator because HEIs are storing this data in their administration. Nevertheless, it might be less feasible to retrieve this information for the different external organizations (e.g. SMEs, large companies and (non-) commercial contracts) and for individual private contracts of professors and researchers, if we were to include these. Concerning the latter, these activities are often not communicated to HEIs and, if they are, these individual contracts are not publicly available. Although the interviewees put forward several questions, no alternative indicators have been proposed.

Box 2: stakeholder interviewee feedback on consultancy activities stimulating knowledge exchange for UCIC
• The type of consultancy it refers to needs to be clarified
• The difference between consultancy and collaborative research contracts is not clearly distinguished in all HEIs
• Private activity is hard to monitor

Indicator feasibility

No information on universities' income, total value, and number of contracts related to services provided to SME, large firms, commercial, non-commercial institutions has been found. Also lacking are indicators, data or information useful in building-up an indicator of this kind. Similarly, no detailed information on universities' income stemming from R&D-related services has been detected in publications or EU reports. According to the availability scale, this indicator is hard (3) to build. As in the case of indicators on universities' research funding, universities' balance sheet information is needed. Universities should provide information on income stemming from spin-offs and university third mission activities. The disclosure of universities' balance sheet information could be hindered by specific privacy policies of EU member states (see Annex 6).

The indicator to measure university activity consultancy is perceived as a good measure. The stakeholders and experts agreed that consultancy is a relevant form of cooperation between universities and business (not focused on R&D) that contributes to innovation. This is also supported by the questionnaire, which demonstrates a high score on appropriateness and usefulness. The measure could be strengthened by clarifying the type of consultancy (e.g. consultancy by the HEI versus consultancy by researchers/professors). At the moment, no data is immediate available for this indicator. The HEIs are able to provide the data for this measure. To gather the information for this indicator, a new survey should be developed.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the variable collaborative R&D. The proposed indicator reports information which is complementary to that required by the original formulation, even if not specifically related to universities' income, total value, number of contracts obtained by SMEs, large firms, commercial, non-commercial entities. In particular, the indicator reports information on the collaboration between firms and universities aiming at generating product or process innovation. This indicator is drawn from the Community Innovation Survey (CIS):

- Number of firms and universities collaborating with the aim of generating new products and processes

6.2.6 Entrepreneurship education promoting an innovative culture by changing mind-sets

Indicator rationale

In a globalized and competitive world, it is important that universities prepare their students adequately so that they are able to participate in a dynamic and entrepreneurial global environment. HEI teaching and learning activities are crucial in this respect. Entrepreneurship education can be an important channel for preparing students and promoting an innovative culture. Entrepreneurship courses can provide students with the innovative capacity by changing the students' mind-set and behaviours and by providing them with the necessary skills. There have been multiple measures in the literature that try to capture the element of entrepreneurship education, including a number of courses for the creation of a critical mass of entrepreneurship teachers and a percentage of staff teaching entrepreneurship courses. The most compelling measure found in the literature has been the number of students enrolled in entrepreneurship courses.

*Expert feedback (*from us and peers)*

Using a teaching and learning activity focusing on students participating in entrepreneurship education corresponds only to a small extent to our core interest. The measure has a low legitimacy, which demonstrates that it is not strongly connected to a core university activity and that it is only to a small extent associated with being relevant to provide students with the mind-set and skills to promote an innovative culture.

The experts have been moderately supportive about the use of this indicator. They agreed that the indicator focuses on an important university activity. Entrepreneurship education can help students develop entrepreneurial intentions which can eventually translate into solid business ideas. Nevertheless, it is important to understand that innovation usually takes place in the long term and therefore differs in the medium term. This means that there is long term variation. The experts point to some limitations that should be taken into account. We should consider not only theoretical entrepreneurship courses, but also take into account practical courses and business courses, especially when HEIs have incubators. In addition, if these courses only increase the interactions between students and firms, there will be no translation into the development of entrepreneurial opportunities. Regarding the technical feasibility of the indicator, the experts have not been clear on whether it would be possible to disaggregate data for this indicator by country.

Box 1: expert feedback on entrepreneurship courses promoting an innovative culture for UCIC

• Need to take into consideration practical/business oriented entrepreneurship courses and awards/competitions

• No direct contribution to innovation capacity if it only increases the instances of interactions

Stakeholder feedback (interviewees and questionnaires)

Compared to the experts, the stakeholders who responded to the questionnaire have been more positive and supportive of this variable. From the questionnaire it was reported that the indicator has been rated 'in the middle' for each of three elements: appropriateness, usefulness and feasibility. Interestingly, academics found this indicator less appropriate than non-academics. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs	2.03	2.03	2.02

We also received qualitative feedback from the interviewees on the relevance and feasibility of this measure. The interviewees confirmed that teaching and learning activities of universities can be supportive of promoting an innovative culture by changing the mind-set of their students. Nevertheless, they did not agree that entrepreneurship education is the most appropriate and relevant teaching and learning activity of HEIs to contribute to innovation capacity. It is necessary to focus on actual interaction of students with innovative businesses which could for example be provided by practical trainings, such as internships. The indicator should also try to capture soft skills such as creativity and flexibility, instead of only more traditional business skills, since employers demand soft skills as well. Despite the low legitimacy for this indicator, the technical feasibility of this indicator has been high. Whereas the information is not collected at this moment, the HEIs expect that the data gathering will be relatively easy. The interviewees suggested several other measures that could be used to capture the university activity of teaching and learning.

Box 2: stakeholder interviewee feedback on entrepreneurship courses promoting an innovative culture for UCIC

- It does not provide any information about the training of the educators on entrepreneurship
- It mainly captures entrepreneurial education and not culture
- It needs to be clear what entrepreneurship courses mean
- The way the indicator is defined is biased towards business-oriented faculties
- Consider entrepreneurship embedded in the curricula
- Consider soft skills
- Focus on the actual interaction of students with innovative businesses as well as individual entrepreneurs
- Elaborate a clear definition of the courses that are to be included in the scope of the indicator – include courses that are not defined strictly as entrepreneurship but do address topics relevant to entrepreneurship and innovation as well

Indicator feasibility

The focus on entrepreneurship courses to address the teaching and learning activities that could contribute to innovation capacity is not regarded as a very good measure. The stakeholders agreed that teaching and learning activities can stimulate an entrepreneurial mind-set in students. However, entrepreneurship courses might not be the most relevant type of education in this respect. The experts have been supportive of this measure, but argued that we should also take into account practical courses and business courses. HEIs expect that it will be relatively easy to collect the data for this indicator. At the moment, no database contains information on this indicator. To gather the information for this indicator, a new survey should be developed.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the variable teaching and learning. The closest proxy is provided by the Eurostat database. The latter reports information on the distribution of graduates in tertiary education in science, mathematics, computing, engineering, manufacturing and construction, as a share of the total population aged 20-29. Although this proxy is far from providing specific information on the share of students enrolled in entrepreneurship courses, it allows us to compare EU countries according to the relative weight of scientific degrees. The indicator is drawn from the Eurostat database:

- Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction-share of students (%) per 1000 of the population aged 20-29

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- Availability of study programmes with internships or on-the-job training in the business sector
- Number of internships/placements in industry
- Number of courses where companies are involved organisations
- % of students involved in collaboration with the industry
- *% of courses including an element of entrepreneurship*
- Number of teachers trained in entrepreneurship
- *Number of university staff with experience in entrepreneurship and innovation*
- Existence of interfaculty-multidisciplinary courses or even study programmes
- Number of workshops aimed at students and/or HEI staff addressing topics relevant to entrepreneurship and innovation
- Availability of courses provided through project-based learning with the industry
- Number of students attending courses provided through project-based learning with the industry

The two indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.2.7 Services to stimulate an infrastructure for commercialization of knowledge

Indicator rationale

One of the elements of university contributions to innovation capacity is that they provide an infrastructure for the commercialisation of knowledge. The commercial exploitation of university research has intensified and has become a policy imperative. This increased attention has also led to considerable efforts on how to provide efficient infrastructure to support commercialisation activities. Various measures have been proposed in the literature to capture the infrastructure for commercialization, including measures of technology transfer offices, incubators and science parks. The most compelling measure of these services for knowledge commercialisation has been the focus on seed corn investment, venture capital and business advice provided within the infrastructure. Seed corn investment can provide basis research needed by industry, venture capital can support enterprises in developing new projects and business advice can be provided to e.g. start-ups.

*Expert feedback (*from us and peers)*

Our focus on services provided, seed corn investment, venture capital and business advice corresponds well to our core interest. The measure has a high legitimacy which demonstrates that is it strongly connected to a core university that has the potential to contribute to innovation capacity. The infrastructure for commercialization provided by universities is considered to be a relevant university activity to equip firms and businesses so as to create new products.

The experts have been moderately supportive about the use of this indicator. They put forward that we should take into account how well-structured the internal processes and the management processes within HEIs are, since this is likely to influence their capacity to contribute to innovation capacity. Moreover, these management processes change over time. They believe that the data will be possible to collect at the EU-level.

Box 1: expert feedback on services to stimulate an infrastructure for commercialization of knowledge
• Consider how management practices change over time
• Need to consider whether universities change the capacity of firms and regions

Stakeholder feedback (interviewees and questionnaires)

There was reasonably strong support amongst stakeholders for this variable. The questionnaire responses show that the indicator was relatively strongly appropriate and useful. The perceived feasibility of the indicator was seen as being 'in the middle'. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)	2.06	2.10	1.67

Alongside these quantitative responses from the survey, interviewees provided a number of qualitative rationales justifying why they found this a compelling variable. They perceived this indicator as highly relevant. Albeit the high relevance of the variable, the indicator could be improved by also including the provision of network/matching activities and advice provided to the public sector. It would also be helpful to define what we mean with business advice to increase the reliability of the measure. Not all the elements have been considered as similarly relevant. Venture capital is considered to be implausible for HEIs and some interviewees would exclude this type of activity. Similar to the relevance of the indicator, the technical feasibility has also been high. It would be relatively easy to collect this data at the institutional level.

Box 2: stakeholder interviewee feedback on services to stimulate an infrastructure for commercialization of knowledge
• Clarify mentioned services. Not all of them are allowed in all countries
• The indicator should capture as many services as possible to private or public bodies
• Consider the impact of the services
• Include networking/matchmaking services

Indicator feasibility

Precise and detailed information on services provided within the commercialization infrastructure, seed corn investment, venture capital and business advice have not been found. Considering the availability scale, this indicator is hard (3) to build. In order to obtain the information needed to build the requested indicator, a survey involving EU member state universities should be realized. Within this survey, a set of specific questions on the existence, characteristics and effectiveness of universities' commercialization infrastructure should be posed (see Annex 6).

The measure has been perceived as a good measure to determine the university activities related to infrastructure for commercialization of knowledge. The activity is relevant, appropriate and useful. The measure could be improved by including network/matching activities and by considering management processes. In addition, the measure could be strengthened by excluding the element venture capital. The information for this measure will be possible to collect at the EU-level at the institutional level. It has to be noted that no indicator yet exists to retrieve this information. A new survey should be developed to gather information.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the variable infrastructure for commercialization. Due to the unavailability of a unique indicator on services provided within the commercialization infrastructure, an alternative is proposed based on data concerning venture capital availability. The latter has been drawn from the World Economic Forum - Global Competitiveness Report – and is based on survey responses on the challenges faced by entrepreneurs with innovative but risky projects in finding venture capital. The alternative indicator retrieved from the World Economic Forum is:

- Venture Capital availability

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- % of large firms/SMEs/non-commercial organizations benefiting from these services
- Number of users/clients of the services
- Presence of networking services
- *Revenues generated by services provided within the commercialisation infrastructure*

The indicator that we believe might offer a reasonable alternative to the overarching indicator is shown in italics.

6.2.8 <u>Educational outreach activities stimulating public engagement and knowledge exchange</u>

Indicator rationale

Universities can exchange knowledge and expand the knowledge economy in more ways than simply the traditional way through commercialization activities. HEIs can strengthen innovation capacity by stimulating social creativity and cultural development. These provide input for a knowledge-based society that is concerned with responsible research and innovation and social innovation. HEIs influence the cultural and creative environment in which they are located by engaging in educational outreach activities to share their knowledge with the public. There have been multiple measures in the literature that try to capture the element of educational outreach activities, including the staff/student numbers allocated to educational outreach activities. The most compelling has been the HEI budget allocated to outreach activities by focusing inter alia on school and public talks and career events. Public outreach expenditure is regarded as a relevant measure to capture the effort of HEIs to make research publicly available and in this way contribute to engagement activity.

*Expert feedback (*from us and peers)*

By including this educational outreach measure, we have focused on a form of academic engagement that moves beyond the traditional means of academic engagement, such as commercialization activities. This might explain why the understanding of the indicator is relatively low. The measure has a low legitimacy, which demonstrates that it is not strongly connected to a core university activity and that it is only to a small extent a relevant activity to engage with the public.

The experts have not been very convinced about the connection of public engagement activities as educational outreach to innovation capacity. They believe it would be necessary to take into account the number of outreach activities/events and the number of people that would attend these activities.

Stakeholder feedback (interviewees and questionnaires)

There was reasonably strong support amongst stakeholders for this variable. From the questionnaire, it was reported that the indicator was relatively strongly appropriate and useful as an impact measure. At the same time, the perceived feasibility of the indicator was seen as being ‘in the middle’. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)	2.03	2.07	1.83

Alongside these quantitative responses from the survey, interviewees provided a number of arguments on the relevance and feasibility of this measure. They perceived this indicator as being to some extent relevant for innovation capacity. The interviewees argued that the dedicated budget does not need to reflect the impact or the quality of these outreach activities. In practice, these activities are often undertaken by staff on an informal basis and the latter do not need to report on these activities. In addition, funding for these activities is not only provided by the HEI, but also by external organizations. Moreover, the indicator should be clearer about what activities are to be considered as educational outreach activities. Concerning the latter, the unprecise definition of the activities makes it difficult to provide information on the amount of money that is allocated by the HEI to these activities.

Stakeholder interviewee feedback on educational outreach activities for UCIC

- Budget does not necessarily reflect the quality or the impact of such activities
- A more precise definition of the activities to monitor should be provided
- Clarify the concept – seems related to lifelong learning and to societal engegement
- Individual initiatives by HEI staff are also present in this field and may not be recorded

Indicator feasibility

A perfect correspondence between the indicator as formulated here and the inspected data sources has not been found. As stated previously, the build-up of an indicator perfectly overlapping the one spelled out above requires putting new questions into an existing approved sample and therefore would be very difficult to obtain in a short time. Therefore, this indicator is hard (3) to build. Also in this case, a survey involving EU member states universities should be realized. To obtain the indicator, balance sheet information reporting details on universities’ budget composition should be collected. The disclosure of universities’ balance sheet information could be hindered by specific privacy policies of EU member states (see Annex 6).

The focus on educational outreach activities to measure the public engagement of HEIs is perceived to be relevant only in some aspects. Education outreach activities are not regarded as a core activity and the possible contribution of these activities to innovation capacity is not clear. The measure would be better if it were to focus on the number of these outreach activities and be clear about what these activities should entail. The information for this measure would be difficult to collect because of the imprecise definition. No international database contains readily available information for this measure. A new survey should be developed to gather information.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the activity education outreach. A proxy is proposed relying on OECD data on education expenditure of a large number of economies. The main difficulty is to split the general expenditure in Higher Education according to the typology of activity. The closest correspondence can be found in the following indicator which provides a detailed quantification of the annual expenditure per student by educational institutions on core services, ancillary services and R&D. Educational outreach activities can be considered as part of core services. The alternative indicator retrieved from the OECD is:

- Annual expenditure per student by educational institutions for educational core services, ancillary services and R&D

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- Number of relative events
- *Amount of time and effort allocated to such activities*
- Number of staff active in outreach activities
- *Number of participants in such events*

The two indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.2.9 International mobility stimulating new skills development and academic entrepreneurship

Indicator rationale

Students, faculty and HEIs as a whole can benefit from internationalization when it is being embedded in the strategy of HEIs. Internationalization can be beneficial for HEIs in various ways. It can modernize pedagogy, stimulate collaboration between students and faculties, and create new opportunities for research collaboration. In addition, internationalization can stimulate skills development of students and staff, such as by revealing new approaches to problems, or through overcoming linguistic or other challenges.

The literature review has put forward several measures that can be used that address the internationalization activities of universities. These include: collaboration in research and development, availability of campuses abroad, international joint degree programmes and the partnerships with higher education institutions abroad that facilitate staff and student exchanges. The most compelling measure we found is the number of ECTS awarded to international exchange students to measure the activity of internationalization. Students that go on exchange can enhance their academic entrepreneurship through their exposure to new (research) environments and new application opportunities. In addition, students can generate new skills because of being in a new and different environment. These opportunities that can be the result of international mobility can be a valuable input for innovation capacity.

*Expert feedback (*from us and peers)*

Our focus on international exchange students corresponds to a small extent with our understanding of developing new skills and academic entrepreneurship through international mobility. The legitimacy of the measure demonstrates that it relates only to some extent to an important channel for HEIs to contribute to innovation capacity. The link is not very clear.

The experts have been positive about this indicator, albeit they put forward that the indicator is not broad enough. They agreed that mobility plays a role in the development of capabilities. International exposure can facilitate the development of innovation capabilities. However, they put forward that in this case academic staff mobility may be more rewarding that student mobility. Concerning the feasibility of collecting the data for the indicator, the experts argued that it might be hard to disaggregate the data by country to determine the contribution to innovation capacity unless we are able to track down the flow of returning exchange students.

Box 1: expert feedback on international mobility stimulating new skills development for UCIC
• Staff mobility may be more rewarding
• Difficult to measure because of disaggregating issues

Stakeholder feedback (interviewees and questionnaires)

There was average support amongst stakeholders for this variable. From the questionnaire, it was reported that the indicator was relatively strongly feasible. At the same time, the perceived appropriateness and usefulness of the indicator was seen as being 'in the middle'. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Number of ECTs awarded to international exchange students (ERASMUS student) as a percentage of ECTS	1.99	2.05	2.17

Interviewees provided a number of qualitative rationales for the appropriateness and feasibility of this measure. The measure is considered to be relevant and it is possible to collect the information for this indicator. However, the indicator should take into account other elements to increase its relevance and legitimacy. Further disaggregation would be meaningful, especially with regard to distinguishing between incoming and outgoing exchange students. Along with disaggregating, the measure would be more relevant in capturing internationalization if it were broadened in some aspects. It is now too restricted by focusing only on Erasmus students. Staff mobility is also crucial to building innovation capacity. They have suggested a few alternative measures to capture their perspectives which can be found in the last box. The information for this indicator would be quite feasible to collect at the faculty-university level.

Box 2: Stakeholder interviewee feedback on inernational mobility stimulating new skills development for UCIC

- Narrow indicator for capturing internationalisation
- Consider also scientists' mobility and the international origin and activity of students and scientists
- Clarify the type of mobility the indicator refers to; it is better to consider both inwards and outwards mobility
- Focus on the number of students and not on ECTS
- Include additional international exchange programmes

Indicator feasibility

Data on ECTS awarded to international exchange students are available by focusing on major University websites taking part in the EU Lifelong Learning Programme (LLP) and, in particular, Erasmus. However, some general statistics at country level can be drawn from the official website of the LLP European Agency. The latter provides general statistics on the number of Erasmus students by destination country, typology of study and average duration[11].

However, information has not been systematically collected at country level and time coverage is fragmentary. The main effort should be to collect the corresponding information and to aggregate it into a unique database at country level. At present, thus, this indicator is graded as 2 (quite hard) since data are not available in a uniform way and must be properly homogenized and matched (see Annex 6).

The focus on the number of ECTS awarded to international exchange students to measure the internationalization activities of HEIs is perceived to be relevant only in some aspects. The measure is too limited to capture all the relevant internationalization activities, including staff mobility. The information needed for this indicator will be easy to collect, the information is already available within the HEIs. At the moment, no immediately available data is accessible. However, it should be fairly easy to make the data uniform and to transform it into an indicator.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the university activity of internationalization. As an alternative proxy, we propose an indicator reporting the number of Erasmus mobilities by typology of study and average duration, stemming from the Lifelong Learning Programme:

- Number of Erasmus mobilities by typology of study and average duration

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- Number of students and scientists with different nationalities
- Number of international internships
- Presence of interfaculty courses with international partners
- *Number of students and researchers in all exchange programmes*
- Number of courses in international languages
- Level of international activity of the professors
- All international activity of students and staff/ all international exchange programmes
- *Number of HEI staff with a PhD from a foreign HEI*
- Number of different countries represented in the total pool of international exchange students

The two indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.2.10 Student start-ups supporting knowledge exchange and stimulating entrepreneurial mind-sets

Indicator rationale

An important element of university contributions to innovation capacity is that they can develop initiatives that support students' enterprise experiences at HEI. One of these entrepreneurship experiences is the development of student start-ups. Student start-ups

[11] Some aggregate numbers on ECTs awarded to Erasmus students can be easily drawn from the Erasmus Programme Statistical Overview at the following link:
file:///C:/Users/User/AppData/Local/Microsoft/Windows/INetCache/IE/87AIJXXN/erasmus1112_en.pdf

can be important entities to exploit academic research and to generate new entrepreneurial activities which are usually set up by professors, young researchers and PhD candidates. There is an increasing attention paid to these student-start up activities generated within an academic context, especially with regard to the impact of student start-ups. There are various measures proposed in the literature for capturing the element of student start-up activity, including measures of estimated employment of student start-ups, total private equity funding raised in start-ups and the total number of start-ups. The most compelling of these is the latter combined with other elements of importance: turnover and private funding raised.

*Expert feedback (*from us and peers)*

By including this measure so as to focus on the university activity of student start-ups, we have included a measure that corresponds to a small extent with our understanding of supporting knowledge exchange and entrepreneurial mind-sets. The legitimacy of the measure demonstrates that it relates only to some extent to an important channel used by HEIs to contribute to innovation capacity.

The experts have been moderately positive about this indicator. They have been in favour of focusing on private funding raised. This is an important aspect because it focuses on financial constraints which are relevant to start-up companies. Universities do not automatically contribute more to innovation capacity when students become entrepreneurs and start their own company. Graduates who start working in an established company can also contribute to innovation capacity. In addition, not all student-start-ups created are innovative (e.g. coffee shops). They suggested focusing on these student start-ups over time, so that we can consider the (employment) growth 3 to 5 years after the foundation year. Moreover, it was suggested to extend the indicator to also include academic start-ups.

Box 1: expert feedback on student start-ups for UCIC
- Not all student start-ups are necessarily innovative
- Academic spin-offs should be taken into account

Stakeholder feedback (interviewees and questionnaires)

The stakeholders who have responded to the questionnaire have a more supportive and positive view, as compared to the experts. The high scores of the indicator for appropriateness demonstrate the support for this measure. However, at the same time, the perceived feasibility of the indicator was seen as being ‘in the middle’. The box below demonstrates the mean scores for three aspects of evaluation on a scale from 1 to 3, with 1 being the minimum and 3 the maximum value.

	Appropriateness	**Usefulness**	**Ease of Data Gathering**
Student start-ups (total active start-ups, turnover, private funding raised)	2.29	2.23	1.63

Alongside these quantitative responses from the survey, interviewees provided a number of qualitative rationales about the relevance and feasibility of the measure. Start-ups can be indicators of the entrepreneurial culture of a HEI. The interviewees mentioned that research fuelled start-ups would provide a more comprehensive picture of their contribution to innovation capacity. It was also suggested to include start-ups founded by HEI staff members, such as professors and researchers. In addition, the indicator should be approached over time in order to understand the sustainability and the growth of these firms. Regarding the feasibility of collecting data for this indicator, only the number of start-ups would be possible to collect. The turnover and private funding raised are hard to collect.

Related to their feedback, the interviewees have proposed several other indicators to measure start-up activity.

Box 2: stakeholder interviewee feedback on student start-ups for UCIC
• Start-up companies are not necessarily spin-offs and are hard to measure
• Spin-offs may be more appropriate but start-ups are also important
• Consider spin-offs by both staff and students
• The regulatory framework at national level affecting university activities may limit or hinder this activity
• Define start-ups and spin-offs and include the definition on the measurement process of the indicator
• Look at the sustainability of the start-ups 3 to 5 years after their launch
• Measures such as turnover and private financing may be quite hard to operationalize

Indicator feasibility

Major information on start-up characteristics, such as average number of founders, age, sex, region, business sector, type of product sold, average revenue, main challenges faced, etc. can be drawn from the European Startup Monitor and, in more detail, from country reports. According to our availability ranking, the realization of this indicator is quite hard (2). The main challenge is to aggregate the qualitative information explained in each country report into a country-level database harmonizing the existing information. Specific information on student start-ups should be built based on the founders' characteristics (see Annex 6).

The focus on the number of student start-ups in order to measure the spin-off activities of HEIs is perceived to be relevant only in some aspects. The qualitative comments we received demonstrate that there is no consensus that student start-ups necessarily contribute to innovation capacity. Not all start-ups created are innovative. It was suggested to include also academic spin-off activity. Regarding the ease of gathering the data for this indicator, the HEI should be able to retrieve the needed data. At the moment, no immediately available data is accessible. However, it should be fairly easy to make the data uniform and to transform it into an indicator.

Other potential indicators

The indicator fiche provides an alternative indicator to measure the variable internationalization. As an alternative proxy, we report data on EU start-ups main characteristics drawn from the European Start Up Monitor website. This indicator provides detailed information on both employees and start-up characteristics. However, it does not allow us to exactly identify student start-ups. The indicator proposed is:

- Start-up characteristics (age and sex of founders, sector of activity, average revenue, number of employees, etc.)

A number of suggestions for alternative indicators were made in the course of the fieldwork. The most relevant of these are listed below:

- Start-ups in incubators/science parks/business accelerator programmes
- Spin-offs and spinouts established by students or HEI staff
- Number of start-ups/spin-offs funded by private investors against the total number of start-ups/spin-offs
- *Turnover of start-ups/spin-offs within 3-5 years after their foundation*
- *Number of employees of start-ups/spin-offs within 3-5 years after their foundation*
- *Private funding raised by start-ups/spin-offs within 3-5 years after their foundation*

- *Capitalization of start-ups/spin-offs within 3-5 years after their foundation*

The indicators that we believe might offer a reasonable alternative to the overarching indicator are shown in italics.

6.3 The readiness of available data sources to populate the final indicator set

In the previous section, we set out the analysis of the individual indicators in our final indicator set. This final indicator set needs to be populated with data. In this section we will determine the readiness of existing data sources that could be used to populate our final indicator set. We have conducted an analysis exploring in depth the available sources of statistical information on innovation, higher education (HE), universities' innovation performances and relationships between universities and private corporations. All major statistical sources have been taken into account at both European and national level, including Eurostat, World Economic Forum – Global Competitiveness Index and DESTATIS - German National Statistical Institute. Moreover, additional information sources have been analysed, including scientific publications on the related topics, as well as EU reports on research and innovation in member states, such as the EU Research and Innovation Observatory reports.

Chapters 2 and 3 identified the ways in which each of the UCIC mechanisms had been measured in the research establishing that they contributed to UCIC. Each mechanism corresponds with a measurement that can be used to quantify that mechanism in a particular context. In a number of cases, the measures corresponded with publicly gathered data (in particular the UK's HEBCIS survey). But a functional indicator set needs to be produced on the basis of standardised data available at the level of Europe as a whole that can be disaggregated to a suitable territorial scale (at least to the regional scale) and which can be produced with a timeliness that fits with a management cycle (typically annually). Given that there is no off-the-peg indicator set for UCIC, it is therefore unsurprising that the necessary data that would be needed to populate the indicator framework is not readily available.

It is however possible to benchmark the indicator set as to its level of readiness on the basis of the available data sets[12]. The basis for this benchmarking is that any existing indicator situation falls between two extremes. At one extreme is a situation whereby the data that is required is already collected and meets the demands of an accepted statistical standard (such as the Frascati manual). At the other end of the spectrum, a mechanism has been identified on the basis of a limited number of pieces of academic research: systematic data would require piloting new measurement protocols and implementing new surveys in order to gather that data. Lying between those two extremes is a situation in which a number of these indicators are located, namely that measures have been developed for research purposes and some data has been gathered but it is not currently systematically collected in ways that would allow its use as an indicator.

A very basic benchmarking exercise of the ten previously-identified indicators allows a derivation of their respective readiness. The basis for the benchmarking was consulting with the metadata within a number of statistical databases[13] to identify each indicator's

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[12] We are here inspired by the US Department of Defense's Technology Readiness Level benchmark, which maps the extent to which a promising idea is developing towards readiness for launch as a new system(from Basic Technology Research To Launch & Operations). Likewise, we benchmark the indicators from being an academic concept to a fully workable indicator.

[13] These were Eurostat; OECD-STAN; Unesco - science and technology database; WIPO – World Intellectual Property Rights Organization database; World Economic Forum – Global Competitiveness Index; Istat - Italian National Statistical Institute; INSEE - French National Statistical Institute of Science and Technology data; DESTATIS - German National Statistical Institute. More information is available in the [Annex on Indicator fiches]

respective readiness against five benchmark levels, reflecting the two poles set out above. Each of the indicators proposed in chapter 6 was benchmarked against this scale to give an overall indication of the readiness. The five benchmark levels chosen are given below:

- 1 ('simple') the data is already held and just needs aggregating and transforming into indicators;
- 2 ('quite hard') the data is not held in a uniform way between agencies but could be made uniform and fairly easily aggregated/ transformed into indicators;
- 3 ('hard') the measurement is well understood but gathering it would require a new survey or sampling of a relatively limited population (e.g. European universities);
- 4 ('very difficult') the measure would involve putting new questions to an existing approved large n-survey;
- 5 ('almost impossible') gathering the data would require standardising definitions, piloting, and a new survey of the order of magnitude of the CIS.

An example of the operation of the benchmarking process is given below, to demonstrate how "participation of non-academic agents in the development of curriculum development" has been benchmarked at an indicator readiness level of 4 (measure not well understood and would require gathering of several new questions in a large scale survey).

Participation of non-academic agents in the definition of curriculum development No information has been found regarding the participation of non-academic agents in curricula definition. Therefore, this mobility indicator should be created by collecting new ad hoc information. According to the availability scale defined above, this indicator is benchmarked as being **very difficult (4) to build**. In fact, no immediately available (as well as limited-access) micro data providing useful information have been found. A survey should be organized so to collect information from EU universities on curricula definition. Universities should be sampled ensuring representativeness and trying to cover the largest possible number of member states. The set of information needed to build the indicator should be collected by national experts in each member state. National experts are almost a necessity for studies where original data need to be collected for a large number of countries. National experts have better access to institutions in their countries and are able to interpret the data collected in the light of the national context, institutions and practices.

This benchmarking was carried out for each of the ten indicators under consideration, and the outcomes in terms of the readiness benchmark level are shown in the table below. More detail concerning the judgments underlying each of the reported readiness level benchmarks is reported in the Annex "EUnivation research on indicator set to measure how universities contribute to innovation capacity via spill-overs" (see Annex 6).

Table 6: Higher education and universities' contribution to innovation capacity – Indicators list

Area	Description	Indicator Readiness Level
Curricula	Participation of non-academic agents in the definition of curriculum development (level measure)	4
Mobility	Percentage of PhDs undertaken jointly with a private (non-academic) partner	4
Lifelong learning	Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)	4
Collaborative R&D	University research funded by industry and by charities/foundations (number of projects, total value	3

	and percentage of total)	
Consultancy	Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)	3
Teaching & Learning	Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs)	3
Infrastructure for commercialisation	Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)	3
Education outreach	HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)	3
Internationalization	Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS	2
Student start-up activity	Student start-ups (total active start-ups, turnover, private funding raised)	2

***** NOTE The shading separates the three indicator coverage spans proposed in Chapter 6 corresponding to core (5), optimal (3) and extensive (2) coverages.***

The message from the benchmarking exercise is clear, and that is that the current state of indicator readiness is relatively low. If the aim is to produce an indicator set that reflects a multi-dimensional model of UCIC (that in turn corresponds to the reality of European HE) then that cannot be readily produced from the existing datasets. The prototype indicator set is therefore a prototype in the classic sense of the word, that is something that gives those developing towards the final product a sense of how it might function. The purpose of a prototype is to provide opportunities for learning through this process how the indicator set might function before committing to large-scale investments in launching the final product.

We note that there is sufficient coherence in the prototype indicator set to proceed to the next step of developing a pilot indicator set. We argue that this pilot stage should reflect the lessons that have been learned from the critical reflection on the prototype indicator set analysed previously. This is particularly salient, given that the next step is - as highlighted above - likely to involve substantial investments of time, effort and other resources from a range of partners to arrive at a standardised set of measures. In chapter 7 we present our recommendations from this study, and in particular the recommendations that are necessary to undertake sufficient learning from this exercise in proceeding towards the development of a pilot indicator scoreboard that will meet the needs of its potential users.

7 Next steps on the operationalisation of the indicator framework

In Chapter 6, we presented our prototype indicator set for measuring the contribution of universities to innovation capacity that was developed on the basis of a coherent conceptual framework. We likewise presented extensive evidence – from a desk analysis, from the peer feedback, from expert interviews, and an extensive survey – that demonstrated that there is broad support across key stakeholders for a better set of measures of university contribution to innovation capacity than those that currently exist. There was support for the areas we proposed and the kinds of indicators that are used in the prototype indicator set to ensure that there is a more balanced approach to measuring UCIC that does not assume that these contributions are exclusively generated via research activities but also reflects the various other pathways by which university knowledge activities stimulate innovation.

We further noted in 6.3 that further work is needed in order to make use of this prototype to generate useful performance management information and meet this need from stakeholders for a more balanced indicator set. Our overall approach is that additional experimention needs to be undertaken to deal with a number of uncertainties that exist within the currently chosen indicators. As 6.3 shows, the necessary data is not immediately and readily available and therefore creating management information will require some kind of additional data gathering exercise. The gathering of data and the population of the indicator framework lie outwith the formal scope of the Eunivation project, but the evidence base gathered and presented in Chapter 6 provides a strong base on which to make recommendations for moving to the next phase of measuring UCIC across Europe.

In chapter 7, we therefore systematically set out these next steps.

- In 7.1, we therefore set out our overall balanced scorecard approach for the ten variables presented in chapter 6 and reflect on the use of this indicator set in practice.
- In 7.2, we argue that a major area of uncertainty remains over the particular measures chosen for the ten variables, and offer a set of alternative measures emerging from the research that might also produce useful information for each variable.
- In 7.3, we propose that the next step should be taken by a series of lead users who find the information useful and valuable in their own context, as a step towards dealing with the measures in the chosen uncertainties and the statistical challenges involved in gathering data.
- We conclude in 7.4 by presenting a set of more detailed recommendations for key stakeholders in this experimental phase, namely the European Commission, National Policymakers, Higher Education Institutions, and social/ economic partners.

7.1 The uses of the prototype indicator set

The indicators that have been developed are intended to present a balanced scorecard of university contributions to innovation capacity. It is important to state that we here make a distinction between the university as the unit of reporting (data gathering) and what will be chosen as the unit of presentation. We have chosen universities as the unit of reporting because the spillovers originate from university activities, and universities are most strongly positioned to report on that data. But we are clear that we see the unit of presentation as being a territorial one, aggregating data from a number of universities to demonstrate where universities are contributing more or less strongly. Our justification for this is that spillovers depend as much upon take-up as outflow, and in weak regional environments, active, successful universities may make a lesser (or less visible) contribution through no fault of their own. We draw an analogy here with the Community Innovation Survey which presents its results regionally and nationally, and not at the level of individual companies. We envisage that a putative University Innovation Contribution scoreboard would report at a territorial scale sufficiently aggregated to prevent the distinction of individual institutions.

Our analysis in this report has been that attempts to measure university contributions to innovation capacity to date have fallen short because of the sub-optimal equilibrium problem. The existence of university R&D measures provides partial coverage of UCIC and has also provided a disincentive to developing new indicators, partly because there is some dispute over the extent to which other kinds of university activity contribute to UCIC. Our literature review developed a single conceptual approach to UCIC, as a set of spillovers facilitating access to complementary innovation assets.

From the literature, it has been demonstrated that there is as much a need to account for human capital contributions through spillovers as knowledge transfer contributions; indeed, the literature review also demonstrated that an element of the assumed benefits of knowledge transfer indeed come through human capital contributions (e.g. inter-sectoral Ph.D. & post-doc mobility). These indicators and the balance that they represent (already presented in chapter 6) are repeated below.

Table 7: Final indicator set

Category	University activity	Indicators
Human capital	Lifelong learning	Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)
Human capital	Mobility	Percentage of PhDs undertaken jointly with a private (non-academic) partner
Human capital	Curricula	Participation of non-academic agents in the definition of curriculum development (level measure)
Knowledge transfer	Collaborative R&D	University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)
Knowledge transfer	Consultancy	Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)
Human capital	Teaching & Learning	Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs)
Knowledge transfer	Infrastructure for commercialisation	Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)
Knowledge transfer	Education outreach	HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)
Human capital	Internationalization	Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS
Knowledge transfer	Student start- up activity	Student start-ups (total active start-ups, turnover, private funding raised)

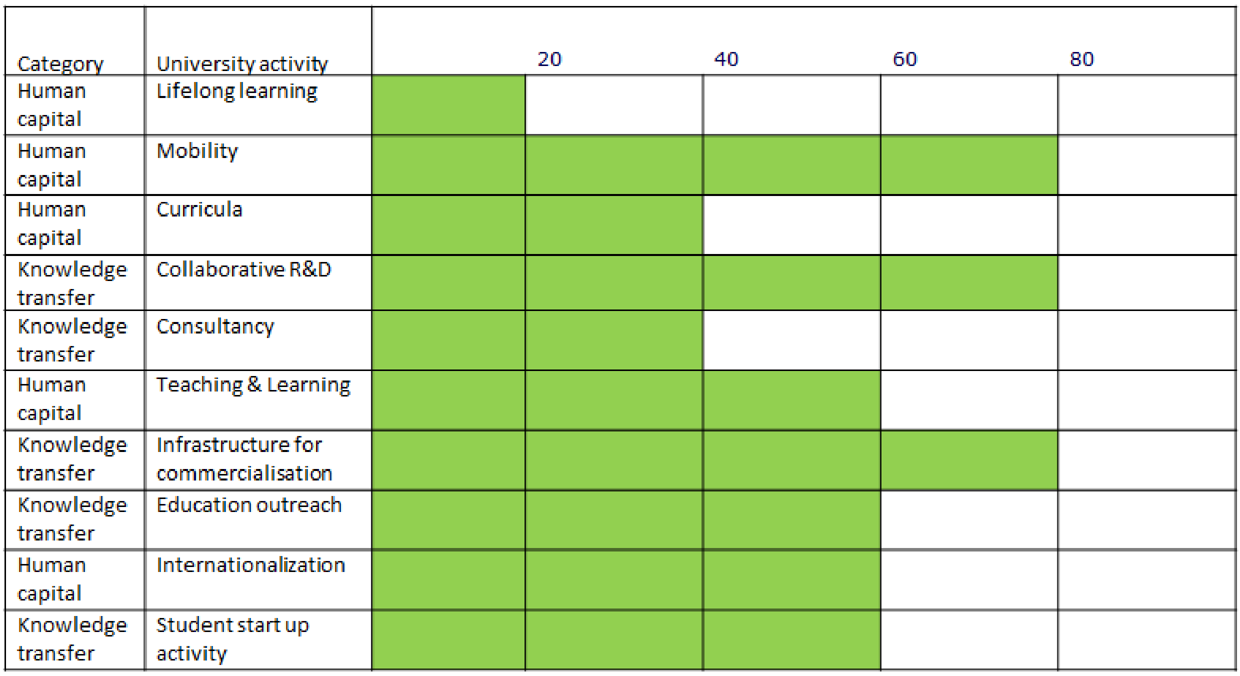
As the indicators do not yet exist in satisfactory form, they will need to be gathered before they can be “used” by policymakers. The use of the indicator set, and therefore the next steps for the indicators, depend on them having strong champions to take them forward. The prototype indicator set is based on the feedback of a range of experts and practioners from across Europe. It therefore provides extensive evidence of the way that universities contribute in many ways to improving societies. Given the pressures that universities are under to demonstrate these contributions, we expect these indicators in the first instance to be of use to universities and university associations to make that broader case. The successful use of the indicator framework is therefore contingent upon the extent to which universities are prepared to take ownership of the framework and use it actively to demonstrate the ways that they contribute to innovation capacity.

The European higher education sector is relatively strongly vertically differentiated; some countries have multiple tiers in their systems (such as the Netherlands or Germany), others make a distinction between elite institutions and other universities (notably France) whilst other systems have a more fine grained distinction between research intensive, teaching intensive and specialised institutions (e.g. the UK). This can also be seen in the existence of different kinds of university associations reflecting the different sectors, where LERU and EURASHE represent research and teaching intensive institutions respectively. Current approaches to UCIC are good at representing the contributions made by research-intensive universities, and also to a lesser extent by more technically-focused applied universities (where they measure contract and applied research activities). There is therefore the question of the willingness across the sector to adopt these measures, or whether they are seen as being part of a normative attempt to gain equal recognition for the less-prestigious teaching intensive universities.

We have noted that we do not see these indicators as performance measures for HEIs, although the peers were clear in warning of the risk that some will regard these as objectives towards which universities need to be steered. Our spillover model relies on the active uptake of the spill-over benefits by active agents, and therefore one would expect that university contributions would be less where there is a weaker demand pull from outside agents. We would hope that policymakers would seek to reinforce the creation of benefits within interactive relationships rather than steer universities to create those benefits. A lack of PhDs jointly undertaken with external partners is in the European context more likely to arise from a lack of expertise in those partners than a lack of willingness in HEIs to host partnership PhDs.

And it is here that we see that the indicators will be at their most useful, in helping policymakers identify where the wider STI policy framework is failing to exploit the potential of universities – namely that of the issue of capacity. A university that reported its performance against the framework below could legitimately argue that despite strong performance in collaborative R&D and joint PhDs (with external partners) there was relative underperformance in the participation of their academics in external teaching and also consultancy. There is the case to be made that their high-level knowledge base required in collaborative R&D and PhDs was not being exploited more widely for lower threshold knowledge transfer activities. That university would therefore have a reasonable claim to ask for public support for these activities and therefore realise its unexploited potential.

Figure 8: An example of use of the indicator set by an HEI to identify latent potential



We note that there have been a number of attempts within DG EAC to develop indicator sets for various purposes, such as U-Multirank (multi-dimensional ranking) and ETER (basic indicators for universities). These have always involved pilot development by identifying a relatively small number of early users to implement the indicators in their own institutional contexts, to drive a learning process with three dimensions:

(i) Improving the practical definition of the indicators and developing protocols for their more extensive gathering

(ii) Creating knowledge about the ways that these indicators can be used within institutions, and the value of those indicators to universities

(iii) Creating knowledge about upscaling the indicator set to include more universities, and the reasons that institutions may be unwilling to implement these indicators.

We therefore see the next step in the process as moving to develop a pilot of these indicators, using the prototype indicator set as the basis for an attempt to implement a pilot indicator set, antecedent to launching the indicators on a European scale. This pilot could usefully proceed by identifying a relatively small group of lead users willing to implement the indicators in their own institutional setting. The learning process will also need to identify which of the indicators are more or less suitable, and it may be that for some of the spillovers that the chosen indicator may prove in practice to be impossible or undesirable to gather. From the data gathering exercise a number of alternatives were proposed, and it would make sense to take these potential alternatives forward in this experimental learning process within the pilot phase.

7.2 Potential alternative indicators for the pilot indicator set

The major challenge in progressing from the prototype to the pilot stage is in the implementability of the indicator set. In the prototype phase we were only able to evaluate that prospectively, on the basis of the *ex ante* stakeholder reflections on whether those indicators would be hypothetically deliverable. What is important for the pilot phase is to develop a set of indicators that provide the balanced scorecard, whilst being implementable in practice. Arguably the greatest risk in this proposed pilot phase is that progress is hindered, and the balance lost, because one or more of the indicators are not implementable. From our prospective evaluation we received a number of suggestions for other indicators that might be just as valid but at the same time be 'better' measures of the underlying indicator. We propose that the pilot exercise should take as a first step a more concrete consideration of which of these alternatives would be the most implementable, developing and synoptically comparing in dialogue with lead users potential measurement frameworks.

In this section we present these potential alternatives, making explicit what is already present in section 6, namely the potential alternatives for the specific measures that could provide the indicator corresponding to the desired measures. Each indicator corresponds to a specific spillover mechanism in which knowledge from within the university is activated and becomes a wider resource for societal innovation. There are different measures for each mechanism that could provide a valid indication, each reflecting the different facets of the pathways by which that activated knowledge flows into society. In general, those elements of the pathways that are closest to the university are likely to be most visible and hence easiest for the universities to measure (and in particular those for which there is a contractual basis). At the same time, when there is a need for a comparative measure – a denominator or divisor or example – then that may raise the practical difficulties in gathering the data for that measure.

7.2.1 Lifelong learning

This measure seeks to capture the ways that universities contribute to the development of human capital in those that are not formally students. The university has particular kinds of knowledge that may be of use to those in the labour market and through post-qualification education activities (short courses etc) that knowledge is made available to societal users (part-time courses are picked up in other indicators). The initial proposed measure is for numbers of lifelong learning courses required by non-academic agents; it was chosen because it is the kind of activity that generates a contractual trail and is therefore relatively straightforwardly countable. In the pilot, it is necessary to determine what precisely can be measured here, whether numbers of courses, the numbers of students, the amount of contact time, or the price paid by users for those courses. If that is too difficult to gather, then it may be easier to simply measure the numbers of participants in these courses. A possible extension of the indicator which may make the indicator more useful is to make it a relative indicator and include a demoninator of total teaching volumes (in terms of student numbers or student contact hours).

Lifelong learning	***Lifelong learning courses required by non-academic agents (firms, public sector, NGOs,…)***
	Number and age of people attending the lifelong learning courses of the HEI
	The proportion of students (and time/credits) spent in courses required by non-academic agents

7.2.2 Mobility

This measure seeks to capture the dynamic interaction through the labour market of those who have experience in conducting research in an academic setting with societal agents (firms, NGOs, policymakers). Universities generate significant amounts of tacit as well as codified knowledge, and one effective way to transfer tacit knowledge for innovation for societal users is for the people creating that knowledge to move closer to or work with those users. In principle this should cover all of the following:

- The secondments and sabbaticals that researchers go on in societal contexts,
- Knowledge-transfer partnerships involving post-docs, and
- placements and internships in research activities, including bachelor and masters activities, as well as joint PhD projects.

We chose the percentage of PhDs undertaken with a private partner for the practical reason that this was most likely to be associated with a contractual audit trail, and therefore easy to count. Universities typically hold data on all PhD numbers at each faculty and joint PhD posts involve contractual relationships with those partners: this information is therefore close to the university and easy to determine. A better measure could be derived from an alumni survey which indicated numbers of doctoral holders working in relevant fields to their PhD (making use of their PhD knowledge). An alternative but easier measure might potentially be external employment or secondment (because of the registration of this activity with university authorities).

Mobility	***Percentage of PhDs undertaken jointly with a private (non-academic) partner***
	Employed doctorate holders working as researchers in the private sector
	Number of HEI staff who hold part-time positions in the industry or other non-academic public organisations

7.2.3 Curriculum

This measure seeks to capture the extent to which curricula are developed in ways that activate the knowledge that the students receive, giving them the transferable skills to use that knowledge outside of the formal academic context. When students encounter real application conditions during their education, it helps them to develop an appreciation of how to apply their theoretical skills but it can also help channel and target their subsequent skill development (because they know what kinds of knowledge might be potentially useful given their desired application context). Our proposed indicator was the participation of non-academic agents in curriculum definition in order to get a broad benchmarking overview of the extent to which conditions of application influenced curriculum design (the 'level' measure). A better measure here would be to capture the amount of learning that students do in an application context, with stakeholders proposing that time spent on internships or on-the-job training by students would provide a useful measure of activated learning. In its most simple form, a measure by universities of the approximate time input from non-academic staff in curriculum development or even teaching activities gives an indication into the potential activation.

Curricula	***Participation of non-academic agents in the definition of curriculum development (level measure)***
	Integration of internships or on-the-job training within the curriculum design (ECTS/ study hrs)

	The number of hours provided by externals to engage in curriculum development

7.2.4 Collaborative R&D / Consultancy

These two indicators are relatively uncontroversial because they correspond with the existing measures that are used for UCIC. In both of these, there is an activation of university knowledge through formal technology transfer/ knowledge exchange/ co-creation activities that are underpinned by a formal contractual relationship. Counting the magnitude of the contractual relationships, in terms of the number of contracts, their value and their relative contribution to university R&D activities provides good indications of the extent to which universities activate their research in application contexts. It is not expected that these indicators will be difficult to measure; however, from the stakeholder interviews it was suggested that it would be useful to capture collaborative R&D applications for joint funding because they are reflective of capacity, even where those applications are not honoured.

Collaborative R&D	***University research funded by industry and by charities/ foundations (number of projects, total value and percentage of total)***
	Joint applications for funding with industry

The consultancy indicator is relatively easy to measure because it relates to things that the universities have to count (income) for accounting purposes and contracts.

Consultancy	***Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)***
	-

7.2.5 Teaching & Learning

This measure seeks to capture the extent to which universities are activating the knowledge that their students have by giving them entrepreneurial skills. Although entrepreneurial thinking is typically associated with enterprise thinking – setting up new businesses – entrepreneurship has at its heart the act of creating new things – innovating – using existing assets in new combinations. Entrepreneurial education is therefore also about the practicalities of innovation – perceiving a gap and a way of doing things better, and assembling and orchestrating the resources to achieve that. Even where university entrepreneurship courses focus on creating new businesses, most student entrepreneurs do not themselves become entrepreneurs but find themselves in business and entrepreneurship education can be applied within wider innovation and change processes. In the prototype indicator set, we therefore proposed measuring the number of students participating in entrepreneurship-enriched education, either in terms of student participation or the volume of participation. If that would prove too difficult to measure then it should be possible to relatively easily identify the number of courses involving an element of entrepreneurship teaching. Harder to measure would be the quality of the entrepreneurship education and its proximity to the application domain, in terms of the past experience of those teaching entrepreneurship courses in entrepreneurship and innovation activities.

Teaching & Learning	***Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs***
	% of courses including an element of entrepreneurship
	Number of university staff with experience in entrepreneurship and innovation

7.2.6 Infrastructure for commercialisation/ education outreach

This measure both seeks to capture the efforts that the university undertakes in making its knowledge resources available to outside users, whether commercial or more widely public users. The rationale for the indicator is that if the university is making a substantive effort to make its knowledge available to the public, then there must be a corresponding uptake of that knowledge by societal users, thereby representing a spill-over of that knowledge and hence a contribution to innovation capacity.

In terms of commercialisation infrastructure, the initial indicator we proposed was the presence of a range of commercialisation services within the university, in terms of seed corn investment, venture capital and business advice, potentially with a volume measure related to the amount spent by the university on those activities. A more detailed measure if available would relate to the revenue and/ or co-founding associated with those activities, although there are some practical concerns around seed corn and venture funding that might be subject to commercial confidentiality.

Infrastructure for commercialisation	***Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)***
	Revenues generated by services provided within the commercialisation infrastructure

In terms of education outreach, the initial indicator we proposed was the HEI budget associated with different kinds of education outreach activities and public events. In the pilot exercise, it would be most useful to try to determine precisely the scope of such measures, and to draw boundaries – Open Days for student recruitment would not count, whilst careers fairs bringing employers to meet and recruit students would potentially be valid. Budget is a proxy for the effort made by the university and its volume of activities, and so improvements would potentially measure the time investments made by universities in those, where not specifically accounted for, and potentially also participation in terms of public hours of audience reached by the universities in these activities.

Education outreach	***HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)***
	Amount of time and effort allocated to such activities
	Number of participants in such events

7.2.7 Internationalisation

This measure seeks to capture the relative diversity of the educational environment provided by universities. Knowledge spillover via human capital works through moving knowledge between different contexts, and specifically between theoretical (within universities) and applied contexts. One of the ways university education facilitates this knowledge mobility is in providing students with exposure to different theoretical contexts, where there are different norms, assumptions and models, in making students more reflective and active in their choice of theoretical models, e.g. by involving international students and teachers in the classrooms. Student exchanges are a very good way of facilitating this by creating a cross-fertilization within educational programmes and therefore we have proposed to measure the volume of internationalisation through the ECTS awarded to international exchange students as a reflection of this. Where information is available on staff and researcher exchanges, that also reflects the extent to which there is activation of these translational experiences within study environments. A final and simpler measure of this internationalisation would be to have the number of HEI staff with a Ph.D. awarded by a foreign HEI or with substantial work experience comparable to a Ph.D. in other international academic contexts.

Internationalization	***Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS***
	Number of students and researchers in all exchange programmes
	Number of HEI staff with a PhD from a foreign HEI

7.2.8 Student start-ups

This measure seeks to capture the extent to which university knowledge is being valorised in activities which external parties find sufficiently important or relevant to support. The knowledge spillover here addressed is where an agent identifies that there are potential applications for a particular piece of university knowledge (an 'innovation') and seeks to translate that knowledge from the university context to the societal context. This may take place through the creation of student start-ups, staff spin-offs, through joint venture companies, or through "intrapreneurship" (where companies hire in staff or buy start ups to create new innovative activities). The reason for the choice of focus on student start-ups was because of the overlap otherwise with commercialisation income – and the income generated from the sale or takeover of spin-off firms in which universities have a stakeholder. The challenge with student companies is that the definition of a 'student' and their attribution to a university and its knowledge base is relatively difficult to make but we anticipate that universities will have information about their successful companies. It would be easier to generate data on the firms in which universities have an active involvement through shareholdings or IP deals (a contractual audit trail). Given the relatively low numbers of firms created, and their legal registration requirements, universities may be able to generate deeper information from annual reports about their numbers, turnover, employment and funding.

Student start up activity	***Student start-ups (total active start-ups, turnover, private funding raised)***
	Turnover of start-ups/spin-offs within 3-5 years after their foundation

	Number of employees of start-ups/spin-offs within 3-5 years after their foundation
	Private funding raised by start-ups/spin-offs within 3-5 years after their foundation
	Capitalization of start-ups/spin-offs within 3-5 years after their foundation

7.3 Recommendations for next steps to develop a working indicator framework

7.3.1 Introduction to recommendations

In the present prototyping study, we have found that there is a strong degree of coherence around university contributions to innovation capacity by considering the different kinds of spillover effects emerging from universities. Our model has identified a number of dimensions by which universities generate resources that improve others' opportunities for innovation. These correspond with a wide range of university activities, and were broadly supported by the fieldwork. The prototype is not itself coherent and ready to immediately proceed unaltered to the development of a Europe-wide scoreboard or indicator set. This is a function of the availability of data to provide information on the indicators we have proposed.

The indicators that we have proposed emerged from the literature review, and have been used in some particular context by a specific policymaker or researcher to address a single process or mechanism that corresponded in some way with the dimensions we identified in the literature. But that does not necessarily mean that those measures are the only way of gathering useful data on that indicator. Unavoidably, the fieldwork gathered data on the basis of indicators that emerged from the literature review, partly as a means of trying to get respondents to have an understanding of the conceptual dimensions with which we are concerned. Any possible effects of this methodology should be considered when taking the prototype indicator set along the next step towards a European 'UCIC Scoreboard' or Survey.

Our overall recommendation is that the Commission proceed to develop a pilot scoreboard for UCIC using the conceptual framework proposed above, and drawing inspiration from the prototype indicator set, as well as the potential alternative indicators. We specifically recommend that this be driven by a group of lead users who have a strong intrinsic commitment to developing the indicators, encompassing the Commission, a set of HEIs and an expert group. We believe that the success of this pilot can be realized by creating a more facilitating environment for the use of these indicators by others, including university representative groups, national higher education and research policymakers, other elements of the Commission and European social partners. In the rest of this section, we set out our headline recommendations, and in 7.4 we conclude with a specific set of detailed recommendations for distinct lead users and facilitators.

7.3.2 Recommendations for the Lead Users

The first lead user for these indicators is the European Commission and specifically DG EAC as the instigator of this research. Thus the Commission should set out what the long term ambitions for this indicator set, and provide clear and concrete examples of how it is to be used. This will help to condition the expectations of participants, and will also stimulate the facilitators to include the future development of this indicator set into their own plans. Alongside a strong long-term statement of its overall desired direction of travel, the

Commission needs to provide an impulse for this next step, to bring together the Pilot HEI Group and the Expert Group (see below). We do not have a specific recommendation for the form that this impulse will take, but we would expect it to follow the format established in previous indicator development activities, such as ETER and U-Multirank. Identifying other potential co-sponsors for this process would be extremely helpful (such as Bertelsmann or the OECD) in making clear that this is not an internal Commission toolkit but something intended to have a wider European added-value to innovation stakeholders in general.

The second lead users for these indicators are a group of HEIs willing to devote resources to the development of indicators. This requires that they have an intrinsic value for those indicators, and that the latter help them either with their internal management process or their wider public representation activities. The biggest risk in the pilot phase is failing to engage and attract the class of universities that see themselves as being the 'losers' from this system, which prior experience suggests will be large research-intensive universities in North West Europe. We recommend that the pilot group should be both relatively small (to ensure overall manageability and convergence within the pilot process) but also relatively diverse (to facilitate its later relevance for upscaling into a Scoreboard). There should be a range of mission types (research intensive/ teaching intensive, specialist colleges/ technical universities/ broad universities) from different kinds of HE systems (Nordic, Anglo-Saxon, Germanic, Eastern European, Southern European). We envisage on the basis of past OECD and Commission exercises (including HEInnovate) that it will be relatively straightforward to identify and assemble such a group.

The groups of lead user will be supported by a third group made up of experts. This support group will oversee and manage the indicator piloting process. The precise nature of this expert group will depend on the format chosen by the Commission for providing the impulse to the indicator development. We recommend a clear division between two roles within this group, between an operational and advisory group. We recommend that a small operational team is appointed to act as the problem owner for the development of the indicators and to co-ordinate the necessary next steps (1. selection of measures with HEIs, 2. developing measurement protocols, 3. gathering data within institutions, 4. assembling data centrally into an indicator set, 5. finalising a measurement manual – cf Frascati, Oslo). We recommend a small advisory group of experts is formed bringing together distinct expertises, in higher education, statistics, innovation policy and performance measurement. This advisory group will provide feedback to the operational group to assist with the finalisation of each phase, and to ensure that the operational steps converge towards the long term aim set out by the Commission (see above).

7.3.3 Recommendations for other facilitators

The first group of facilitators for this process are university representative associations both at the national and European levels. We note that EURASHE have been developing their own indicators for measuring the research outcomes in universities of applied science, and this is strongly complementary with a UCIC Scoreboard. We recommend that these associations engage with the pilot process to ensure that what emerges allows universities across Europe to demonstrate their widespread contributions to society as effectively as possible. We therefore recommend that university associations are invited to participate as partners in the piloting process and are provided with opportunities to participate in indicator finalisation, and a set of supporting stakeholder meetings.

The second group of facilitators for this process are interested non-user HEIs: universities who are interested in the principle of demonstrating their contributions to innovation capacity but unable to participate in the core group. This group has considerable knowledge relating to gathering data within university contexts that will be vital for any subsequent upscaling of the indicator set into a Scoreboard. We therefore recommend that a reference group of universities is assembled to provide commentary on the finalisation and operationalisation of the indicators.

The third group of facilitators for the process are national policymakers in the fields of higher education and innovation. One of the strongest factors which has driven the persistent dominance of the commercialisation income indicators as proxies for innovation contributions has been a consensus between these national policymakers. Part of this consensus has been driven by higher education policy and the importance of research (and the subordination of teaching) as the gold standard for university activity. The other element has been around the commercialisation perspective from innovation policymakers seeking to leverage existing knowledge assets to create economic growth. Funding incentives increasingly regard teaching as a commodity separate from research, thereby reducing the opportunities for it to be activated in ways that help students apply their knowledge to stimulate innovation. Likewise, research funding rewards publication excellence rather than activities antecedent to inter-sectoral mobility and innovation (with the exception of spin-off activities supported by business plan competitions).

We therefore recommend that national policymakers acknowledge the importance of knowledge transfer for innovation through people (critically through students and researcher mobility). We recommend that national policymakers ensure that funding incentives are specifically tailored to stimulate university activities that contribute to a full range of innovation activities. We finally recommend that policymakers also develop instruments and tools to support the first order users of those university contributions.For instance, policy makers could create multi-stakeholder open fora inviting students and civil society to raise awareness about entrepreneurship opportunities and student placements. Moroever, policymakers could provide administrative support and/or funding to create incentives for fims and civil society to develop PhD postions and student placements, e.g. by covering the social insurance expenses.

A final set of facilitators are the European groupings of relevant stakeholders and we here recommend to establish a standing dialogue with these partners to reframe the definitions of innovation and university contributions to innovation capacity. The current perspective – of UCIC being derived from commercialisation – is strongly institutionalised at the European level through bodies such as the University Business Forum. Realising the long-term goals of a more balanced approach to innovation (encompassing the role played by education in activating research) likewise requires building up a European institutional framework to represent these perspectives. We therefore recommend the establishment of a University Innovation Forum comprised of universities together with other actors in the innovation process (with particular emphasis on policy users, NGOs, and civil society groups as well as firms),. This would establish a more extensive dialogue towards a broader innovation perspective in the Europe 2020 strategy.

7.4 Overview of recommendations by group

7.4.1 Directorate General for Education and Cuture

We recommend that DG EAC:

- Provide a clear statement of the DG's long-term ambitions for the development and subsequent deployment of a UCIC indicator set

- Provide clear examples of how that indicator set will be used in practice as a policy tool in the European institutional setting
- Provide a clear research commitment to a follow-on activity for developing the prototype indicators into a pilot scoreboard
- Identify potential co-sponsors and partners in the development of a European Scoreboard of University Innovation
- Assemble a group of HEIs willing to work on the finalisation and operationalisation of the indicator set
- Provide support for an expert group to manage the practicalities of developing a convergent indicator set and to provide advisory feedback on the piloting process
- Develop an institutionalised stakeholder dialogue at a European level to deepen understandings of innovation as a driver for a smart, social and sustainable Europe, and of the role of universities in supporting this innovation.
- Disseminate the findings and follow-up of this report to other European Commission services and to other EU institutions.

7.4.2 National Policymakers

We recommend that:

- National Higher Education policymakers across Europe take notice of the interdependence of teaching and research, and the potential for research activities to activate teaching in ways that increase its subsequent societal value.
- National Higher Education policymakers identify mechanisms and instruments within existing funding frameworks to reward and stimulate 'activated' approaches to teaching and learning in order to optimise the realised flow of innovation skills into sectors where that innovation is to be realised.
- National Research policymakers take notice of the multiple pathways through which research is taken up in society, and in particular the ways in which 'activated' teaching and learning contributes to the societal uptake of research.
- National Research policymakers identify mechanisms and instruments within existing funding frameworks to reward and stimulate the involvement of students in research so as to optimise the uptake of newly-created knowledge within society.
- National innovation policymakers take notice of the potential of students and inter-sectoral mobility as a mechanism to stimulate a wide range of innovation activities stimulating social, economic and environmental development processes.
- National innovation policymakers develop and deploy new mechanisms and instruments to encourage and support societal partners so as to absorb different kinds of knowledge spillovers emerging from universities in their innovation processes.

7.4.3 Representative Groups

We recommend that:

Higher Education Institution representative groups:

- Take notice of the potential of the University Innovation Contribution scoreboard to give a more realistic public representation of the manifold ways in which HEIs contribute to their sponsoring societies
- Engage with the development of the pilot indicator scoreboard to ensure that it best represents university contributions to innovation capacities
- Consult with their membership on their needs and wishes for the development of an indicator scoreboard in terms of reporting and representation
- More strongly advocate for a recognition of the wider range of contributions made by universities to building smart, social and sustainable societies, beyond a very limited range of commercialisation and consultancy activities.

Other innovation actors:

- Take notice of the potential within HEIs to provide resources that help a wide range of socio-economic actors to innovate, by developing new products, processes, techniques and approaches that can improve their members' overall performance.
- Engage with the development of the pilot indicator scoreboard to ensure that it retains its salience and legitimacy for a high-level discussion of European innovation policy within Europe 2020 and beyond.
- Form a standing dialogue group on university innovation contributions as a means of developing a broad-based understanding of the potential of universities to contribute to supporting improvements across the spectrum of the Innovation Triangle.

7.4.4 Higher education institutions

We recommend that:

- University leaders take notice of the opportunities of the indicator prototype set to present a stronger case for the contributions that universities make to realising societal development goals.
- University institutional research organisations take notice of the indicator framework as a means of providing new management and performance information regarding university valorisation activities.
- A group of lead user universities participate in the development of a pilot indicator scoreboard.
- A wider group of interested universities engage in an ongoing dialogue to agree on a final indicator handbook as the basis for a Europe-wide University Innovation Scoreboard.
- University researchers seek to contribute to a re-evaluation of the framings of innovation and UCIC, specifically considering a wider perspective on innovation encompassing green innovation, public sector innovation, social innovation and open innovation.

Annexes

Annex 1: Methodology for the fieldwork

The draft version of the prototype set of indicators which was defined through the comprehensive literature review conducted in Phase 2 of the project (i.e. the Conceptualization stage) was assessed by various stakeholders through fieldwork and three carefully designed methodological tools, including: (i) in-depth **interviews**, (ii) an online **survey** and (iii) **case studies**.

Interviews

A large number of interviews were conducted in 13 European countries as well as the USA, with a view to better understanding the contribution of higher education to innovation capacity and identifying metrics employed for its measurement in each country, as well as assessing, in a qualitative manner, the first draft set of indicators proposed by EUniVation. In particular, the target groups of the interviews were:

- Policy makers, as potential users of the indicators proposed, providing therefore valuable feedback from the perspective of the end user;
- Representatives of industry associations, who provided insights into the needs of the industry with respect to higher education and innovation; and
- Representatives of HEIs, who provided meaningful feedback on what the HEIs can offer in terms of data and metrics, as the main data source in the framework of measuring the contribution of HEIs to innovation capacity.

Survey

An online survey was conducted targeting representatives of HEIs and industry associations across Europe in order to collect quantitative feedback on the proposed draft version of the prototype set of indicators on an even larger scale than the interviews.

Case Studies

Based on the input gathered from the fieldwork and complemented with targeted desktop research, thematic and geographically-driven case studies were prepared focusing on the innovation needs of businesses for higher education and how these may be measured and ultimately met.

All in all, this multi target-group, multi-level and multi-tool approach enabled us to study the contribution of HEIs to innovation capacity from a multitude of perspectives, gain meaningful insights into its drivers and impediments and collect valuable feedback on the selection of the most suitable metrics.

The subsections that follow provide further information with respect to the implementation of the methodological tools employed in the frame of collecting feedback on the draft prototype set of indicators, as well as the results that emerged in this respect.

Annex 1.1: Organisation of the fieldwork

The fieldwork was conducted with the overarching aim to validate the types of indicators that will enable the effective measurement of the contribution of HEIs to innovation capacity and collect information about other indicators already developed and utilised in the context of the different targeted countries. The interviews had a regional/national character and were conducted either via physical visits and face-to-face meetings or through digital means (e.g. by using Skype) based on the most efficient logistics arrangement in each case. Each interview lasted approximately one hour and collected meaningful feedback on the first draft set of indicators proposed by EUniVation from the following target groups:

Target groups of fieldwork interviews:

- Policy makers who will potentially employ the indicators proposed: in funding agencies, research councils, high-level policy bodies, etc.
- Business and industry association representatives who provided insights into the innovation needs of the business with respect to higher education and how these may be measured.
- Representatives of higher education institutions who provided insights on what HEIs can offer.

An extensive list of contacts from the abovementioned target groups was prepared, based on desk research and network contacts of consortium partners, so as to serve as a substantial pool of potential interviewees. An outline of the main sources and criteria utilised to identify relevant stakeholders suitable for participation in the fieldwork interviews of each country is provided in the following table:

Table 8: Sources/criteria for the identification of interviewees

Type of Stakeholder	Sources / criteria employed for the identification of interviewees
Policy makers	• ERAWATCH, the European platform on research and innovation policies and systems. • Relevant organizations within the national R&I systems of EU countries, as proposed by the Research and Innovation Observatory of HORIZON 2020 Policy Support Facility. • Coordinators and/or participants in European national and regional initiatives related to ERA coordination, RDI policies, innovation economics, foresight exercises, etc. • National statistic collection agencies for higher education and innovation. • National public authorities responsible for higher education and innovation (i.e. Ministries).
Industry Association representatives	• National chambers of commerce and industry, federations, etc. • National representatives of industrial European networks and associations (e.g. BUSINESSEUROPE, etc.) • Representatives of innovative companies
Representatives of Higher Education Institutions	• Universities, Research centres and department of Economics (with emphasis on the economics of innovation) • Innovation-oriented programmes and clusters (from industry, academia, etc.) at regional, national and international level

In line with the three target groups of the interviews, three respective interview guides were developed and specifically tailored to capture the views of each target group with respect to the proposed set of indicators, as well as their own approaches towards monitoring the contribution of HEIs to innovation capacity. The interview guides are annexed to this report (Annex 2).

A significant number of key relevant stakeholders were interviewed under the scope of thematic and geographically-driven case studies, as further explained in the section which follows.

Annex 1.2: Selection of the case studies

Introduction

The overall aim of the case studies is to meaningfully structure and present the findings which emerged from the fieldwork, providing valuable insights from the perspective of policy makers and representatives of HEIs and industry associations across the EU, paving the way towards the refinement and validation of the prototype set of indicators proposed by EUniVation. In the design of the case studies, two factors that shape the degree of HEI contribution to innovation capacity were taken into account:

- The diverse starting-points (levels) of innovation capabilities in the different countries and the level of existent absorptive capacity of innovation and technological know-how; and
- The diverse structures and organisational characteristics of the labour market in the different countries which endogenously affect the contribution of HEIs to innovation capacity.

The subsections below provide further details on the methodology that was utilised in order to group EU countries, before presenting the case studies that were ultimately selected.

Level of innovation capabilities

In order to identify the level of innovation capabilities of each EU country, the ranking of the Innovation Union Scoreboard (IUS) was employed. The IUS "provides a comparative assessment of the research and innovation performance of the EU Member States and the relative strengths and weaknesses of their research and innovation systems". As such it served as a meaningful proxy for ranking the existent potential of EU countries in terms of innovation as well as their capabilities in relation to innovation.

Typology and characteristics of labour market organisation

In terms of differences in the organisation of their labour market, EU countries were grouped according to two conceptual models (Rubery and Grimshaw, 2003; Saar, Bjorn and Holferd, 2013; de Grip and Wolbers, 2003):

- The Occupational Labour Market (OLM), characterising national training structures and systems with recognized and accredited occupational qualifications (e.g. apprenticeships), which are readily transferrable between employers and provide access to jobs at particular levels. In OLM systems, employers are incentivised to ensure that their staff – via recruitment and training – achieve these accredited levels, and thus training tends to be oriented towards acquiring external recognition.
- The Internal Labour Market (ILM), characterizing countries with educational systems that do not provide occupational-specific skills (Gangl, 2001). Accordingly, in ILM systems, skills recognition encompasses the extent to which what individuals can do

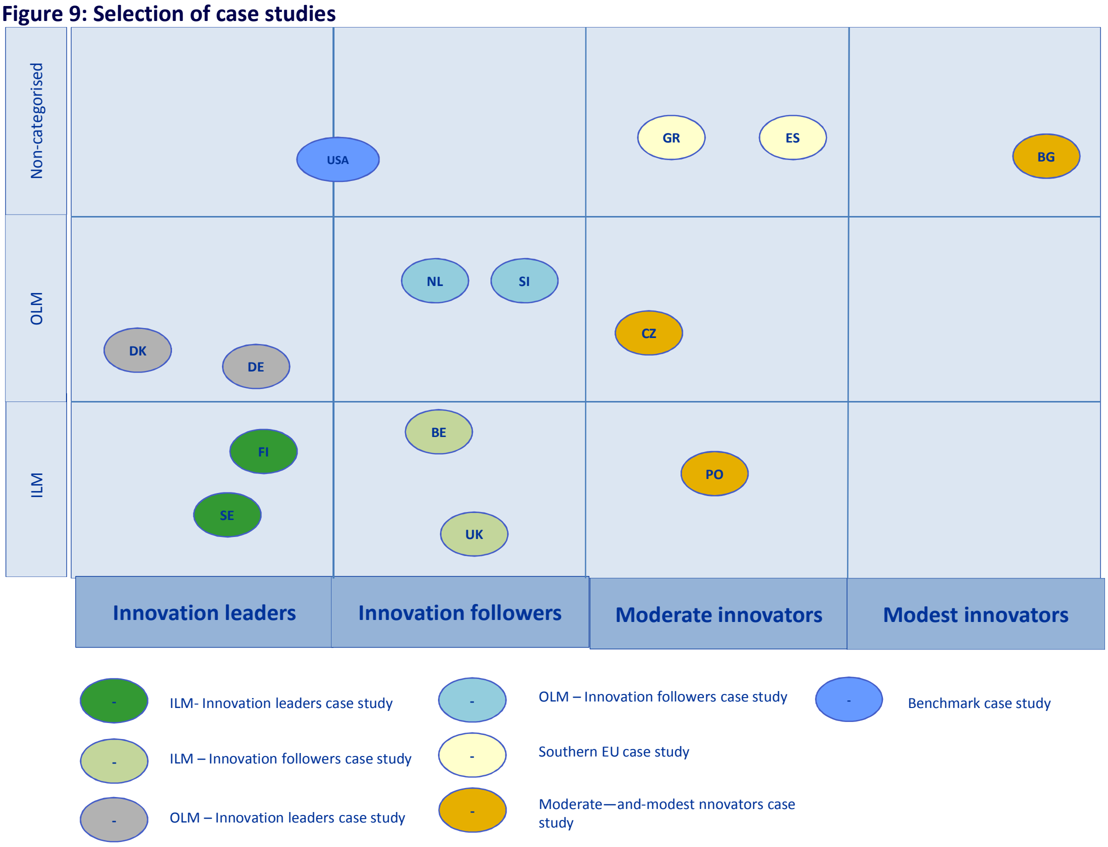
corresponds with the immediate needs of firms. In ILMs, firms are far more oriented towards training their employees only with skills that meet those immediate needs.

It is important to note that ILM and OLM characteristics exist in all countries. Still, the relative importance of one of the two models is typically higher (Eyaud, Marsden and Silvestre, 1990).

Grouping of countries and selection of case studies

All EU-28 countries were grouped in terms of similar innovation capabilities as well as the typology and characteristics of their labour market organisation, with a view to determining the geographical and thematic variations of the case studies to be selected. The following figure provides an illustrative overview of the thematically and geographically driven case studies that were selected based on this grouping exercise.

Figure 9: Selection of case studies



In addition to the proposed EU case studies, a similar geographically-driven case study was developed with a focus on the higher education system of the USA and its contribution to innovation capacity, to be employed as a benchmark for the rest of the case studies. All in all, the thematic and geographically-driven case studies that were ultimately selected in cooperation with the EC and elaborated in the frame of EUniVation are as follows:

Thematic case studies

- ILM - Innovation leaders' case study: Sweden and Finland
- ILM - Innovation followers' case study: Belgium and the United Kingdom

- OLM - Innovation leaders' case study: Denmark and Germany
- OLM - Innovation followers' case study: The Netherlands and Slovenia
- Moderate & modest innovators' case study: Bulgaria, the Czech Republic and Poland

Geographically-driven case studies

- Southern EU countries: Greece and Spain
- USA case study (as a benchmark)

All case studies elaborated in the framework of EUniVation are annexed to this report (see Annex 3).

Annex 1.3: Set up of the survey

Objective of the survey

The main objective of the survey in the context of EUniVation is to serve as an effective quantitative tool providing valuable insights into how diverse stakeholders across Europe perceive the first draft set of indicators that was proposed by the study. In parallel, the survey aimed to provide a better understanding of the different factors that are important in shaping these perceptions amongst stakeholders. In other words, the survey's objective was to shed ample light on the perceptions of stakeholders (and the significant differences among them) along with their different characteristics (e.g. background, organizational setting, etc.).

The questionnaire

In order to effectively meet the objective of the survey, a structured questionnaire was developed for each of its target groups, namely[14]:

- Higher Education Institution representatives involved with the development and/or usage of indicators related to the measurement of innovation impacts (e.g. Liaison Offices, Research Centres of HEIs, HEI Research Committees, etc.); and
- Industry association representatives from different sectors that produce and /or use innovative products, services and/or processes.

With a view to capturing the opinions of both target groups in a concise and comparable manner, the two questionnaires were structured similarly yet with distinct differences, tailored to the particular characteristics of each group. The following table provides further details regarding the structure of the questionnaires:

Table 9: Overview of the structure of the survey questionnaires

Questionnaire addressing Higher Education Institutions	Questionnaire addressing Industry Associations
Introduction Short introduction explaining the objectives of the survey and providing "instructions" related to its completion.	Introduction Short introduction explaining the objectives of the survey and providing "instructions" related to its completion.
General Questions These questions aimed at collecting information on the HEIs that the respective	General Questions These questions aimed at collecting information on the industry association that

[14] Given that the views of policy makers were captured through the fieldwork interviews and, as experience has shown, this target group is more prone to provide insights through interviews rather than surveys, they were not targeted by the survey.

Questionnaire addressing Higher Education Institutions	Questionnaire addressing Industry Associations
participants represented, to be employed in the analyses conducted later on.	the respective participants represented, to be employed in the analyses conducted later on.
<u>Indicator-related Questions</u> Each set and each indicator was provided to respondents so as to evaluate: • Their perceived Appropriateness *(i.e. How appropriate is the indicator for measuring the impact of Higher Education on innovation capacity?)* • Their perceived Usefulness *(i.e. How useful is this indicator for HEIs' internal strategic purposes?)* • Their perceived Feasibility (i.e. *How easy will it be to collect information for each indicator?*)	<u>Indicator-related Questions</u> Each set and each indicator was provided to respondents so as to evaluate: • Their perceived Appropriateness *(i.e. How appropriate is each indicator for measuring the impact of Higher Education on innovation capacity?)* • Their perceived Usefulness *(i.e. How useful is this indicator for the internal strategic purposes of the industry association?)*

Technical implementation of the survey

The well-tailored questionnaires developed for the purposes of the survey were coded and uploaded online using a professional online survey tool (i.e. Survey Monkey), enabling prospective participants to conveniently access and complete the survey through their dedicated web links (one for each target group). The uploaded questionnaires were tested internally by experienced members of the consortium to ensure that their online version is free of bugs and to locate any potential faults that might have been overlooked at that point. Final adjustments and refinements were made based on testing results and the final version of the survey was launched. The main means employed to distribute the web links of the survey to potential survey participants were personalized invitation letters, sent by email to the list of identified suitable stakeholders. In addition to the extensive list of participants, further dissemination channels of the European Commission were also utilized.

Overall, a total of 477[15] responses were collected from Tuesday the 6th of June 2016 over to Thursday the 30th of June 2016. The responses of the survey targeting industry associations (16 in total) were not included in the analysis, as their number was not sufficient to fuel a stand-alone analysis that would yield meaningful results (from a statistical point of view). Moreover, a total of 174 questionnaires were not deemed complete enough to be included in the analysis. As a result, 287 responses were considered valid for further analysis.

Insights stemming from the analysis of the data collected through the survey are integrated with the feedback received from stakeholders during the interviews, as presented in Chapter 4 of the current report. The detailed report on the findings of the survey is provided as an annex (see Annex 5).

[15] In total 461 responses were received from representatives of Higher Education Institutions, whereas 16 responses were provided by representatives of industry associations.

Annex 2: Interview guides

Annex 2.1: Interview guide for HEI representatives

A GENERAL INFO

A.1 Type of stakeholder: HEI representative

A.2 Description of organization

Name

Contact info (address, t./f., contact e-mail)

Webpage

Description

A.3 Interviewee

Name

Contact info (t./ f, contact e-mail)

Position

Job description and responsibilities

Other participants

B DISCUSSION

B.1 Discussion about HEIs spillover effects regarding their contribution to innovation capacity and relevant metrics

Below you may find a list of proposed indicators to measure the HEI's contribution to innovation capacity.

1. Do you use any of the provided indicators? For what purpose (internal use, funding requirements etc.)?
2. Please comment on the ***technical/ conceptual appropriateness*** of the provided indicators (do they measure what you would like them to?)
3. Please comment on the ***policy relevance/ acceptance*** of the provided indicators (according to your organisation's/ region's/ country's vision)
4. Please comment on the ***technical feasibility*** of the provided indicators (how easy are they to collect?)

Increasing the human capital skill pool	**Proposed Indicators**
1. Leadership & Governance (The availability of an internal entrepreneurial culture in the HEI that allows the stimulation of innovation of all kinds and nurtures the creation with stakeholders of synergies between teaching, research and university societal engagement. Indicative characteristics of such an entrepreneurial culture in an organization are the simplicity of managerial systems, the participation of external stakeholders in HEI management)	**Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative board)*
2. Curricula (The availability of intra- and/or extra-curricular courses fostering an entrepreneurial culture, as well as standard entrepreneurial courses across disciplines)	**Participation of non-academic agents in the definition of curriculum development (level measure)*
3. Teaching & Learning (The provision of specific training for teachers on entrepreneurship, the inclusion of entrepreneurs and practitioners into educators)	**Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS*
4. Internationalization culture (International mobility of scientists and students, partnerships with higher education institutions for staff and student exchanges, collaboration in research and development, international joint degree programmes and the opening of campuses abroad)	**Number of ECTS awarded to international exchange students (ERASMUS students) as a percentage of ECTS*

Increasing the workforce pool	**Proposed Indicators**
***5.* Graduates**	**Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation* **Number of STEM grads; Number of total grads; Number of total HEI staff with postgrad degrees*
6. Mobility	**Percentage of PhDs undertaken jointly with a private (non-academic) partner*
7. Lifelong learning	**Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs, …)*
8. Talent attraction (Attraction of new students, graduates drawn to the region to work and develop their career)	**Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university*

Commercialisation	Proposed Indicators
9. KT income	**IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)*
10. Spin-off activity	**Student start-ups (total active start-ups, turnover, private funding raised)*
11. Infrastructure for commercialisation	**Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership* **Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)*

Research reach out	*Proposed Indicators*
12. Collaborative R&D	**Number of publications between academic researchers and industry* **University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)*
13. Consultancy	**Income, total value, number of contracts (by: SME, large firms, commercial, non-commercial)*

Public engagement	*Proposed Indicators*
14. Media engagement	**Presence in traditional and social media by staff and by students relating their knowledge*
15. Societal engagement	**Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies*
16. Educational outreach	**HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)*

B.2 Set of questions on indicators used in-house to capture HEIs contribution to innovation capacity:

1. Do you use any other metrics/ indicators to capture your institution's contribution to innovation capacity?
2. Are there other indicators that could more appropriately analyse HEIs contribution to innovation capacity?

B.3 Other points to discuss

- *Additional HEIs activities that contribute to innovation capabilities and that you consider important*
- *Examples of underdeveloped and under-utilized metrics that could be used for capturing HEIs contribution to innovation capacity*
- *Factors facilitating or hindering the contribution of HEIs on innovation capabilities in your country/ region*

Annex 2.2: Interview guide for Industry representatives

A GENERAL INFO

A.1 Type of stakeholder: Industry representative/ association

A.2 Description of organization

Name

Contact info (address, t./f., contact e-mail)

Webpage

Description

A.3 Interviewee

Name

Contact info (t./ f, contact e-mail)

Position

Job description and responsibilities

Other participants

B DISCUSSION

B.1 Discussion about HEIs spill over effects of contribution to innovation capacity and relevant metrics

Below you may find a list of proposed indicators to measure the HEIs contribution to innovation capacity.

1. Do you use any of the provided indicators? For what purpose?
2. Which of the provided indicators will better serve the needs of your industry?
3. Please comment on the ***suitability*** of the provided indicators in reflecting the impact of HEIs contribution (do they measure what you would like them to?)

Increasing human capital skill pool	Proposed Indicators
1. Leadership & Governance (The availability of an internal entrepreneurial culture in the HEIs that allows the stimulation of innovation of all kinds and nurtures the creation of synergies with stakeholders between teaching, research and university societal engagement. Indicative characteristics of such an entrepreneurial culture in an organization are the simplicity of managerial systems, the participation of external stakeholders in HEIs management)	**Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative board)*
2. Curricula (The availability of intra- and/or extra-curricular courses fostering an entrepreneurial culture, as well as of standard entrepreneurial courses across disciplines)	**Participation of non-academic agents in the definition of curriculum development (level measure)*
3. Teaching & Learning (The provision of specific training for teachers on entrepreneurship, the inclusion of entrepreneurs and practitioners into educators)	**Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS)*
4. Internationalization culture (International mobility of scientists and students, partnerships with higher education institutions for staff and student exchanges, collaboration in research and development, international joint degree programmes and the opening of campuses abroad)	**Number of ECTS awarded to international exchange students (ERASMUS student) as a percentage of ECTS*

Increasing the workforce pool	Proposed Indicators
***5.* Graduates**	**Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation* **Number of STEM grads; Number of total grads; Number of total HEI staff with postgrad degrees*
6. Mobility	**Percentage of PhDs undertaken jointly with a private (non-academic) partner*
7. Lifelong learning	**Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs, …)*
8. Talent attraction (Attraction of new students, graduates drawn to the region to work and develop their career)	**Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university*

Commercialisation	Proposed Indicators

9. KT income	**IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)*
10. Spin-off activity	**Student start-ups (total active start-ups, turnover, private funding raised)*
11. Infrastructure for commercialisation	**Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership* **Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)*

Research reach out	*Proposed Indicators*
12. Collaborative R&D	**Number of publications between academic researchers and industry* **University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)*
13. Consultancy	**Income, total value, number of contracts (by: SME, large firms, commercial, non-commercial)*

Public engagement	*Proposed Indicators*
14. Media engagement	**Presence in traditional and social media by staff and by students relating their knowledge*
15. Societal engagement	**Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies*
16. Educational outreach	**HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)*

B.2 Set of questions on indicators used in-house to capture HEIs contribution to innovation capacity:

1. Do you use any metrics/ indicators to capture HEIs contribution on industry innovation?
2. New indicators that need to be developed in order to measure HEIs contribution, from the point of view of UIC, to innovation capacity
3. On industry level, do you use any metrics/ indicators to capture collaborations with HEIs, from the point of view of university-business collaboration?

B.3 Other points to discuss

- *Weaknesses in current metrics to capture HEIs contribution, from the point of view of UIC, to innovation capacity*

Annex 1.3: **<u>Interview guide for Policy makers</u>**

A GENERAL INFO

A.1 Type of stakeholder: Policy maker/ public institution

A.2 Description of organization

Name

Contact info (address, t./f., contact e-mail)

Webpage

Description

A.3 Interviewee

Name

Contact info (t./ f, contact e-mail)

Position

Job description and responsibilities

Other participants

B DISCUSSION

B.1 Discussion about HEIs activities that contribute to innovation capacity and relevant metrics

Below you may find a list of proposed indicators to measure the HEIs contribution to innovation capacity.

1. Do you use any of the provided indicators? For what purpose (internal use, funding requirements etc.)?
2. Please comment on the ***technical/ conceptual appropriateness*** of the provided indicators (do they measure what you would like them to?)
3. Please comment on the ***policy relevance/ acceptance*** of the provided indicators (according to your organisation's/ region's/ country's vision)
4. Please comment on the ***technical feasibility*** of the provided indicators (how easy are they to collect)

Increasing human capital skill pool	Proposed Indicators
1. Leadership & Governance (The availability of an internal entrepreneurial culture in the HEIs that allows the stimulation of innovation of all kinds and nurtures the creation of synergies with stakeholders between teaching, research and university societal engagement. Indicative characteristics of such an entrepreneurial culture in an organization are the simplicity of managerial systems, the participation of external stakeholders in HEIs management)	**Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative board)*
2. Curricula (The availability of intra- and/or extra-curricular courses fostering an entrepreneurial culture, as well as of standard entrepreneurial courses across disciplines)	**Participation of non-academic agents in the definition of curriculum development (level measure)*
3. Teaching & Learning (The provision of specific training for teachers on entrepreneurship, the inclusion of entrepreneurs and practitioners into educators)	**Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS)*
4. Internationalization culture (International mobility of scientists and students, partnerships with higher education institutions for staff and student exchanges, collaboration in research and development, international joint degree programmes and the opening of campuses abroad)	**Number of ECTS awarded to international exchange students (ERASMUS student) as a percentage of ECTS*

Increasing the workforce pool	Proposed Indicators
***5.* Graduates**	**Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation* **Number of STEM grads; Number of total grads; Number of total HEI staff with postgrad degrees*
6. Mobility	**Percentage of PhDs undertaken jointly with a private (non-academic) partner*
7. Lifelong learning	**Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs, …)*
8. Talent attraction (Attraction of new students, graduates drawn to the region to work and develop their career)	**Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university*

Commercialisation	Proposed Indicators

9. **KT income**	**IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)*
10. **Spin-off activity**	**Student start-ups (total active start-ups, turnover, private funding raised)*
11. **Infrastructure for commercialisation**	**Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership* **Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)*

Research reach out	*Proposed Indicators*
12. **Collaborative R&D**	**Number of publications between academic researchers and industry* **University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)*
13. **Consultancy**	**Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)*

Public engagement	*Proposed Indicators*
14. **Media engagement**	**Presence in traditional and social media ofstaff and students relating their knowledge*
15. **Societal engagement**	**Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies*
16. **Educational outreach**	**HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)*

B.2 Set of questions on indicators used in-house to capture HEI contribution to innovation capacity.

1. Do you use any metrics/ indicators to capture HEI contribution to innovation capacity?
2. Are there other indicators that could more appropriately analyse HEI contribution to innovation capacity (in your country/ region)?

B.3 Other points to discuss

- *Additional HEI activities that contribute to innovation capabilities and that you consider important*

- *Examples of underdeveloped and under-utilized metrics that could be used for capturing HEI contribution to innovation capacity*
- *Areas/ Spill-over effects where more effective metrics are needed in your country/region in terms of HEI contribution to innovation capacity*

Annex 3: Case Studies

The case studies developed in the frame of the EUNIVATION study are provided separately.

Annex 4: Survey questionnaire

Annex 4.1: Questionnaire addressed to Higher Education Institutions

Introduction

The **EUNIVATION project** (www.eunivation.eu) aims to provide evidence on the **key factors determining the contribution of higher education institutions (HEIs) to innovation capacity** and to expand the understanding of this **contribution beyond traditional measures**. To this end, this survey is launched so as to evaluate the indicators that have been compiled after the conduct of an extensive literature review by MIOIR, CHEPS and Ingenio and their review by prestigious experts in the field.

We kindly ask you to complete the present questionnaire **having in mind your entire organisation** and **not** only your research team, faculty or unit/department.

General questions

1. Where is your HEI established?

3. Which of the following best describes your HEI (please choose one)?

- ○ Polytechnic/Technical University/ University of Applied Sciences
- ○ University
- ○ College of education
- ○ School of Arts
- ○ Other (please specify)

3. Please indicate the extent to which your HEI collaborates with international institutes/universities (i.e. through student exchange, HEI staff exchange, etc.):

- ○ High
- ○ Medium
- ○ Low

4. Does your HEI have a Technology Transfer Office:

- ○ Yes
- ○ No

5. Please indicate the ***primary*** *type of collaboration with* *Industry* *your institution has participated in over the* ***past 5 years*** *(please choose only one option):*

○ R&D Collaboration (i.e. joint R&D activities, contract research, R&D consulting, cooperation in innovation, joint publications with firm scientists/researchers, joint supervision of theses with firm scientists/researchers in cooperation with business and student projects in cooperation with business)

○ Student / Academic mobility (Temporary or permanent movement of professors or researchers from HEIs to business; and employees, managers and researchers from business to HEIs)

○ Knowledge transfer/ exchange/ commercialisation of results (through spin-offs, disclosures of inventions, patenting and licenses)

○ Curriculum development & Delivery (Collaboratively create a learning environment with members of the business community including creation of a fixed programme of courses or planned experiences)

○ Lifelong learning (it refers to all learning activity undertaken throughout life through a HEI, whether formal or informal)

○ Collaboration in relation to Entrepreneurship (Actions within or involving HEIs towards the creation of new ventures or developing an innovative culture within the HEI in cooperation with business)

○ Collaboration at Governance or Management level (Cooperation between HEI and business at a management level of the HEI or firm)

○ Other (please specify)

6. What is ***your primary*** *position in your HEI (please choose only* *one* *option)?*

○ University management/administration

○ Academic

○ Representative of liaison office

○ Business development manager

○ Researcher

○ Other (please specify)

Indicator-related questions

*7. **Skill pool:** The following indicators aim to measure the role of education in the development of the individual's skill pool, which is the primary role of HEIs. Overall, are these indicators capturing this role of HEIs?*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived Usefulness *(How useful is this indicator for your internal strategic purposes?)* [Values: Not useful (1) – Highly useful (3) + 4: Non-Applicable]	Perceived Feasibility (*How easy will it be to collect info for this indicator?*) [Values: Very difficult (1) - Very easy (3) + 4: Non-Applicable]
Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)			
Participation of non-academic agents in the definition of curriculum development (level measure)			
Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS			
Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS			
Add any other indicators you see fit in this area			

8. ***Workforce pool:*** *Complementary to the pool of highly-skilled individuals with the ability and the potential to envision future innovation, the educated workforce is another pool that can contribute to the translation of innovation capacity into real innovation. Are the indicators hereunder assessing the continuous adjustment of knowledge and skills through the entire life cycle of technologies, labour market institutions and of individuals?*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived Usefulness *(How useful is this indicator for your internal strategic purposes?)* [Values: Not useful (1) – Highly useful (3) + 4: Non-Applicable]	Perceived Feasibility *(How easy will it be to collect info for this indicator?)* [Values: Very difficult (1) - Very easy (3) + 4: Non-Applicable]
Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation			
Number of STEM grads; Number of total graduates; Number of total HEI staff with Postgraduate degrees			
Percentage of PhDs undertaken jointly with a private (non-academic) partner			
Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs, ...)			
Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university			
Add any other indicators you see fit in this area			

9. ***Commercialisation pool:*** *The commercial exploitation of university research has become a policy imperative and with it the efforts to quantify the impact of these activities have intensified. Are the following indicators appropriate for measuring this objective?*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived Usefulness *(How useful is this indicator for your internal strategic purposes?)* [Values: Not useful (1) – Highly useful (3) + 4: Non-Applicable]	Perceived Feasibility *(How easy will it be to collect info for this indicator?)* [Values: Very difficult (1) - Very easy (3) + 4: Non-Applicable]
IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)			
Student start-ups (total active start-ups, turnover, private funding raised)			
Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership			
Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)			
Add any other indicators you see fit in this area			

*10. **Research reach-out:** Another broad channel of knowledge exchange is more 'relational' or collaborative in nature, involving a variety of bi-directional links and processes for knowledge sharing between firms and universities: collaboration in R&D projects and transfer mechanisms such as consulting agreements, contract research and use of universities' facilities and equipment by industry. Are the following indicators appropriate for measuring this concept?*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived Usefulness *(How useful is this indicator for your internal strategic purposes?)* [Values: Not useful (1) – Highly useful (3) + 4: Non-Applicable]	Perceived Feasibility *(How easy will it be to collect info for this indicator?)* [Values: Very difficult (1) - Very easy (3) + 4: Non-Applicable]
Number of publications between academic researchers and industry			
University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)			
Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)			
Add any other indicators you see fit in this area			

*11. **Public engagement pool:** A final broad channel of knowledge exchange is when universities make their knowledge available as a public asset for society without necessarily having an underlying contractual relationship with users. This may be through having public lectures, events, exhibitions, festivals or other facilities. It might likewise involve having the academic research reported upon in public media, whether reporting a particular new discovery, or using academic expertise to comment on a contemporary news issue. Finally, they might be building links to other tiers of education (primary & secondary) to support educational outcomes.*

Indicators proposed	**Perceived Appropriateness** ***(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)*** **[Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]**	**Perceived Usefulness** ***(How useful is this indicator for your internal strategic purposes?)*** **[Values: Not useful (1) – Highly useful (3) + 4: Non-Applicable]**	**Perceived Feasibility** ***(How easy will it be to collect info for this indicator?)*** **[Values: Very difficult (1) - Very easy (3) + 4: Non-Applicable]**
Presence in traditional and social media of staff and students relating their knowledge			
Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies			
HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)			
Add any other indicators you see fit in this area			

Annex 4.2: <u>Questionnaire addressed to Industry Associations</u>

Introduction

The **EUNIVATION project** (www.eunivation.eu) aims to provide evidence on the **key factors determining the contribution of higher education institutions (HEIs) to innovation capacity** and to expand the understanding of this **contribution beyond traditional measures**. To this end, this survey is launched so as to evaluate the indicators that have been compiled after the conduct of an extensive literature review by MIOIR, CHEPS and Ingenio and their review by prestigious experts in the field.

We kindly ask you to complete the present questionnaire on behalf of your **Industry Association**.

General questions

1. Where is your organization established?

2. Please indicate the main sector in which your organization is active:

- ○ A - Agriculture, forestry and fishing
- ○ B - Mining and quarrying
- ○ C - Manufacturing
- ○
- ○ D - Electricity, gas, steam and air conditioning supply
- ○ E - Water supply; sewerage; waste management and remediation activities
- ○ F – Construction
- ○ G - Wholesale and retail trade; repair of motor vehicles and motorcycles
- ○ H - Transporting and storage
- ○ I - Accommodation and food service activities
- ○ J - Information and communication
- ○ K - Financial and insurance activities
- ○ L - Real estate activities
- ○ M - Professional, scientific and technical activities
- ○ N - Administrative and support service activities
- ○ O - Public administration and defence; compulsory social security
- ○ P - Education
- ○ Q - Human health and social work activities
- ○ R - Arts, entertainment and recreation
- ○ S - Other services/ activities

*3. To your knowledge, please indicate the **primary** type of collaboration between your Industry (Association and/or Members) and HEIs over the **past 5 years**: (only one option)*

- ○ R&D Collaboration (i.e. joint R&D activities, contract research, R&D consulting, cooperation in innovation, joint publications with firm scientists/researchers, joint supervision of theses with firm scientists/researchers in cooperation with business and student projects in cooperation with business)
- ○ Student / Academic mobility (Temporary or permanent movement of professors or researchers from HEIs to business; and employees, managers and researchers from business to HEIs)
- ○ Knowledge transfer/ exchange/ commercialisation of results (through spin-offs, disclosures of inventions, patenting and licenses)
- ○ Curriculum development & Delivery (Collaboratively create a learning environment with members of the business community including creation of a fixed programme of courses or planned experiences)
- ○ Lifelong learning (it refers to all learning activity undertaken throughout life through a HEI, whether formal or informal)
- ○ Collaboration in relation to Entrepreneurship (Actions within or involving HEIs towards the creation of new ventures or developing and innovative culture within the HEI in cooperation with business)
- ○ Collaboration at Governance or Management level (Cooperation between HEI and business at a management level of the HEI or firm)
- ○ Other (please specify)

4. What is the level of collaboration of <u>your Association</u> (to the extent of your knowledge) with <u>international institutes/universities</u>: High / Medium / Low

- ○ High
- ○ Medium
- ○ Low

5. *What is the level of* collaboration *of <u>your Members</u> (to the extent of your knowledge) with <u>international institutes/universities</u>: High / Medium / Low*

- ○ High
- ○ Medium
- ○ Low

Indicator-related questions

6. ***Skill pool****: The following indicators aim to measure the role of education in the development of the individual's skill pool, which is the primary role of HEIs. Overall, are these indicators capturing this role of HEIs?*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived importance (How probable is to use this indicator for strategic purposes internally?) [Values: Highly improbable (1) – Very probable (3) + 4: Non-Applicable]
Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)		
Participation of non-academic agents in the definition of curriculum development (level measure)		
Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs		
Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS		
Add any other indicators you see fit in this area		

7. ***Workforce pool****: Complementary to the pool of highly-skilled individuals with the ability and the potential to envision future innovation, the educated workforce is another pool that can contribute to the translation of innovation capacity into real innovation. Are the indicators hereunder assessing the continuous adjustment of knowledge and skills through the entire life cycle of technologies, labour market institutions and of individuals?*

Indicators proposed	**Perceived Appropriateness** ***(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)*** **[Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]**	**Perceived importance** **(How probable is to use this indicator for strategic purposes internally?)** **[Values: Highly improbable (1) – Very probable (3) + 4: Non-Applicable]**
Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation		
Number of STEM grads; Number of total graduates; Number of total HEI staff with Postgraduate degrees		
Percentage of PhDs undertaken jointly with a private (non-academic) partner		
Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs, …)		
Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university		
Add any other indicators you see fit in this area		

8. ***Commercialisation pool***: The commercial exploitation of university research has become a policy imperative and with it the efforts to quantify the impact of these activities have intensified. Are the following indicators appropriate for measuring this objective?

Indicators proposed	**Perceived Appropriateness** *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* **[Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]**	**Perceived importance** **(How probable is to use this indicator for strategic purposes internally?)** **[Values: Highly improbable (1) – Very probable (3) + 4: Non-Applicable]**
IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)		
Student start-ups (total active start-ups, turnover, private funding raised)		
Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership		
Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)		
Add any other indicators you see fit in this area		

9. ***Research reach-out****: Another broad channel of knowledge exchange is more 'relational' or collaborative in nature, involving a variety of bi-directional links and processes for knowledge sharing between firms and universities: collaboration in R&D projects and transfer mechanisms such as consulting agreements, contract research and use of universities' facilities and equipment by industry. Are the following indicators appropriate for measuring this concept?*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived importance (How probable is to use this indicator for strategic purposes internally?) [Values: Highly improbable (1) – Very probable (3) + 4: Non-Applicable]
Number of publications between academic researchers and industry		
University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)		
Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)		
Add any other indicators you see fit in this area		

*10. **Public engagement pool**: A final broad channel of knowledge exchange is when universities make their knowledge available as a public asset for society without necessarily having an underlying contractual relationship with users. This may be through having public lectures, events, exhibitions, festivals or other facilities. It might likewise involve having the academic research reported upon in public media, whether reporting a particular new discovery, or using academic expertise to comment on a contemporary news issue. Finally, they might be building links to other tiers of education (primary & secondary) to support educational outcomes.*

Indicators proposed	Perceived Appropriateness *(How appropriate is the indicator for measuring the impact of Higher Education on Innovation?)* [Values: Not appropriate (1) - Highly appropriate (3) + 4: Non-Applicable]	Perceived importance (How probable is to use this indicator for strategic purposes internally?) [Values: Highly improbable (1) – Very probable (3) + 4: Non-Applicable]
Presence in traditional and social media of staff and students relating their knowledge		
Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies		
HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)		
Add any other indicators you see fit in this area		

Annex 5: Survey findings

The current Annex presents the findings which stemmed from the online survey launched within the framework of EUniVation and is structured as follows:

1. Introduction
2. Survey findings per indicator
   - 2.1 Increasing human capital skill pool indicators
     - 2.1.1 Percentage of external members on university bodies (senate/ council/ government body/ oversight/ faculty/ consultative board)
     - 2.1.2 Participation of non-academic agents in the definition of curriculum development (level measure)
     - 2.1.3 Number of students enrolled in entrepreneurship courses as percentage of all students/ percentage of ECTs
     - 2.1.4 Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTs
   - 2.2 Increasing the workforce pool indicators
     - 2.2.1 Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation
     - 2.2.2 Number of STEM graduates; Number of total graduates; Number of total HEI staff with postgrad degrees
     - 2.2.3 Percentage of PhDs undertaken jointly with a private (non- academic) partner
     - 2.2.4 Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs etc.)
     - 2.2.5 Percentage of students (by cohort) who moved to the region (travel- to-study area) of the university
   - 2.3 Commercialisation indicators
     - 2.3.1 IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)
     - 2.3.2 Student start-ups (total active start-ups, turnover, private funding raised)
     - 2.3.3 Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership
     - 2.3.4 Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)
   - 2.4 Research reach out indicators
     - 2.4.1 Number of publications between academic researchers and industry
     - 2.4.2 University research funded by industry and by charities/ foundations (number of projects, total value and percentage of total)
     - 2.4.3 Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)

1. Introduction

This survey is conceived as a quantitative tool that will bring insights and facilitate the understanding and evaluation of the numerous indicators collected and put forward by the various study activities.

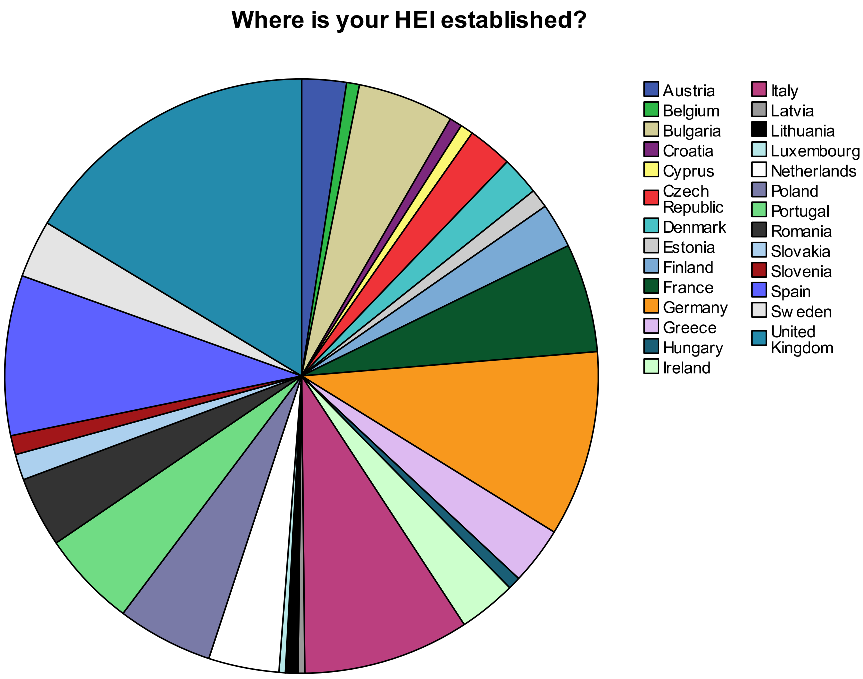
The primary goal is to collect the perceptions of a wide spectrum of stakeholders on selected indicators. Participants were asked to rate the appropriateness, usefulness and feasibility of each indicator. These metrics cover three aspects of evaluation of the selected indicators. The second goal of the study is to understand the differences among the stakeholders that are important in shaping these perceptions. More simply put, the survey aims to better understand these perceptions (and significant differences) in relation to different stakeholder characteristics (e.g. background, organizational setting).

The survey ran between 6/6/2016 and 30/6/2016, and 461 participants responded in total. Out of these, the responses of 287 participants were included in the analysis presented in this report based on the assessment of completeness of the answers[16]. Due to the technical aspects of many of the questions the survey design made it possible to skip questions. The analysis is performed in an indicator specific manner allowing the utilization of responses that only evaluated a subset of the indicators.

The respondents' demographics are presented in the following figures.

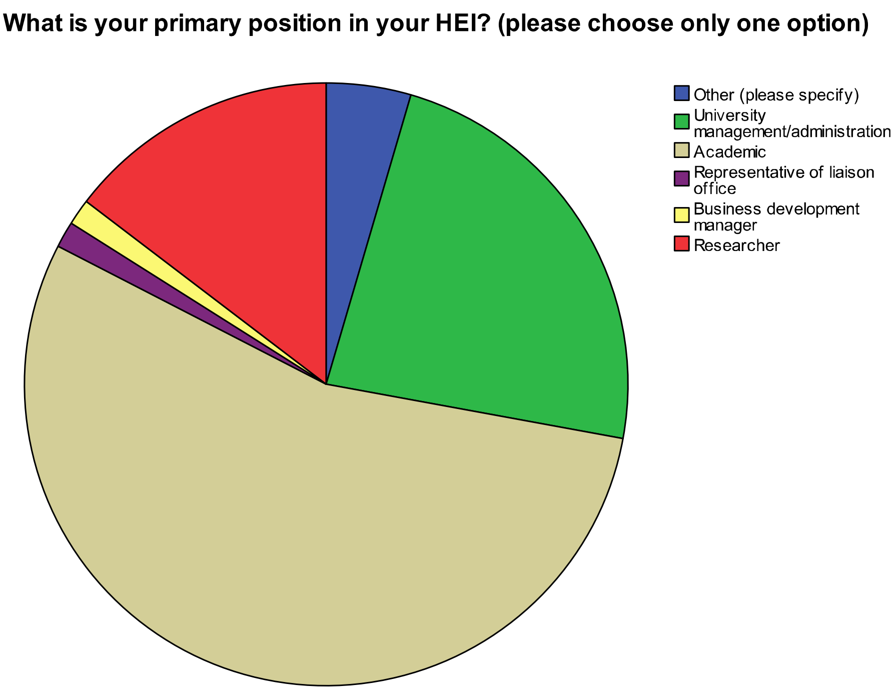
[16] In addition to the 461 responses that were received from representatives of Higher Education Institutions, a total of 16 responses were also provided by representatives of industry sessions. However, the responses of the survey targeting industry associations were not included in the analysis as their number was not sufficient to fuel a stand-alone analysis that would yield meaningful results (from a statistical point of view).

Figure 10 Countries where the HEIs of the participants are established



Participants hold different roles in their HEIs. The following chart shows that the majority of the respondents are academics and administrators.

Figure 11 The roles of participants in their HEIs



The respondents had to respond to some broad questions with regard to their HEIs. As can be seen in the chart below, the majority of the respondents work for universities. The majority of the respondents indicate that their HEI enjoys a high level of international collaborations (i.e. through student / staff exchange), while a small part of them declared that their HEI scores low on international collaboration (figure 4).

Figure 12 Which of the following describes your HEI?

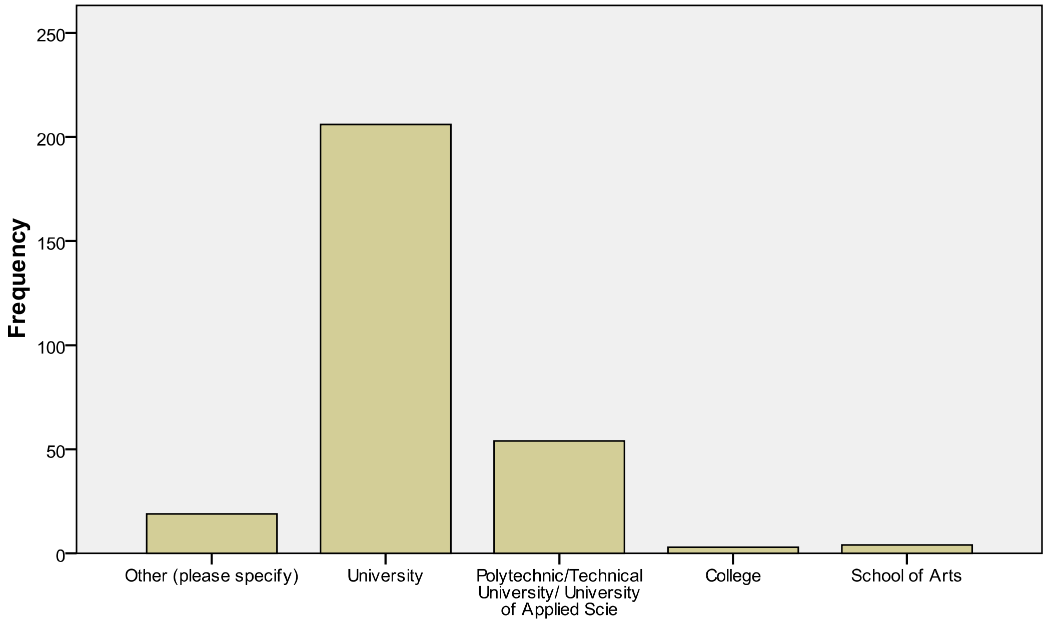
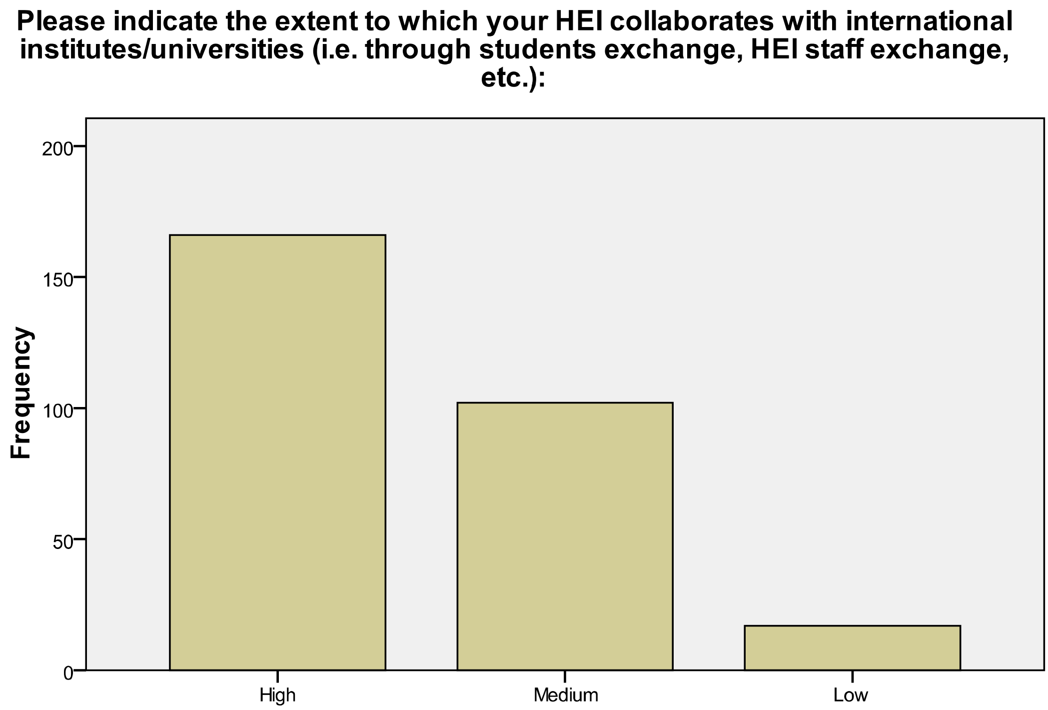
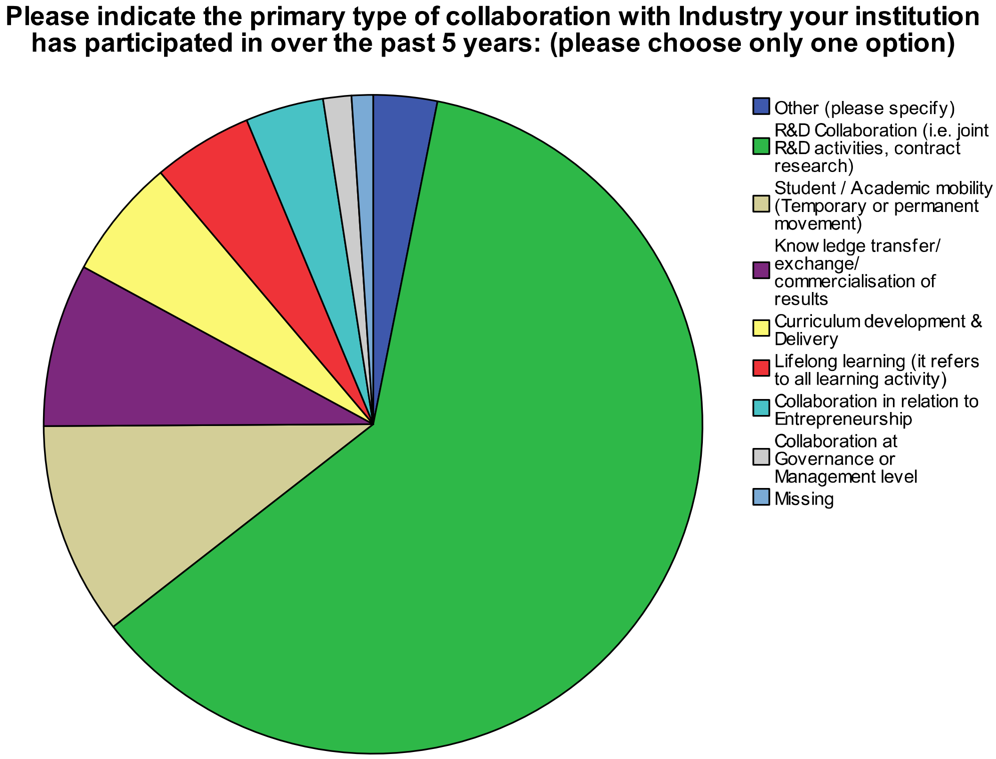


Figure 13 Level of international collaboration

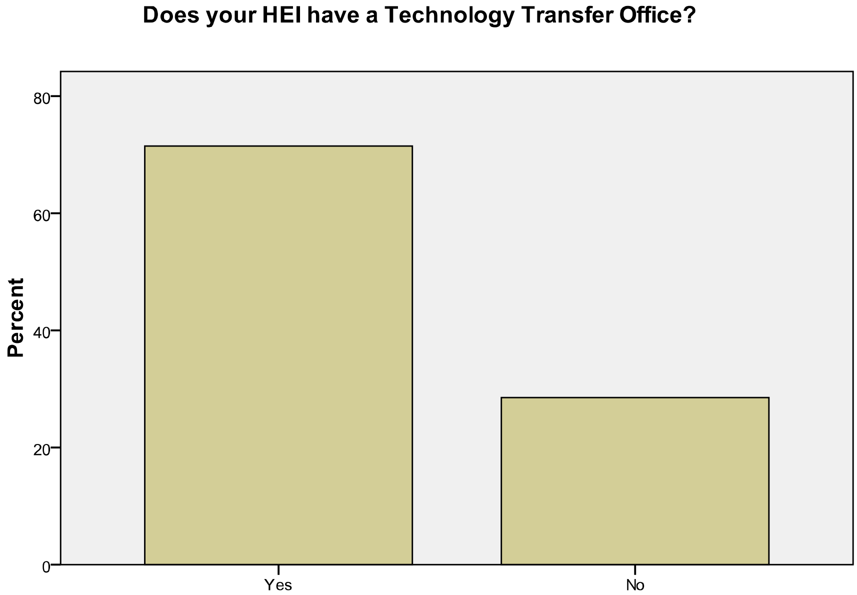


The industrial collaborations most typical are R&D activities and contract research, but there is a variety of other types of collaborations that HEIs engage in (e.g. knowledge transfer).

Figure 14 Type of collaboration between HEIs and industry



The large majority of HEIs are reported to have a technology transfer office.



2. Survey Findings per indicator

The findings are organized in relation to five pools of indicators which contain the results for each indicator under that pool. The main findings for each pool are summarized at the beginning and the mean scores for the individual indicators are presented subsequently. For all indicator mean scores a scale of 1-3 is applied (1 is the minimum and 3 is the maximum value). In addition, we tested the effects on these main scores produced by other characteristics of participants or their HEIs (e.g. participant role in the HEI) and all significant results were incorporated within the relevant indicators.

2.1 Increasing human capital skill pool indicators

Four indicators fall under the 'Increasing human capital skill' pool. No particular indicator stands out (the Perceived appropriateness and usefulness scores are all average); the only exception is the indicator 'Participation of non-academic agents in the definition of curriculum development', which scores low on feasibility.

For all these four indicators, the perceived appropriateness was driven primarily by perceived usefulness ($p<.000$). In other words, the more useful participants deemed an indicator to be, the more appropriate they found it. Feasibility had a similar effect which was less strong only for the indicators in subchapter 2.1.3 and 2.1.4. The feasibility scores for the first two indicators did not affect the perceived appropriateness ($p=.245$ and $p=.519$ respectively). This suggests that whether these indicators are considered feasible to collect, this does not have an effect on their appropriateness.

2.1.1 Percentage of external members on university bodies (senate/ council/ government body/ oversight/ faculty/ consultative board)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	270	1.90	.61
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	263	1.95	.58
Perceived Feasibility (How easy will it be to collect info for this indicator?)	265	2.11	.68

2.1.2 Participation of non-academic agents in the definition of curriculum development (level measure)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	264	1.96	.61
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	260	2.03	.59
Perceived Feasibility (How easy will it be to collect info for this indicator?)	250	1.67	.61

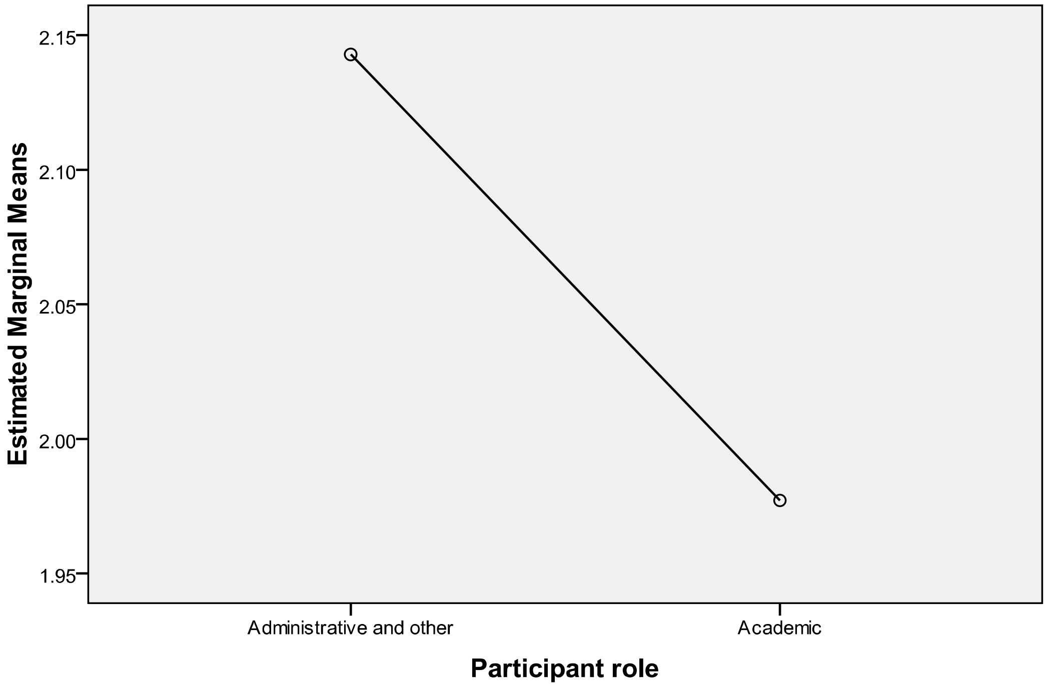
2.1.3 Number of students enrolled in entrepreneurship courses as percentage of all students/ percentage of ECTs

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	252	2.03	.65
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	245	2.03	.61
Perceived Feasibility (How easy will it be to collect info for this indicator?)	241	2.02	.62

It should be noted that academics tend to find this indicator less appropriate[17] than non-academics[18]. As the following figure demonstrates, academics rate the appropriateness of this indicator significantly lower. This effect was not found for other indicators in this pool.

[17] Analysis of variance (ANOVA) results, p=0.61
[18] 'Non-academics' refers to all the respondent categories in figure 2, excluding researchers and academics.

Figure 15 The effect of the participant's role on the Perceived Appropriateness of indicator 'Number of students enrolled in entrepreneurship courses as percentage of all students/ percentage of ECTs'



2.1.4 Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTs

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	265	1.99	.63
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	259	2.05	.61
Perceived Feasibility (How easy will it be to collect info for this indicator?)	254	2.17	.61

2.2 Increasing the workforce pool indicators

Three of the indicators in this pool (2.2.1, 2.2.2 and 2.2.3) were rated higher than average both in terms of appropriateness and in terms of usefulness. For all the indicators in this pool, appropriateness was driven by usefulness. The perceived feasibility did not have a significant effect on the appropriateness rating participants awarded. This is important when considering that the indicator in 2.2.1, which is the highest rated in appropriateness and usefulness, received a low score on feasibility.

2.2.1 Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	264	2.36	.59
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	262	2.38	.57
Perceived Feasibility (How easy will it be to collect info for this indicator?)	259	1.65	.61

2.2.2 Number of STEM graduates; Number of total graduates; Number of total HEI staff with postgrad degrees

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	250	2.17	.61
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	249	2.14	.59
Perceived Feasibility (How easy will it be to collect info for this indicator?)	238	2.18	.59

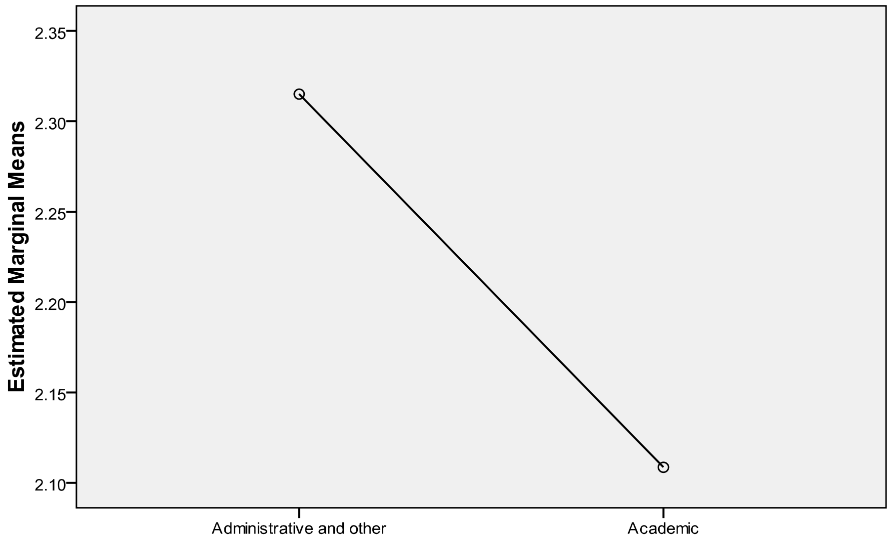
2.2.3 Percentage of PhDs undertaken jointly with a private (non- academic) partner

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	248	2.17	.62
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	242	2.14	.62
Perceived Feasibility (How easy will it be to collect info for this indicator?)	234	1.99	.61

While this indicator receives a clearly above average score, it has to be noted that there is a significant difference when it comes to the role the participants have in their HEIs. Administrative and other types of roles rate the appropriateness of the indicator significantly higher[19] than academics do, as can be seen in the figure below.

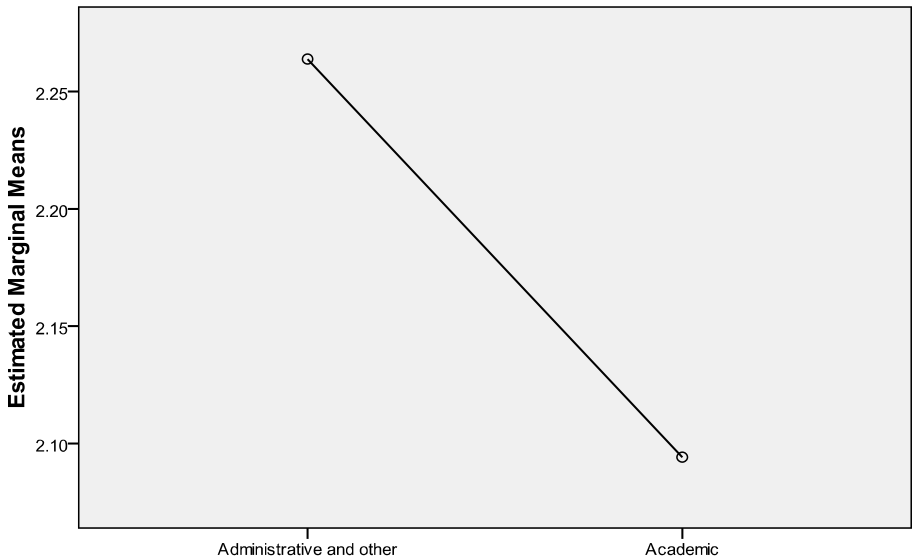
[19] ANOVA, p=.016

Figure 16 The effect of the participant's role on the Perceived Appropriateness of indicator 'Percentage of PhDs undertaken jointly with a private (non- academic) partner'



A similar- less strong- effect[20] is observed in the perceived usefulness, as academics again rate this indicator at a significantly lower level.

Figure 17 The effect of the participant's role on the Perceived Usefulness of indicator 'Percentage of PhDs undertaken jointly with a private (non- academic) partner'



It should be further noted that the perceived feasibility did not differ between the two groups.

2.2.4 Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs etc.)

[20] ANOVA, p=.050

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	247	2.02	.66
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	243	1.97	.64
Perceived Feasibility (How easy will it be to collect info for this indicator?)	240	1.77	.64

2.2.5 Percentage of students (by cohort) who moved to the region (travel- to- study area) of the university

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	246	1.85	.69
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	248	1.84	.68
Perceived Feasibility (How easy will it be to collect info for this indicator?)	235	1.85	.68

2.3 Commercialisation indicators

Two indicators – 2.3.2 and 2.3.3 - stand out in this pool for higher than average mean scores in appropriateness and usefulness. It is noteworthy that for both these indicators appropriateness was significantly affected by both usefulness and feasibility[21]. This is particularly important for the indicator in subchapter 2.3.2, as the low score in feasibility (1.63) is likely to have negatively influenced the already high perceived appropriateness (2.29). More simply put, this particular indicator is expected to have been even higher, if it was deemed more feasible.

2.3.1 IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)

[21] In the two regression models, perceived feasibility was a significant predictor (p=.020 for 2.3.2 and p=.004 for indicator 2.3.3)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	242	2.09	.68
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	238	2.06	.64
Perceived Feasibility (How easy will it be to collect info for this indicator?)	231	1.80	.70

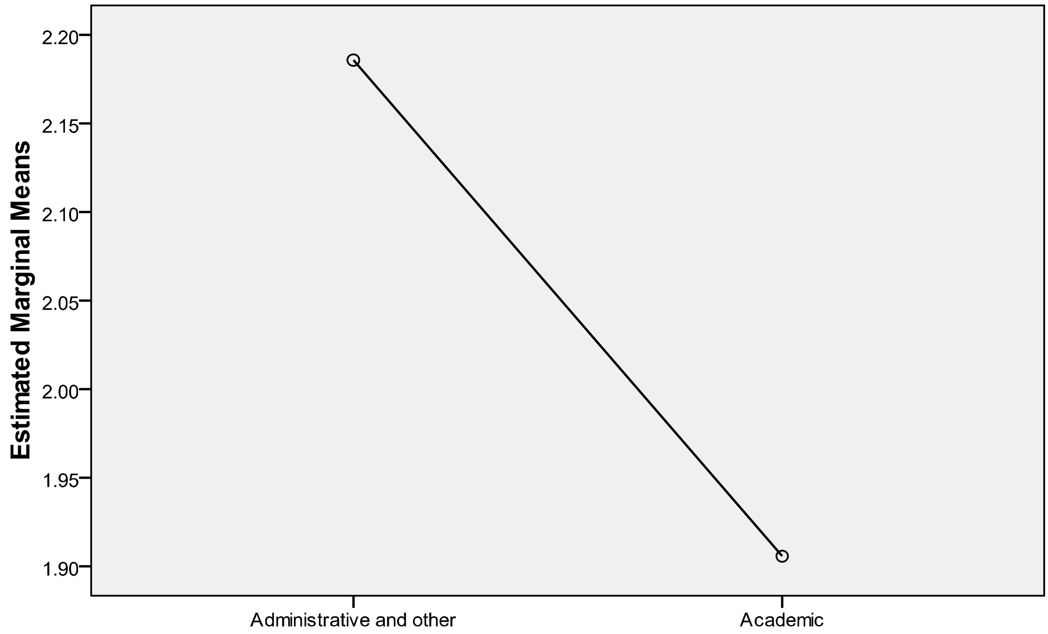
2.3.2 Student start-ups (total active start-ups, turnover, private funding raised)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	244	2.29	.71
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	239	2.23	.65
Perceived Feasibility (How easy will it be to collect info for this indicator?)	232	1.63	.62

2.3.3 Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	241	2.22	.62
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	237	2.20	.57
Perceived Feasibility (How easy will it be to collect info for this indicator?)	229	1.99	.64

The Perceived Feasibility was significantly different for academics (low scores) and non-academics, as shown in the figure which follows, indicating that administrative people find it easier to collect the information for this indicator. No similar differences were found in this particular pool of indicators, thus suggesting that this effect only involves in this specific indicator.



2.3.4 Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	235	2.06	.61
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	229	2.10	.60
Perceived Feasibility (How easy will it be to collect info for this indicator?)	215	1.67	.62

2.4 Research reach out indicators

This pool of indicators is marked by overall high scoring indicators (2.4.1 and 2.4.2 and 2.4.3). There are significant differences between academics and non-academics for indicators 2.4.2 and 2.4.3 for all three dimensions of measurement (appropriateness, usefulness and feasibility). In all cases, the non-academics give the indicators a consistently higher score. These effects are not found in indicator 2.4.1.

2.4.1 Number of publications between academic researchers and industry

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	261	2.27	.64
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	253	2.28	.64
Perceived Feasibility (How easy will it be to collect info for this indicator?)	250	2.01	.67

2.4.2 University research funded by industry and by charities/ foundations (number of projects, total value and percentage of total)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	262	2.37	.65
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	254	2.37	.59
Perceived Feasibility (How easy will it be to collect info for this indicator?)	250	2.06	.63

As noted earlier in this subchapter, all three key dimensions for this indicator differ significantly[22] between academics and non-academics (as illustrated in the following figures).

[22] ANOVA results: p=.006 p=.020, p=.004 for the three models with Appropriateness, Usefulness and Feasibility as dependent variables respectively.

Figure 18 The effect of the participant's role on the Perceived Appropriateness of indicator 'University research funded by industry and by charities/ foundations'

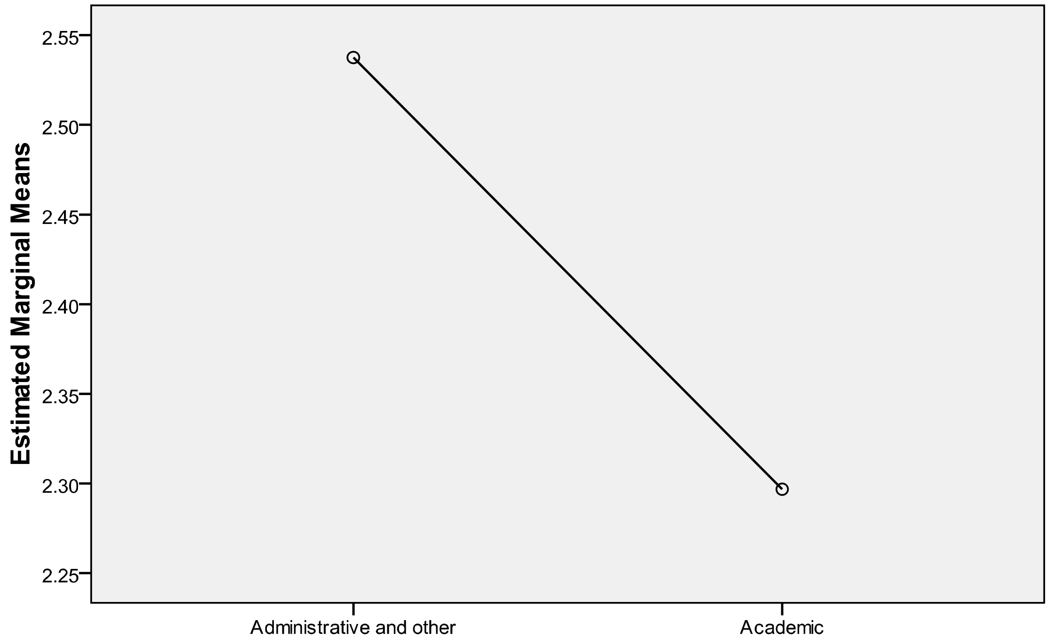


Figure 19 The effect of the participant's role on the Perceived Usefulness of indicator 'University research funded by industry and by charities/ foundations'

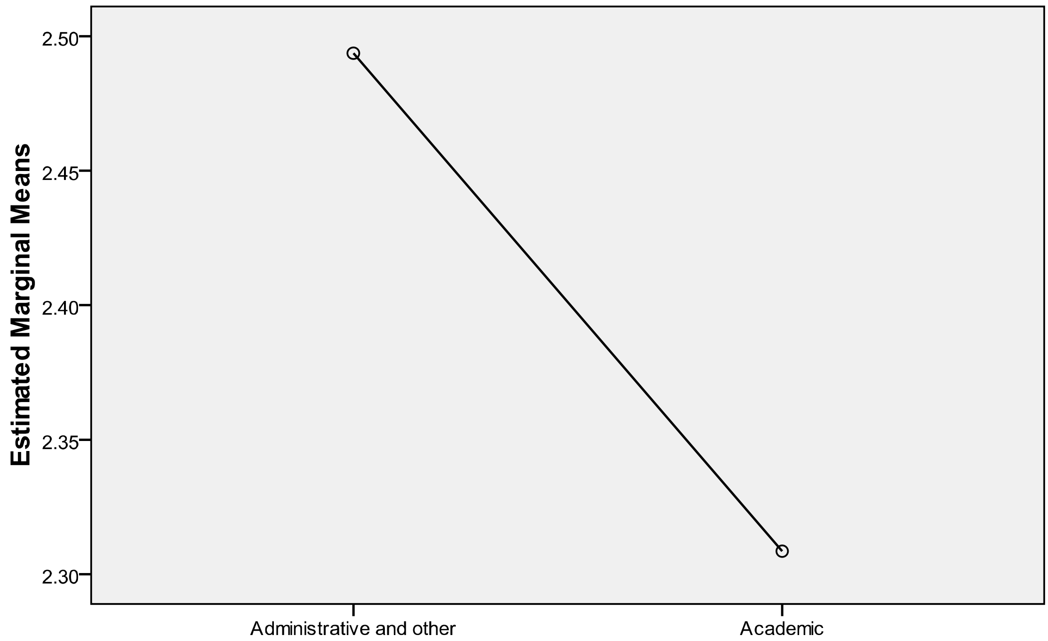
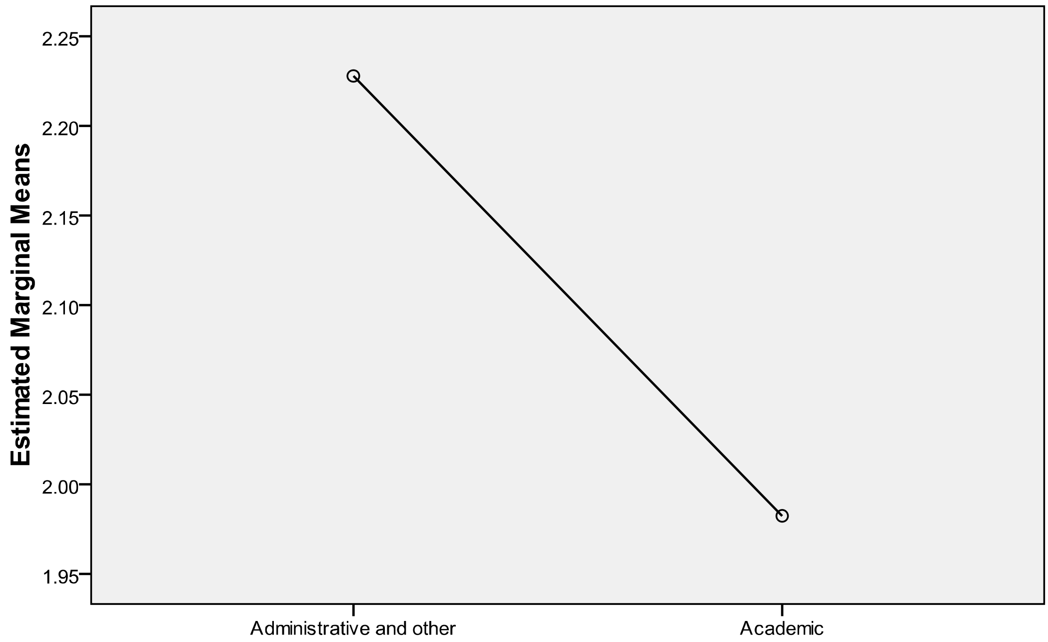


Figure 20 The effect of the participant's role on the Perceived Feasibility of indicator 'University research funded by industry and by charities/ foundations'



2.4.3 Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	259	2.26	.65
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	250	2.28	.60
Perceived Feasibility (How easy will it be to collect info for this indicator?)	242	1.89	.64

The same pattern as for the indicator above was found in this indicator, with non-academic respondents awarding higher scores to all three dimensions as can be seen in the three figures that follow. These effects were stronger[23] in this indicator (than in the indicator 2.4.2).

[23] In all three models p=.000

Figure 21 The effect of the participant's role on the Perceived Appropriateness of indicator 'Income, total value, number of contracts'

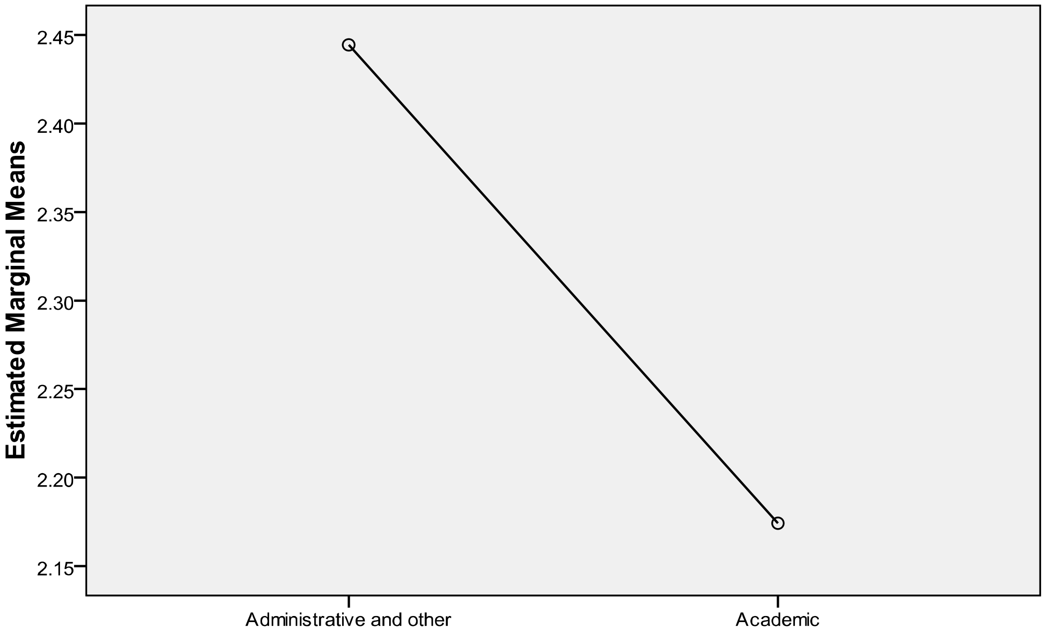


Figure 22 The effect of the participant's role on the Perceived Usefulness of indicator 'Income, total value, number of contracts'

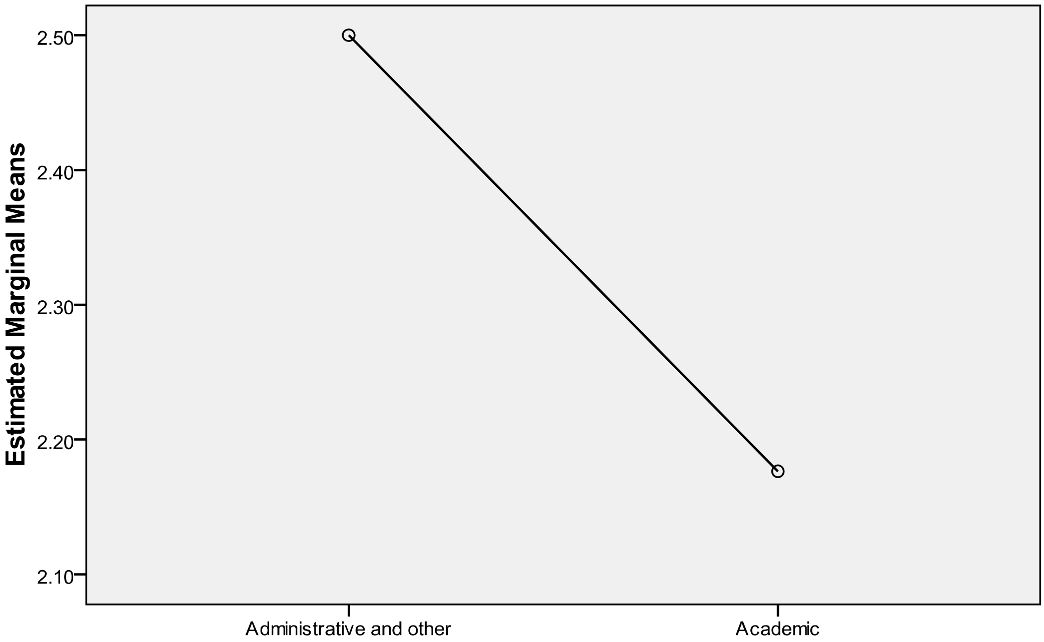
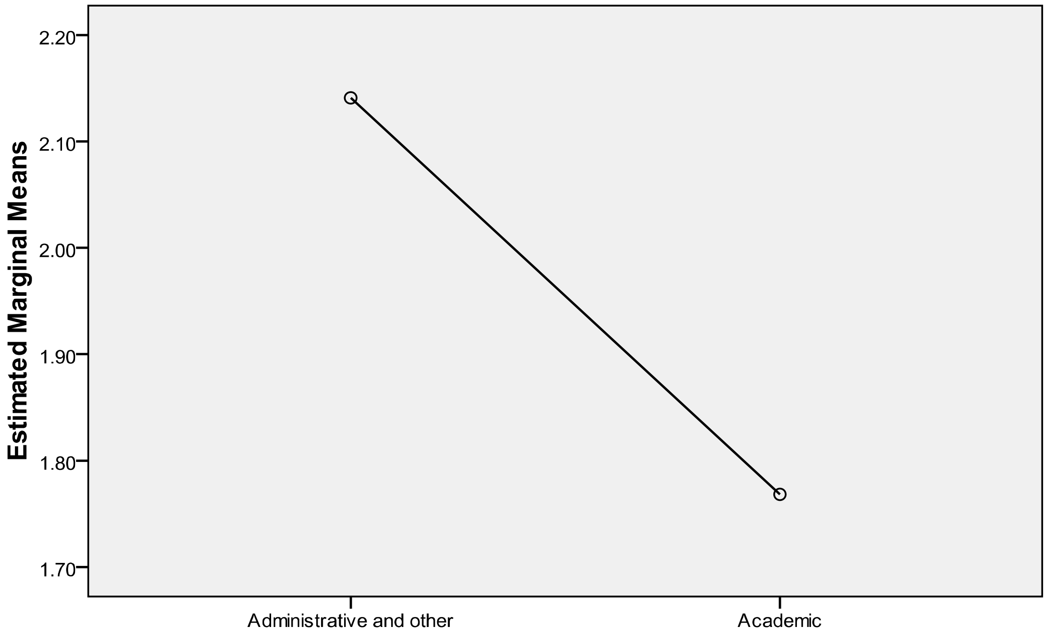


Figure 23 The effect of the participant's role on the Perceived Feasibility of indicator 'Income, total value, number of contracts'



2.5 Public engagement indicators

The first two indicators in this pool are evaluated positively in terms of Appropriateness and Usefulness. In all three indicators, only perceived usefulness had a direct effect on perceived appropriateness; feasibility was not found to have a significant effect on appropriateness.

2.5.1 Presence in traditional and social media ofstaff and students relating their knowledge

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	261	2.18	.63
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	254	2.13	.62
Perceived Feasibility (How easy will it be to collect info for this indicator?)	248	1.64	.67

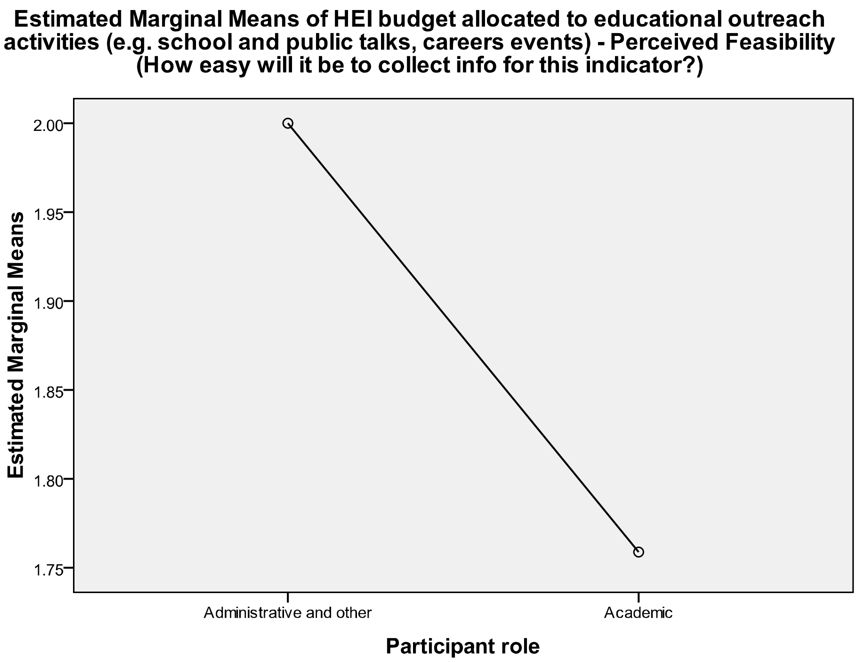
2.5.2 Third Mission/ Societal Engagement objectives included in HE policy or strategies

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	260	2.18	.60
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	257	2.14	.62
Perceived Feasibility (How easy will it be to collect info for this indicator?)	248	1.68	.62

2.5.3 HEI budget allocated to educational outreach activities

Descriptive Statistics	N	Mean	Std. Deviation
Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)	251	2.03	.65
Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)	247	2.07	.62
Perceived Feasibility (How easy will it be to collect info for this indicator?)	242	1.83	.64

Feasibility was significantly different for academics and non-academics following the pattern already seen before in other indicators (academics perceive indicators as less feasible), as illustrated by the following figure.



3. Indicator pools and construct validity

The indicators in this study were placed in pools that were decided by the experts in our team based on the indicators' nature/characteristics. This study tested the consistency of these indicator groups in terms of the responses as regards appropriateness. The factor analysis revealed that in most cases the groupings chosen by the team are consistent. In some cases, additional indicators could fit a different pool which signals that these indicators have more in common with the other pool. We present this information in the table below where common pools are marked with the same colour.

	Component				
	1	2	3	4	5
Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)	-.017	.529	-.004	.313	-.196
Participation of non-academic agents in the definition of curriculum development (level measure)	.224	.596	-.146	-.034	.130
Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS	.355	.476	.127	-.111	.056
Number of ECTS awarded to international exchange students (ERASMUS student) as a percentage of ECTS	-.051	.567	.302	.147	.144
Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation -	.197	-.087	.080	.233	.752
Number of STEM grads; Number of total graduates; Number of total HEI staff with Postgraduate degrees	-.052	.333	.236	.009	.674
Percentage of PhDs undertaken jointly with a private (non-academic) partner	.356	.321	.317	.094	.130
Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)	.187	.674	-.003	.129	.166
Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university	-.055	.579	.255	.278	-.154
IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)	.653	.149	.316	.102	-.009
Student start-ups (total active start-ups, turnover, private funding raised) - Perceived Appropriateness	.811	.072	.174	-.004	-.052
Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership	.807	.084	.169	.118	.103
Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N) - Perceived Appropriateness	.755	.064	.123	.039	.124
Number of publications between academic researchers and industry	.262	.162	.649	.011	.204
University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)	.237	-.016	.780	.149	.051
Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)	.256	.062	.793	.035	.063
Presence in traditional and social media of staff and students relating their knowledge	.015	.067	.150	.777	-.017
Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies	.227	.167	-.022	.792	.078
HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)	-.010	.148	.065	.707	.227

4 Conclusions

This survey was designed as a tool to provide quantitative evidence on a larger scale to enrich our understanding and evaluation of a moderate number of indicators proposed and developed throughout the study.

The survey provided mean scores on three primary dimensions that are key to the indicators, namely Appropriateness, Usefulness and Feasibility. All indicators were evaluated along these three dimensions allowing an auxiliary measure for evaluating them. The indicators with higher than average performance were highlighted in this report.

On top of the descriptive statistics that provide an evaluation in numeric terms, the survey analysis went deeper in order to increase our understanding of how participant perceptions vary. While usefulness always had a strong link to the indicator appropriateness, the effect of feasibility varies – for some indicators it is important, for some others it is not – while altogether its importance is less strong (than that of usefulness). An interesting difference between academics and non-academics was found in several indicators. While this difference was not found true for every indicator, the same pattern (non-academics scoring higher than academics) did apply whenever the effect was present. This was particularly true in feasibility scores which could signal that non-academic personnel are more acquainted with the data available/necessary for the computing of the indicators.

The final conclusion is that the internal construct (the indicator pools) was largely supported by the empirical evidence, the only exception being the second pool 'Increasing the workforce pool indicators' where only two of the indicators are clearly part of the same pool and two others have a better fit with the first pool. This grouping information provides valuable insights into how the participants group indicators indirectly (they were never asked to group indicators, the analysis tested the internal factor structure indirectly).

5 Frequency Tables

Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	15	5.2	5.5	5.5
	Appropriate	140	48.8	51.3	56.8
	Highly Appropriate	109	38.0	39.9	96.7
	Non-Applicable	9	3.1	3.3	100.0

		Frequency	Percent	Valid Percent	Cumulative Percent
	Total	273	95.1	100.0	
Missing	System	14	4.9		
Total		287	100.0		

Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	12	4.2	4.4	4.4
	Useful	138	48.1	51.1	55.6
	Highly useful	112	39.0	41.5	97.0
	Non-applicable	8	2.8	3.0	100.0
	Total	270	94.1	100.0	
Missing	System	17	5.9		
Total		287	100.0		

Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	109	38.0	41.1	41.1
	Easy	132	46.0	49.8	90.9
	Very easy	18	6.3	6.8	97.7
	Non-applicable	6	2.1	2.3	100.0
	Total	265	92.3	100.0	
Missing	System	22	7.7		
Total		287	100.0		

Number of STEM grads; Number of total graduates; Number of total HEI staff with Postgraduate degrees - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	28	9.8	10.5	10.5
	Appropriate	151	52.6	56.6	67.0
	Highly Appropriate	71	24.7	26.6	93.6
	Non-Applicable	17	5.9	6.4	100.0

	Total	267	93.0	100.0	
Missing	System	20	7.0		
Total		287	100.0		

Number of STEM grads; Number of total graduates; Number of total HEI staff with Postgraduate degrees - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	28	9.8	10.6	10.6
	Useful	157	54.7	59.2	69.8
	Highly useful	64	22.3	24.2	94.0
	Non-applicable	16	5.6	6.0	100.0
	Total	265	92.3	100.0	
Missing	System	22	7.7		
Total		287	100.0		

Number of STEM grads; Number of total graduates; Number of total HEI staff with Postgraduate degrees - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	24	8.4	9.1	9.1
	Easy	147	51.2	55.9	65.0
	Very easy	67	23.3	25.5	90.5
	Non-applicable	25	8.7	9.5	100.0
	Total	263	91.6	100.0	
Missing	System	24	8.4		
Total		287	100.0		

Percentage of PhDs undertaken jointly with a private (non-academic) partner - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	30	10.5	11.0	11.0
	Appropriate	146	50.9	53.7	64.7

	Highly Appropriate	72	25.1	26.5	91.2
	Non-Applicable	24	8.4	8.8	100.0
	Total	272	94.8	100.0	
Missing	System	15	5.2		
Total		287	100.0		

Percentage of PhDs undertaken jointly with a private (non-academic) partner - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	31	10.8	11.6	11.6
	Useful	145	50.5	54.1	65.7
	Highly useful	66	23.0	24.6	90.3
	Non-applicable	26	9.1	9.7	100.0
	Total	268	93.4	100.0	
Missing	System	19	6.6		
Total		287	100.0		

Percentage of PhDs undertaken jointly with a private (non-academic) partner - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	44	15.3	16.6	16.6
	Easy	148	51.6	55.8	72.5
	Very easy	42	14.6	15.8	88.3
	Non-applicable	31	10.8	11.7	100.0
	Total	265	92.3	100.0	
Missing	System	22	7.7		
Total		287	100.0		

Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	51	17.8	19.0	19.0
	Appropriate	140	48.8	52.2	71.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	Highly Appropriate	56	19.5	20.9	92.2
	Non-Applicable	21	7.3	7.8	100.0
	Total	268	93.4	100.0	
Missing	System	19	6.6		
Total		287	100.0		

Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	53	18.5	20.2	20.2
	Useful	144	50.2	54.8	74.9
	Highly useful	46	16.0	17.5	92.4
	Non-applicable	20	7.0	7.6	100.0
	Total	263	91.6	100.0	
Missing	System	24	8.4		
Total		287	100.0		

Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	83	28.9	31.8	31.8
	Easy	130	45.3	49.8	81.6
	Very easy	27	9.4	10.3	92.0
	Non-applicable	21	7.3	8.0	100.0
	Total	261	90.9	100.0	
Missing	System	26	9.1		
Total		287	100.0		

Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	79	27.5	29.9	29.9

	Appropriate	125	43.6	47.3	77.3
	Highly Appropriate	42	14.6	15.9	93.2
	Non-Applicable	18	6.3	6.8	100.0
	Total	264	92.0	100.0	
Missing	System	23	8.0		
Total		287	100.0		

Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	81	28.2	30.9	30.9
	Useful	126	43.9	48.1	79.0
	Highly useful	41	14.3	15.6	94.7
	Non-applicable	14	4.9	5.3	100.0
	Total	262	91.3	100.0	
Missing	System	25	8.7		
Total		287	100.0		

Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	74	25.8	28.7	28.7
	Easy	122	42.5	47.3	76.0
	Very easy	39	13.6	15.1	91.1
	Non-applicable	23	8.0	8.9	100.0
	Total	258	89.9	100.0	
Missing	System	29	10.1		
Total		287	100.0		

IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	46	16.0	17.4	17.4
	Appropriate	129	44.9	48.9	66.3
	Highly Appropriate	67	23.3	25.4	91.7
	Non-Applicable	22	7.7	8.3	100.0
	Total	264	92.0	100.0	
Missing	System	23	8.0		
Total		287	100.0		

IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	41	14.3	15.8	15.8
	Useful	141	49.1	54.2	70.0
	Highly useful	56	19.5	21.5	91.5
	Non-applicable	22	7.7	8.5	100.0
	Total	260	90.6	100.0	
Missing	System	27	9.4		
Total		287	100.0		

IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	84	29.3	32.7	32.7
	Easy	109	38.0	42.4	75.1
	Very easy	38	13.2	14.8	89.9
	Non-applicable	26	9.1	10.1	100.0
	Total	257	89.5	100.0	

Missing	System	30	10.5		
Total		287	100.0		

Student start-ups (total active start-ups, turnover, private funding raised) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	36	12.5	13.6	13.6
	Appropriate	102	35.5	38.5	52.1
	Highly Appropriate	106	36.9	40.0	92.1
	Non-Applicable	21	7.3	7.9	100.0
	Total	265	92.3	100.0	
Missing	System	22	7.7		
Total		287	100.0		

Student start-ups (total active start-ups, turnover, private funding raised) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	29	10.1	11.1	11.1
	Useful	126	43.9	48.1	59.2
	Highly useful	84	29.3	32.1	91.2
	Non-applicable	23	8.0	8.8	100.0
	Total	262	91.3	100.0	
Missing	System	25	8.7		
Total		287	100.0		

Student start-ups (total active start-ups, turnover, private funding raised) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	104	36.2	40.3	40.3
	Easy	111	38.7	43.0	83.3
	Very easy	17	5.9	6.6	89.9
	Non-applicable	26	9.1	10.1	100.0

	Total	258	89.9	100.0	
Missing	System	29	10.1		
Total		287	100.0		

Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	25	8.7	9.5	9.5
	Appropriate	139	48.4	52.9	62.4
	Highly Appropriate	77	26.8	29.3	91.6
	Non-Applicable	22	7.7	8.4	100.0
	Total	263	91.6	100.0	
Missing	System	24	8.4		
Total		287	100.0		

Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	19	6.6	7.3	7.3
	Useful	151	52.6	57.9	65.1
	Highly useful	67	23.3	25.7	90.8
	Non-applicable	24	8.4	9.2	100.0
	Total	261	90.9	100.0	
Missing	System	26	9.1		
Total		287	100.0		

Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	47	16.4	18.3	18.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	Easy	137	47.7	53.3	71.6
	Very easy	45	15.7	17.5	89.1
	Non-applicable	28	9.8	10.9	100.0
	Total	257	89.5	100.0	
Missing	System	30	10.5		
Total		287	100.0		

Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	38	13.2	14.5	14.5
	Appropriate	146	50.9	55.7	70.2
	Highly Appropriate	51	17.8	19.5	89.7
	Non-Applicable	27	9.4	10.3	100.0
	Total	262	91.3	100.0	
Missing	System	25	8.7		
Total		287	100.0		

Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	30	10.5	11.6	11.6
	Useful	145	50.5	56.0	67.6
	Highly useful	54	18.8	20.8	88.4
	Non-applicable	30	10.5	11.6	100.0
	Total	259	90.2	100.0	
Missing	System	28	9.8		
Total		287	10 0.0		

Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	88	30.7	34.2	34.2
	Easy	109	38.0	42.4	76.7
	Very easy	18	6.3	7.0	83.7
	Non-applicable	42	14.6	16.3	100.0
	Total	257	89.5	100.0	
Missing	System	30	10.5		
Total		287	100.0		

Number of publications between academic researchers and industry - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	28	9.8	10.4	10.4
	Appropriate	134	46.7	49.8	60.2
	Highly Appropriate	99	34.5	36.8	97.0
	Non-Applicable	8	2.8	3.0	100.0
	Total	269	93.7	100.0	
Missing	System	18	6.3		
Total		287	100.0		

Number of publications between academic researchers and industry - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	26	9.1	9.9	9.9
	Useful	130	45.3	49.4	59.3
	Highly useful	97	33.8	36.9	96.2
	Non-applicable	10	3.5	3.8	100.0
	Total	263	91.6	100.0	
Missing	System	24	8.4		
Total		287	100.0		

Number of publications between academic researchers and industry - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	55	19.2	21.2	21.2
	Easy	137	47.7	52.9	74.1
	Very easy	58	20.2	22.4	96.5
	Non-applicable	9	3.1	3.5	100.0
	Total	259	90.2	100.0	
Missing	System	28	9.8		
Total		287	100.0		

University research funded by industry and by charities/foundations (number of projects, total value and percentage of total) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	25	8.7	9.3	9.3
	Appropriate	115	40.1	42.8	52.0
	Highly Appropriate	122	42.5	45.4	97.4
	Non-Applicable	7	2.4	2.6	100.0
	Total	269	93.7	100.0	
Missing	System	18	6.3		
Total		287	100.0		

University research funded by industry and by charities/foundations (number of projects, total value and percentage of total) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	14	4.9	5.3	5.3
	Useful	133	46.3	50.6	55.9
	Highly useful	107	37.3	40.7	96.6
	Non-applicable	9	3.1	3.4	100.0
	Total	263	91.6	100.0	
Missing	System	24	8.4		

University research funded by industry and by charities/foundations (number of projects, total value and percentage of total) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	14	4.9	5.3	5.3
	Useful	133	46.3	50.6	55.9
	Highly useful	107	37.3	40.7	96.6
	Non-applicable	9	3.1	3.4	100.0
	Total	263	91.6	100.0	
Missing	System	24	8.4		
Total		287	100.0		

University research funded by industry and by charities/foundations (number of projects, total value and percentage of total) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	42	14.6	16.2	16.2
	Easy	151	52.6	58.3	74.5
	Very easy	57	19.9	22.0	96.5
	Non-applicable	9	3.1	3.5	100.0
	Total	259	90.2	100.0	
Missing	System	28	9.8		
Total		287	100.0		

Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	30	10.5	11.2	11.2
	Appropriate	132	46.0	49.3	60.4
	Highly Appropriate	97	33.8	36.2	96.6
	Non-Applicable	9	3.1	3.4	100.0
	Total	268	93.4	100.0	
Missing	System	19	6.6		
Total		287	100.0		

Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial) - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	20	7.0	7.7	7.7
	Useful	140	48.8	53.6	61.3
	Highly useful	90	31.4	34.5	95.8
	Non-applicable	11	3.8	4.2	100.0
	Total	261	90.9	100.0	
Missing	System	26	9.1		
Total		287	100.0		

Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	64	22.3	24.9	24.9
	Easy	141	49.1	54.9	79.8
	Very easy	37	12.9	14.4	94.2
	Non-applicable	15	5.2	5.8	100.0
	Total	257	89.5	100.0	
Missing	System	30	10.5		
Total		287	100.0		

Presence in traditional and social media ofstaff and students relating their knowledge - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	33	11.5	12.4	12.4
	Appropriate	148	51.6	55.4	67.8
	Highly Appropriate	80	27.9	30.0	97.8
	Non-Applicable	6	2.1	2.2	100.0
	Total	267	93.0	100.0	
Missing	System	20	7.0		

Presence in traditional and social media ofstaff and students relating their knowledge - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	33	11.5	12.4	12.4
	Appropriate	148	51.6	55.4	67.8
	Highly Appropriate	80	27.9	30.0	97.8
	Non-Applicable	6	2.1	2.2	100.0
	Total	267	93.0	100.0	
Missing	System	20	7.0		
Total		287	100.0		

Presence in traditional and social media of staff and students relating their knowledge - Perceived Usefulness(How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	35	12.2	13.3	13.3
	Useful	152	53.0	57.6	70.8
	Highly useful	67	23.3	25.4	96.2
	Non-applicable	10	3.5	3.8	100.0
	Total	264	92.0	100.0	
Missing	System	23	8.0		
Total		287	100.0		

Presence in traditional and social media ofstaff and students relating their knowledge - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	116	40.4	44.3	44.3
	Easy	105	36.6	40.1	84.4
	Very easy	27	9.4	10.3	94.7
	Non-applicable	14	4.9	5.3	100.0
	Total	262	91.3	100.0	
Missing	System	25	8.7		
Total		287	100.0		

Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	28	9.8	10.5	10.5
	Appropriate	158	55.1	59.2	69.7
	Highly Appropriate	74	25.8	27.7	97.4
	Non-Applicable	7	2.4	2.6	100.0
	Total	267	93.0	100.0	
Missing	System	20	7.0		
Total		287	100.0		

Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies - Perceived Usefulness (How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	34	11.8	12.9	12.9
	Useful	154	53.7	58.3	71.2
	Highly useful	69	24.0	26.1	97.3
	Non-applicable	7	2.4	2.7	100.0
	Total	264	92.0	100.0	
Missing	System	23	8.0		
Total		287	100.0		

Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	99	34.5	37.9	37.9
	Easy	129	44.9	49.4	87.4
	Very easy	20	7.0	7.7	95.0
	Non-applicable	13	4.5	5.0	100.0
	Total	261	90.9	100.0	
Missing	System	26	9.1		
Total		287	100.0		

HEI budget allocated to educational outreach activities (e.g. school and public talks, career events) - Perceived Appropriateness (How appropriate is this for measuring the impact of HEI on Innovation?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not appropriate at all	49	17.1	18.4	18.4
	Appropriate	145	50.5	54.3	72.7
	Highly Appropriate	57	19.9	21.3	94.0
	Non-Applicable	16	5.6	6.0	100.0
	Total	267	93.0	100.0	
Missing	System	20	7.0		
Total		287	100.0		

HEI budget allocated to educational outreach activities (e.g. school and public talks, career events) - Perceived Usefulness(How useful is this indicator for your internal strategic purposes?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not useful at all	40	13.9	15.3	15.3
	Useful	150	52.3	57.3	72.5
	Highly useful	57	19.9	21.8	94.3
	Non-applicable	15	5.2	5.7	100.0
	Total	262	91.3	100.0	
Missing	System	25	8.7		
Total		287	100.0		

HEI budget allocated to educational outreach activities (e.g. school and public talks, career events) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	74	25.8	28.4	28.4
	Easy	135	47.0	51.7	80.1
	Very easy	33	11.5	12.6	92.7
	Non-applicable	19	6.6	7.3	100.0
	Total	261	90.9	100.0	
Missing	System	26	9.1		

HEI budget allocated to educational outreach activities (e.g. school and public talks, career events) - Perceived Feasibility (How easy will it be to collect info for this indicator?)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very difficult	74	25.8	28.4	28.4
	Easy	135	47.0	51.7	80.1
	Very easy	33	11.5	12.6	92.7
	Non-applicable	19	6.6	7.3	100.0
	Total	261	90.9	100.0	
Missing	System	26	9.1		
Total		287	100.0		

Annex 6: Indicator fiches

1. Introduction

The present analysis reports the results of a mapping of indicators accounting for the contribution of universities to innovation capacity in the EU. The analysis has been conducted exploring in depth the available sources of statistical information on innovation, higher education (HE), universities' innovation performances and relationships between universities and private corporations. All the major statistical sources have been taken into account at both European and national level. Moreover, additional information sources have been analyzed, including scientific publication on the related topics, as well as EU reports on research and innovation in member states.

The data sources considered for this mapping are: Eurostat; OECD-STAN; Unesco - science and technology database; WIPO – World Intellectual Property Rights Organization database; World Economic Forum – Global Competitiveness Index; Istat - Italian National Statistical Institute; INSEE - French National Statistical Institute Science and Technology data; DESTATIS - German National Statistical Institute. As argued, we put additional effort in searching for information on the contribution of universities to innovation and we explored the availability of University-owned databases on that topic. Regarding existing publications, the EU Research and Innovation Observatory (RIO) reports have been inspected to verify the availability of further sources of information.
The investigation carried out here regards a set of indicators related to a large range of aspects concerning universities' contribution to innovation capacity. The main areas involved in the analysis are:

1) collaboration between universities and non-academic agents in the definition of universities' curricula (curricula);
2) working activities of PhD students participating in jointly (universities-companies) organized and funded PhD programmes (mobility);
3) participation of professors and researchers in courses organized by non-academic organizations (life-long learning);
4) universities' research projects funded by external organizations, such as private companies, foundations and charities (collaborative R&D);
5) economic benefits experienced by universities carrying out consultancy activities on behalf of SMEs and large firms (consultancy);
6) incidence of entrepreneurship and business courses over the total (teaching and learning);
7) number of services provided by universities by means of the commercialization infrastructure (infrastructure for commercialization);
8) relevance of 'education outreach' activities within universities' budget (education outreach);
9) relevance of internationalization activities within overall universities activities (internationalization);
10) number of actual or former university student start-ups (student start-up activities).

For each of these research areas connected to the universities' contribution to innovation via spillover, we selected an indicator. The complete list is shown in Table 1.

Table 1. Higher education and universities' contribution to innovation capacity – Indicator list

Area	Description
Curricula	1. Participation of non-academic agents in the definition of curriculum development (level measure)
Mobility	2. Percentage of PhDs undertaken jointly with a private (non-academic) partner
Lifelong learning	3. Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)
Collaborative R&D	4. University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)
Consultancy	5. Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)
Teaching & Learning	6. Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs
Infrastructure for commercialisation	7. Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)
Education outreach	8. HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)
Internationalization	9. Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS
Student start up activity	10. Student start-ups (total active start-ups, turnover, private funding raised)

The exploration of the available statistical sources highlighted that detailed information about the topic under analysis is lacking. At present, indicators as formulated in Table 1 – as well as ready-to-use statistical sources useful for a build-up of such indicators – seem not to be available. All the inspected statistical sources provide information at a higher level of aggregation and not all the selected areas are covered. More specifically, we have found no detailed information on curricula design, PhD programmes or universities' R&D project funding or on universities' income stemming from innovation related activities. In particular, indicators providing highly detailed information about employment conditions of tertiary educated or PhD students have not been found.[24] In addition, no restricted-access databases providing more detailed micro-level information on universities' activities seem to be available.

Some isolated information concerning specific areas within the set under analysis have been found in publications, such as the RIO country reports. However, this information cannot be gathered in the form of statistical indicators but can only give some (country specific) insights on universities' contribution to innovation. The same holds for the set of information provided by the European Agency for Special Needs and Inclusive Education. The latter provides information,

[24] For detailed information is meant the level of detail characterizing indicators as they are formulated above.

at a country level, on specific characteristics of education systems and focuses on organizational and juridical characteristics of EU countries' education institutions.
A lack of detailed and updated information on the topics under investigations emerged also when reviewing the European Research Area (ERA) country reports provided by the EU JRC. These reports contain information on EU member states' progress towards the implementation of the ERA. The latter monitors member states' progress along a set of 'priorities' on R&D, innovation, higher education, internationalization and knowledge transfer activities.
The list of priorities includes:

1) effectiveness,
2) cooperation,
3) researchers, gender,
4) knowledge.

Two of these ERA priorities (researchers and knowledge) closely concern issues related to the investigation carried out here. However, no relevant information is reported due to member states not providing the data.
The inspection of the available data sources has shown that information (concerning the areas of interest spelled out in Table 1) is available only at a level of aggregation higher than that required by the indicators under analysis. Moreover, no details are reported on universities' activities and collaboration in the innovation domain. For example, there is no detailed information on EU universities' R&D project funding origin, on agents (universities, research centers, foundations, charities, private companies) involved in curricula design or on universities' income stemming from consultancy, spin-offs or innovation related activities. The same holds for universities' ECT classified by student characteristics. Similarly, no significant information on student start-ups emerged.

Overall, the richest source of information proved to be the Eurostat database, where a relevant amount – in terms of country and time coverage - of information on the number of graduates by field is accessible. Concerning the employment status of tertiary educated and former PhD students, Eurostat provides information on labour market conditions and careers, classifying employed people on the basis of the following criteria:

1) previous education according to the ISCED categories (in the case of former PhD students also the scientific field is provided);
2) gender;
3) professional classification according to ISCO categories.

Two specific data sections regard the careers of former PhD students and the Human Resources employed in Science and Technology (HRST).
Furthermore, the Community Innovation Survey (CIS) survey – the results of which are available on the Eurostat website - provides a number of indicators on firms-university partnerships in innovative activities; while the R&D Eurostat database (BERD and GERD) reports information on tertiary educated employees and researchers in HE institutions. However, nothing is mentioned about the institutions organizing and funding the PhD programmes in which students are involved (i.e. information on PhD careers refers only to country, gender, number of years after the PhD attainment and education field). No detailed information is available on innovative performance of universities, and their collaboration – in terms of activities related to innovation

- with corporations. In this respect, the source providing the largest amount of data is the CIS. Nevertheless, this information is strongly focused on firms and does not provide accurate details on their cooperation with universities.

The outcomes of our investigation are now reported. First, we ranked each indicator listed in Table 1 according to its degree of availability, on a 1-5 scale The meaning of the grades is the following;

a) 1 (simple) data already available which just needs gathering and aggregating;
b) 2 (quite hard) data not held in a uniform way, which could be made uniform and fairly easily aggregated;
c) 3 (hard) would require a new survey or sampling of a relatively limited population (e.g. European universities);
d) 4 (very difficult) requires putting new questions to an existing approved large n-survey;
e) 5 (almost impossible) would require a new survey of the order of magnitude of the CIS.

When the target information is not available, the investigation moves towards indicators closer to the ones listed in Table 1 but characterized by a higher level of aggregation.[25] These proxies are provided when they are significantly close to the indicators' original formulation.

The next section provides the outcome of the mapping of indicators as listed in Table 1. The information is summarized in fiches referring to:

1) indicators' synthetic description,
2) data source,
3) unit of analysis,
4) country coverage,
5) periodicity,
6) availability of sub indicators,
7) advantages and shortcomings.

As argued, when no information is available to match the formulation in Table 1, alternative indicators are provided.

2. Indicators

In this Section, the outcome of the analysis is reported following the list of indicators, as in Table 1.

- Participation of non-academic agents in the definition of curriculum development (level measure) – area: curricula

No information has been found regarding the participation of non-academic agents in curricula definition. Therefore, this *mobility* indicator should be created by collecting new and ad hoc information. According to the availability scale defined above, this indicator is *very difficult* (4) to build. In fact, no immediately available (as well as limited-access) micro data providing useful

[25] Obviously, the level of aggregation is driven by the information available in the considered data sources.

information have been found. A survey should be organized so as to collect information from EU universities on curricula definition. Universities should be sampled ensuring representativeness and efforts made to try and cover the largest possible number of member states. The set of information needed to build the indicator should be collected by national experts in each member state. National experts are almost a necessity for studies where original data need to be collected from a large number of countries. National experts have better access to institutions in their countries and are able to interpret the data collected in the light of the national context, institutions and practices.

- Percentage of PhDs undertaken jointly with a private (non-academic) partner - area: mobility

We found no data or immediately available information on the percentage of PhD programmes undertaken jointly with private non-academic partners. As in the case of the previous one, this mobility indicator should be created by collecting new and ad hoc information.[26] According to the availability scale defined above, this indicator is *very difficult* (4) to build. Also in this case, a survey should be organized so as to collect information from EU universities on the number of PhD programmes characterized by a collaboration with non-academic partners. The survey should be very much the same as the one described above.

As a proxy for the percentage of PhDs undertaken jointly with a private (non-academic) partner, we provide an indicator reporting on the number of former PhD students employed as researchers in private organizations. This proxy provides information on the amount of PhD students continuing to do research as employee in private corporations. This may partially capture the linkages between universities and the private sector regarding PhD programmes. The indicator is drawn from the Eurostat database.

Indicator: *employed doctorate holders working as researchers in the private sector*	
Description	Percentage of doctoral holders working as researchers in the private sector
Data source	Eurostat database – careers of doctorate holders (cdh_e_mob)
Unit of analysis	Country level
Country coverage	The data collection on education statistics covers the following EU countries: Belgium, Bulgaria, Spain, Croatia, Hungary, Netherlands, Poland, Slovenia. Data are also available for Iceland and Russia
Time coverage	The indicator is available only for the year 2009
Strength	This indicator provides information on Doctoral holders' careers, focusing on those working as researchers after having finished their PhD programme. In particular, it provides information on the sector

[26] At present, a set of useful information could be held by the institutions managing the Erasmus + programme. The latter, in fact, includes funding of joint projects (at both the advanced tertiary and at Doctoral education level) between universities, public research centers and private corporation across EU members states. These joint programs, however, require intra-EU mobility of the PhD students involved. This means that no information on joint projects or PhD programs carried out by universities and private (non-academic) partners located in the same country are provided.

	(public, non-profit, private, business sector) of performance.
Shortcoming	The strength of the indicator is limited by the lack of longitudinal data that would allow comparison over time. An additional shortcoming regards the lack of data on a number of EU member states.
Sub-Indicators	Percentage of doctoral holders working as researchers in the private sector by job-mobility
Country coverage	Same as the main indicator
Time coverage	Same as the main indicator

- Percentage of academics teaching in courses demanded by non-academic agents (firms, public sector, NGOs,…) – area: lifelong learning

No data or immediately available information on academics teaching in courses required by non-academic agents have been found. As previously, the indicator should be created collecting ad hoc information. According to the availability scale defined above, this indicator is *very difficult* (4) to build. Data can be collected by means of the same survey described above.

No reliable proxies have been found.

- University research funded by industry and by charities/foundations (number of projects, total value and percentage of total) – area: collaborative R&D

No information has been found on universities' research funded by industry and by charities/foundations. As for the other indicators, new data should be collected. According to the availability scale defined above, this indicator is *hard* (3) to build. In order to build this indicator, universities' balance sheet information should be collected. Such collection requires a survey similar to the one described above. Universities should provide information on the source and composition of their funding. However, the disclosure of universities' balance sheet information could be hindered by specific privacy policies of EU member states
As an alternative proxy, we report the Eurostat indicator on the share of private funding of tertiary education. This proxy does not provide any specific information on the composition of universities' research project funding. Nevertheless, it allows an assessment of the relative importance of private funding of HE across EU member states.

Indicator: *Total tertiary educational expenditure by non–educational private sector*	
Description	Total expenditure (millions of euros – both current and in Purchasing Power Parities) on tertiary education (ISCED categories) by non-educational private sector

Data source	Eurostat database – education and training outcome thematic indicators (educ_uoe_fine01)
Unit of analysis	Country level
Country coverage	The data collection on education statistics covers almost all EU Member States (Belgium, Bulgaria, Czech Republic, Germany, Estonia, Greece, Spain, France, Ireland, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Hungary, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovak Republic, Finland, Sweden and United Kingdom), excluding Croatia and Denmark; the EFTA/EEA countries (Iceland, Liechtenstein, Norway and Switzerland), the candidate countries (FYR of Macedonia and Turkey), South-East European countries (Albania) as well as OECD Member States situated outside Europe (Australia, Canada, Japan, Korea, Mexico, New Zealand, United States) and other countries (e.g. Israel). The dissemination of education statistics by Eurostat is generally limited to the 27 EU Member States, the EFTA/EEA, Candidate and South-East European countries. Information on OECD Member States situated outside Europe can be provided by OECD
Time coverage	The indicator is available only for the years 2012 and 2013
Strength	This indicator provides information on the relative importance of private funding of HE across member states and OECD countries over a considerably long time period. This allows for both geographical and over time comparisons.
Shortcoming	The strength of the indicator is limited by the lack of more detailed information on recipient institutions and on funding aims (i.e. specific projects, PhD courses, etc.)
Sub-Indicators	No sub-indicators available

- Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial) – area: consultancy

No information on universities' income, total value, number of contracts related to services provided to SMEs, large firms, commercial, non-commercial institutions has been found. Also lacking are indicators, data or information useful in building-up an indicator of this kind. Similarly, no detailed information on universities' income stemming from R&D-related services has been detected in publications or EU reports.
According to the availability scale defined above, this indicator is *hard* (3) to build. As in the case of indicators on universities' research funding, universities' balance sheet information are

needed. Universities should provide information on income stemming from spin-off and universities' third mission activities. As before, the disclosure of universities' balance sheet information could be hindered by the specific privacy policies of EU member states.

Due to unavailability of indicators perfectly matching the proposed formulation, an alternative is proposed. The proposed indicator reports information which is complementary to that required by the original formulation, even if not specifically related to universities' income, total value, number of contracts obtained by SMEs, large firms, commercial, non-commercial entities. In particular, the indicator reports information on the collaboration between firms and universities aiming at generating product or process innovation. This indicator is drawn from the Community Innovation Survey (CIS).

Indicator: *Number of firms and universities collaborating with the aim of generating new products and processes*	
Description	Cooperation between universities and firms aimed at generating innovation - share of firms (%)
Data source	Eurostat database – Community Innovation Survey (CIS)
Unit of analysis	Country and sectoral level – share of firms collaborating with universities within a specific sector-country pair
Country coverage	EU 28 Member States. CIS 2012 has also been conducted in three associated countries (Norway, Serbia and Turkey).
Sectoral coverage	NACE Rev. 2 in accordance with EC regulation (Commission Regulation N° 995/2012)
Time coverage	1996-2012. Community Innovation Surveys (CIS) are organized in waves released every three-four years. Each wave reports information referring to the previous three years. The available waves are the CIS 2 (1998), CIS 3 (2000), CIS 4 (2004), CIS 5 (2006), CIS 6 (2008), CIS 7 (2010) and CIS 8 (2012).
Strength	This indicator provides detailed information on the cooperation between universities and firms distinguished by size and sector. Moreover, a specific question on the importance of collaborating with universities (in the field of innovation) is posed allowing comparison between countries and sectors about the relevance of the university-firms cooperation.
Shortcoming	No information on the type of cooperation engaged. Lack of time series, data available only in waves of three to four years.
Sub-Indicators	Cooperation between universities and firms aimed at generating innovation by firms' size.

Country coverage	Same as the main indicator
Time coverage	1996-2012

- Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs – area: teaching and learning

The inspection of the available data sources displays a lack of specific statistical information on students enrolled in entrepreneurship courses. The highest level of detail is provided by the Eurostat database. The latter reports data on the distribution of students according to the ISCED classification or focuses on students enrolled in science-related courses (including science, math, computing and engineering). No country-level data on the distribution of students measured using ECTs. Some information on entrepreneurship courses is randomly provided by universities' websites. However, such information is not systematically collected and provided, and is thus not reliable for building a representative indicator.

Using the abovementioned availability scale, the realization of this indicator is evaluated as hard (3). To build an indicator reporting on *the number of students enrolled in entrepreneurship courses as a percentage of all students*, a survey directed to a sample of European universities should be realized. A representative sample of universities should be created – covering all EU regions and including both public and private universities. Subsequently, a set of questions should be posed regarding the number of students enrolled in entrepreneurship courses - trying to obtain information for more than one year so as to appreciate the dynamics over time; the share of students enrolled in entrepreneurship courses with respect to total students or ECTs; the distribution of students enrolled in entrepreneurship courses by gender and age.

Due to the unavailability of adequate statistical information, an alternative indicator is proposed. The closest proxy is provided by the Eurostat database. The latter provides information on the distribution of graduates in tertiary education in science, mathematics, computing, engineering, manufacturing and construction, as a share of the total population aged 20-29. Although this proxy is far from providing specific information on the share of students enrolled in entrepreneurship courses, it allows us to compare EU countries according to the relative weight of scientific degrees.

Indicator: *Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction-*	
Description	Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction - share of students (%) per 1000 of the population aged 20-29
Data source	Eurostat database - educ_uoe_grad04
Unit of analysis	Country level
Country coverage	This indicator is available for the following EU Member States: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France,

	Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Spain
Time coverage	The indicator is available for the years 2013 and 2014
Strength	This indicator provides detailed information on the share of graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction aged 20-29.
Shortcoming	The information has a high level of aggregation and no details on enrolment in social sciences, business and entrepreneurship courses are provided.
Sub-Indicators	Share of graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction over the total student population by stage of tertiary education (Bachelor, Master of Science and Doctoral courses); gender.
Country coverage	Same as the main indicator
Time coverage	2013-2014

- Services provided within the commercialization infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N) - area: infrastructure for commercialization

Precise and detailed information on services provided within the commercialization infrastructure, seed corn investment, venture capital and business advice has not been found. Considering the availability scale, this indicator is *hard* (3) to build. In order to obtain the information needed to build the requested indicator, a survey involving EU member state universities should be realized. Within this survey, a set of specific questions on the existence, characteristics and effectiveness of universities' commercialization infrastructure should be posed.

Due to the unavailability of a unique indicator on services provided within the commercialization infrastructure, an alternative is proposed based on data concerning venture capital availability. The latter has been drawn from the World Economic Forum - Global Competitiveness Report – and is based on survey responses on the challenges faced by entrepreneurs with innovative but risky projects in finding venture capital.

Indicator: *Venture Capital availability*	
Description	Venture Capital Availability (1 = not true, 7 = true)

Data source	World Economic Forum – Global Competitiveness Index http://reports.weforum.org/global-competitiveness-report-2014-2015/rankings/
Unit of analysis	Country
Country coverage	144 world economies
Time coverage	2006-2015. The Global Competitiveness Index is organized in annual waves: 2006-2007; 2007-2008; 2008-2009; 2009-2010; 2010-2011; 2011-2012; 2012-2013; 2013-2014; 2014-2015.
Strength	This indicator provides country information on difficulties faced by enterprises in finding venture capital funds to develop their own projects. Information is detailed and yearly collected.
Shortcoming	No information on other aspects of other commercialization infrastructure services, such as seed corn investment or presence of business advice, is provided by the infrastructure.
Sub-Indicators	Venture capital availability is already a sub-indicator of the Global Competitiveness Index
Country coverage	Same as the main indicator
Time coverage	2006-2015

- HEI budget allocated to educational outreach activities (e.g. school and public talks, career events) - area: education outreach

A perfect correspondence between the indicator as formulated here and the inspected data sources has not been found. As stated previously, the build-up of an indicator perfectly overlapping the one spelled out above requires putting new questions to an existing approved sample and therefore, it could be very difficult to obtain answers in a short time. Therefore, this indicator is *hard* (3) to build. Also in this case, a survey involving EU member state universities should be realized. The indicator balance sheet information reporting details on universities' budget composition should be collected. As for the indicators regarding universities' income and funding, the disclosure of universities' balance sheet information could be hindered by the specific privacy policies of EU member states.

A proxy is proposed by relying on OECD data on education expenditure of a large number of economies. The main difficulty is to split the general expenditure in Higher Education according to the typology of activity. The closest correspondence can be found in the following indicator which provides a detailed quantification of the annual expenditure per student by educational institutions on core services, ancillary services and R&D. Educational outreach activities can be considered as part of core services.

Indicator: *Annual expenditure per student by educational institutions for educational core services, ancillary services and R&D*	
Description	Annual expenditure per student by educational institutions on core services, ancillary services and R&D
Data source	OECD Indicators – Education at a glance http://www.oecd.org/edu/educationataglance2015indicators.htm
Unit of analysis	Country and sectoral level – share of firms collaborating with universities within a specific sector-country pair
Country coverage	OECD countries (Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States)
Time coverage	2012
Strength	This indicator provides detailed information on the composition of educational expenditure by educational level – primary, secondary, tertiary education – and type of activity, allowing us to disentangle the weighting of so-called core activities compared to ancillary services and R&D.
Shortcoming	No direct information on the amount of expenditure in outreach activities is provided.
Sub-Indicators	No sub-indicator is provided
Country coverage	Same as the main indicator

- Number of ECTs awarded to international exchange students (ERASMUS students) as a percentage of ECTS - area: internationalization

Data on ECTs awarded to international exchange students are available by focusing on major Universities' websites taking part in the Lifelong Learning Programs – LLP - and, in particular, the Erasmus' one. However, some general statistics at country level can be drawn from the official website of the LLP European Agency. The latter provides general statistics on the number of Erasmus students by destination country, typology of study and average duration.

Some aggregate numbers on ECTs awarded to Erasmus students can be easily drawn from the Erasmus Programme Statistical Overview at the following link:

file:///C:/Users/User/AppData/Local/Microsoft/Windows/INetCache/IE/87AIJXXN/erasmus1112_en.pdf

However, information has not been systematically collected at country level and time coverage is fragmentary. The main effort should be to collect the corresponding information and to aggregate it into a unique database at country level. At present, thus, this indicator is 2 (quite hard), since data are not available in a uniform way and must be properly homogenized and matched.

As an alternative proxy, we propose an indicator reporting the number of Erasmus mobilities by typology of study and average duration and stemming from the Lifelong Learning Programme.

Indicator: *Number of Erasmus mobilities by typology and average duration*	
Description	Number of Erasmus mobilities by typology of study and average duration
Data source	Statistics for all – Lifelong Learning Programme
Unit of analysis	Country level
Country coverage	EU 28 Member States and selected countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom).
Time coverage	2008-2011
Strength	This indicator provides detailed information on the cooperation between universities and firms distinguishing by firms' size and sector. Moreover, a specific question on the importance of collaborating with universities (in the field of innovation) is posed allowing us tomake comparisons between countries and sectors about the relevance of the university-firms cooperation.
Shortcoming	No information on the type of cooperation engaged. Lack of time series, data available only in waves of three to four years.

Sub-Indicators	No sub indicators

- Student start-ups (total active start-ups, turnover, private funding raised) - area: student start-up activity

Major information on start-up characteristics, such as average number of founders, age, sex, region, business sector, type of product sold, average revenue, main challenges faced, etc. can be drawn from the *European Startup Monitor* and, in more detail, from country reports. According to our availability ranking, the realization of this indicator is quite hard (2). As in the previous case, the main challenge is to aggregate the qualitative information explained in each country report into a country-level database harmonizing the existing information. Specific information on student start-ups should be built based on their founders' characteristics.

As an alternative proxy, we suggest data on EU start-ups' main characteristics drawn from the European Start Up Monitor website. This indicator provides detailed information on both the employees' and the start-ups' characteristics. However, it does not allow us to exactly identify student start-ups.

Indicator: *Start-up characteristics (age and sex of founders, sector of activity, average revenue, number of employees, etc.)*	
Description	Start-up main characteristics
Data source	European Startup Monitor http://europeanstartupmonitor.com/esm/country-reports/
Unit of analysis	Country level
Country coverage	Austria, Belgium, Germany, Spain, Sweden
Time coverage	2015
Strength	This indicator provides detailed information on both the employees' and the start-ups' characteristics.
Shortcoming	Information should be aggregated from country reports to a unique database. Data on student start-ups need to be built specifically relying on the founders' characteristics.
Sub-Indicators	Many sub-indicators can be built based on the employees' and the start-ups' characteristics (average age of founders, share of women employed in startups, etc.).

Country coverage	Same as the main indicator
Time coverage	2015

Annex 7: The Feasibility Study

This project seeks to develop a proposal for an indicator set that is suitable for providing policymaker insight into university contributions to innovation capacity. In an ideal situation, a single indicator measures the most significant elements of performance and variation in the underlying characteristic. The literature reviews and policy quick scan have been able to identify that there is clearly no single compositional variable available. Higher education involves an extremely diverse set of institutions undertaking many different kinds of activities that contribute to innovation activity, with a high degree of specialisation between institutions. There is a high degree of horizontal differentiation – for example between research-intensive and teaching-intensive institutions. It is therefore necessary to reflect the breadth of this diversity in ensuring that the contributions of all kinds of HEIs are recognised and that there is not an implicit distinction made in the kinds of contributing HEIs based on arbitrary project choices rather than the underlying reality.

University contribution to innovation capacity is not a tightly-defined technical measure, but a policy concept that captures something around which there is a consensus as to its importance but for which there is no single definition. As a consequence of that, it is not possible to identify a single UCIC indicator or a reasonable composite (in the absence of reasonable certainty over the internal composition between the factors[27]). In this annex, we make a final selection of the 19 shortlisted indicators on the basis of a set of decision-rules in order to try to provide information that best captures the processes by which universities contribute to innovation capacity.

- Annex 6.1 sets out the approach, by selecting three possible levels of coverage in a putative indicator set, ranging from a core set that gives a glimpse of relative performance, towards an extensive data set that provides coverage of all the most important contributions.
- Annex 6.2 develops a set of constraints around which the indicator sets need to be optimised, to ensure balance, optimising the quality of the selected indicators and maximising external validity.
- Annex 6.3 explains the methodology by which the constraints were applied in an optimisation process leading to the selection of the three indicator sets.

[27] This raises a risk that performance variations emerging in that single composite indicator are a consequence of the artificial weighting between elements rather than reflecting real differences in performance.

- Annex 6.4 sets out a summary of the results of the optimisation process, and makes the final proposition for an indicator set measuring university contribution to innovation capacity.

Annex 6.1: Introduction to the final indicator selection process

It is vital to clearly explain at the outset that that there is no single statistic that currently exists that could effectively measure the contribution of universities to innovation capacity (UCIC) – and indeed that implicitly was the starting point for this project. It is therefore necessary to develop a novel indicator set, and this development process in turn demands a series of logical steps to assure that the relevant indicators provide the best possible degree of insight into the phenomenon under consideration. Our step-wise approach has been firstly to develop a conceptual model for how that contribution might arise, identify the various **dimensions** of that contribution, and then identify the **mechanisms** by which universities might in practice make that kind of contribution (Chapter 2). In Chapter 3 we set out a long list of the kinds of **indicators** that have already been used in practice in order to capture various elements of those mechanisms, with various degrees of success and coverage, and to propose a long list of the strongest potential indicators. In Chapters 4 and 5, we set out the responses of key stakeholders to this indicator long-list identifying which enjoyed the greatest legitimacy and also identifying other potential indicators. The next step is to bring these various elements together to propose a potential indicator set optimised in terms of a number of dimensions:

(1) Providing the broadest possible coverage of the full range of dimensions of UCIC
(2) Includes indicators that are technically the most suitable for measuring these dimensions
(3) Includes indicators that stakeholders regard as having sufficient legitimacy
(4) Includes those indicators that can be sensibly measured on an institutional basis.

Any indicator set seeks to provide useful information regarding the performance of particular relevant processes. An indicator set can never provide a complete measurement of all the elements that contribute to the process, but a satisfactory indicator set is one that is able to make clear distinctions between levels of performance ('resolution'). Gathering information on indicators represents a cost that would ideally be minimised, and including more indicators in a set therefore increases the associated costs. In constructing an indicator set, there are diminishing returns to increasing the number of indicators included in the set: a good indicator set is the one that provides the highest level of resolution with the lowest effort involved in gathering the indicators. Although there is a convention (the '80/ 20' rule) that you can gain 80% of the coverage using 20% of the indicators, it is very difficult to measure this resolution vs effort trade-off *ex ante*.

Ultimately, because of the aforementioned complexity of UCIC as a policy concept, and the need for an indicator set that is both politically legitimate and conceptually valid, this uncertainty means that we are not in a position to determine the extent to which an indicator set provides sufficient resolution. In this report we have therefore provided three potential indicator sets that provide an overview of the potential options that are open to policymakers if they wish to measure the contribution of universities to innovation capacity. These three indicator sets can be described as follows.

- **A core indicator set**: a short set of headline indicators that will provide a high-level overview of UCIC in a coarse way reflecting the diversity in mechanisms across a range of different conceptual dimensions.
- **An additional indicator set**: a more extensive set of indicators that provides sufficient coverage of all main UCIC dimensions sufficiently robustly to avoid egregious artefacts where a few units' real performance is not fairly captured
- **An extensive indicator set**: a broader set of indicators that includes sufficient indicators to avoid artificial vertical differentiation (where different kinds of universities make different kinds of contributions that are both dealt with fairly)

These three indicator sets (derived from the long list set out in 3, see table X below) provide a range of potential breadths of coverage as the basis for a well-informed policymaker choice.

Table 10: Proposed indicator set for measuring how universities contribute to innovation capacity via spill-overs

Category	University activity	Proposed indicators	Value of the data	Cost of gathering
Skill pool	Leadership/ Governance	**1.** Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)	✓	✓✓
	Curricula	2. Participation of non-academic agents in the definition of curriculum development (level measure)	✓✓	✓
	Teaching & Learning	3. Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTS	✓	✓✓✓
	Internationalization	4. Number of ECTS awarded to international exchange students (ERASMUS students) as a percentage of ECTS	✓	✓✓✓
Workforce pool	Graduates	5. Percentage of former students (by cohort) employed in an occupation that matches their human capital level within one year of graduation 6. Number of STEM grads; Number of total grads; Number of total HEI staff with postgrad degrees	✓ ✓✓	✓ ✓✓✓
	Mobility	7. Percentage of PhDs undertaken jointly with a private (non-academic) partner	✓✓	✓✓
	Lifelong learning	8. Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs etc.)	✓	✓
	Talent attraction	9. Percentage of students (by cohort) who moved to the region (travel-to-study area) of the university	✓	✓
Commercialisation	KT Income	10. IP revenues (licenses) in total and as a percentage of total KT income (consultancy, collaborative R&D, IP)	✓✓	✓✓
	Spin-off activity	11. Student start-ups (total active start-ups, turnover, private funding raised)	✓	✓✓
	Infrastructure for commercialisation	12. Presence (Y/N) or Number (#) of the following, where the university has an active involvement: On-campus incubators; Small office areas; Other incubators locally; Science parks on campus with university ownership 13. Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N	✓✓✓ ✓✓✓	✓✓✓ ✓✓✓
Research reach out	Collaborative R&D	14. Number of publications between academic researchers and industry (total value and % of total) 15. University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)	✓✓ ✓✓	✓✓✓ ✓✓
	Consultancy	16. Income, total value, number of contracts (by: SMEs, Non SME commercial, non-commercial)	✓✓✓	✓
Public engagement	Media engagement	17. Presence in traditional and social media of staff and students relating their knowledge	✓	✓
	Societal engagement	18. Third Mission/ Societal Engagement objectives (e.g. with social communities, schools) included in HE policy or strategies	✓	✓✓✓
	Educational	19. HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)	✓	✓✓

Category	University activity	Proposed indicators	Value of the data	Cost of gathering
	outreach			

Ranking:
--: not relevant/feasible
✓: relevant conceptually in some aspects/ some information available or some information easy to collect
✓✓: very relevant conceptually / information available or easy to collect
✓✓✓: excellent conceptually (captures all aspects) / information already available

Annex 6.2: Deciding on the boundary conditions for an optimised indicator set

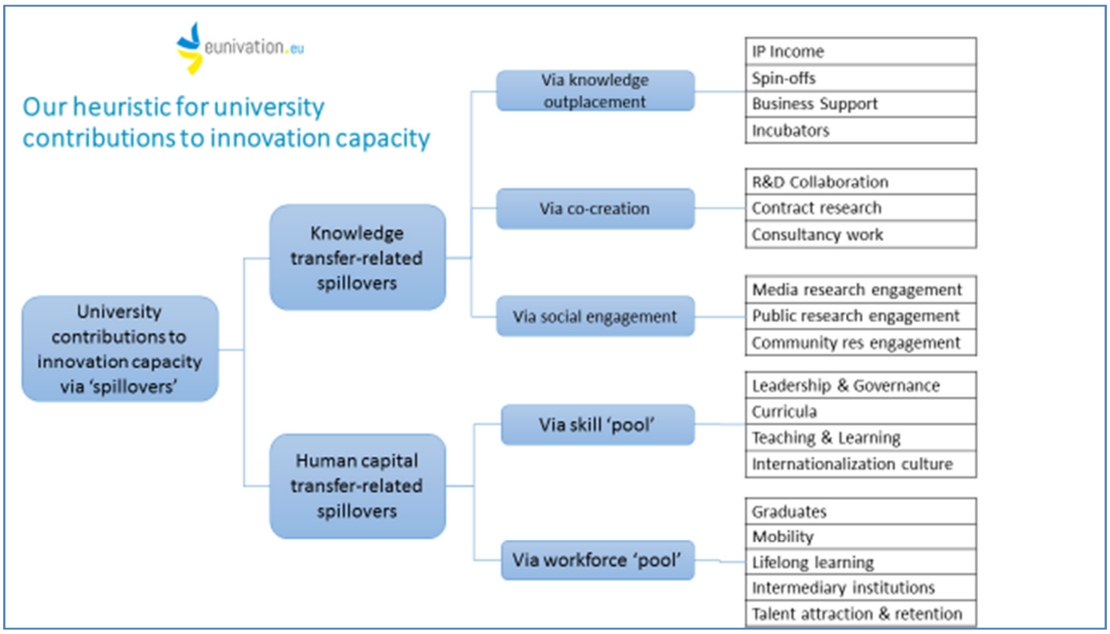
The issue with which this Annex is concerned is in making a selection from the 19 potential indicators set out below in order to provide a range of opportunities for potential indicator sets. Each indicator has a series of individual characteristics which we analysed in chapters 3 and 5. This partly reflects their technical suitability and their political legitimacy but also the degree of coverage they provide regarding the set of mechanisms by which UCIC is delivered. The indicator selection process is therefore an optimisation challenge, which requires us to select a set of indicators, minimising their weaknesses and maximising their strengths, whilst using as few indicators as possible and maximising the total coverage of the contribution mechanisms. Given the qualitative way in which these various characteristics have been expressed, this inevitably brings a degree of subjectivity into this selection process; the overall aim is to produce an indicator set which is the most legitimate, most technically suitable, most limited in number and most expansive in total coverage. Our approach to this is set out in the next section, 6.2, and then in section 6.3 we present the three indicator set options reflecting the three kinds of breadth set out above.

Optimising balance within the indicator set options

The most urgent issue for an indicator set is to capture the majority of the mechanisms affecting the overall process using the most limited number of indicators. UCIC as a policy concept is a composite of a number of different mechanisms, and the indicator set must therefore attempt to ensure a degree of balance between the different mechanisms (shown below). "Balance" here means ensuring the minimisation of two kinds of imbalance:

(i) **A priori**: some of the mechanisms are very closely related to creating innovation capacity whilst others are less important to this as a whole.

(ii) **Emergent**: as universities do more of some tasks than others, these mechanisms are in practical terms the most important to examine the ways that universities contribute to innovation capacity and will be used where the most practical variations can be observed.



To come to a balance, we therefore need to understand

(i) which of these mechanisms are most important to creating innovation capacity, and
(ii) which mechanisms are the most prevalent in terms of university outputs.

As a first assumption, knowledge transfer and human capital effects are comparable in terms of an order of magnitude – universities have two primary tasks – teaching and research –and therefore we assume that we require a mix of indicators from each side of the spillover effects.

The second element of balance is that there are some elements of each that are seen as being most important and most directly affecting the contributions made. Clearly where universities are working with innovators and innovators are paying them for that work, there is a demonstration that the benefit matters, and much contract research, consultancy and collaborative R&D is conducted in innovative sectors (co-creation spillovers). Likewise, highlyskilled workers with the capacity to use their knowledge creatively and innovatively are strongly associated with innovativeness, and it is therefore important to capture elements in which universities are creating workforces of innovators (these may be through either pool effect).

The third element of balance is that there are some indicators that can be considered negligible when looking at the overall balance of tasks within universities[28]. Social engagement through the media and by public engagement activities are both knowledge transfer spillovers that are negligible, with extremely indirect effects and a relatively low priority in universities (although community research engagement is not because it involves direct contributions to social innovation). Likewise, we regard leadership & governance as being a priori negligible because the kinds of mechanisms that are picked up are relatively small and often based around heroic versions of leadership – if the leadership is that good in stimulating external benefits then the external benefits will also be visible.

On this basis we adopt three rules to achieve balance in the overall optimisation process.

Rule 1: there should be a balance of indicators from both KT and HC elements of the new model

Rule 2: the most basic indicator sets should include indicators measuring co-creation and whole workforce measures

Rule 3: far upstream and far downstream indicators can only be included as part of a drive for completeness in the broadest indicator set.

Optimising indicator quality

The second element of developing an indicator set is in choosing indicators that are intrinsically good as regards the purposes for which the indicator set is to be used. We have here set out two underlying criteria for determining their quality, and these also require application in the final optimisation process.

1. The technical quality of the indicators: the extent to which the indicator proposed corresponds to the conceptual spill-over mechanism
2. The legitimacy quality of the indicator: the extent to which policymakers believe that the indicator is a legitimate measure of the quality.

[28] Although they do represent a priori mechanisms by which universities can contribute to UCIC, in practice their contribution to UCIC overall is very small and can therefore be discounted for the purposes of capturing the most important elements.

The technical quality of each of the variables was initially assessed during the interim report phase and was one of the criteria leading to the indicator being proposed for the long-list (29 indicators) and short-list (19). The technical quality was estimated by the project team on the basis of the underlying mechanism for which the variables were an indicator (see 3.2). The legitimacy quality was estimated against the extent to which the indicator contained three elements deemed necessary for policy legitimacy (see 3.3[29]). These values were revised, sharpened and better specified the particular indicators in response to input arising from the expert meetings and the fieldwork. Therefore we re-evaluated the technical quality of the short-list variables in their contemporaneous form before undertaking the final optimisation. For the sake of comparability, this was done on a four-point scale:

Score	Technical Quality	Legitimacy Quality
✓✓✓	The indicator corresponds directly to the underlying UCIC mechanism	The indicator includes all elements deemed important by policymakers
✓✓	The indicator is strongly associated to the underlying UCIC mechanism	The indicator includes a majority of the elements deemed important by policymakers
✓	The indicator captures an element of the underlying UCIC mechanism	The indicator includes a minority of the elements deemed important by policymakers
(-)	The indicator is loosely associated with the underlying UCIC mechanism	The indicator includes no elements deemed important by policymakers

There can only be a justification for including a variable with a lower indicator quality, if there are very strong indications across all the other areas that the variable is worth choosing[30]. We therefore seek to maximise the overall technical quality of the indicators chosen, within an overall optimisation approach that considers all dimensions simultaneously.

The second element is the legitimacy quality of the variable, that is the extent to which the indicator is able to capture what policymakers believe to be important in demonstrating UCIC. In the interim report, we highlighted that a valid indicator makes the case that **universities** are **contributing** to **innovation capacity** if it is able to convincingly demonstrate three characteristics, namely:

1. **Universities**: the spillover involves knowledge capital that has been produced by higher education teaching and/ or research activity
2. **Contributing**: there is an underlying transaction by which a spillover sees university knowledge being appropriated and creating an external benefit
3. **Innovation capacity**: there is a user – a 'problem owner' – who is the one to appropriate and benefit from the spillover resource.

[29] These three elements were that (a) the indicator related to a core university knowledge process, (b) external users signalled their interest by committing their own resources to it and (c) they resulted in something tangibly different happening in the underlying university activity.

[30] this kind of argument is often made when talking about "employment in high and medium-high technology sectors" as an innovation indicator – it is very loosely associated with innovation activities but nevertheless it is still seen by policymakers as being important and therefore does feature in various innovation scoreboards.

As with the technical quality, there can only be a justification for including a variable with a lower legitimacy if there are very strong indications across all other areas that the variable is worth choosing.

On this basis, we adopt two further rules as the basis for our optimisation approach.

Rule 4: any variable, which has low technical quality, can only be included if the case can be made convincingly that its inclusion is vital to achieve balance, legitimacy and support.

Rule 5: any variable, which has low policy legitimacy, can only be included if the case can be made convincingly that its inclusion is vital to achieve balance, legitimacy and support.

Optimising the external validity of the indicators

A third consideration in the optimisation of the indicator set is the external validation of our own analyses. The conceptual framework has been developed through an extensive literature review and has its own internal validity relating to the spillover model. It is therefore necessary to ensure that the indicators also have a degree of external validity, and that the optimisation process includes two separate variables relating to their external validity.

The first of these is the **expert validity indicator** provided through the project expert reference group, comprising four academic experts specialising in the field of universities and innovation. Following the decision of the indicator long-lists and short-lists, the expert reference group provided specific *sui generis* comments on each of these indicators (against criteria that they determined themselves rather than criteria that we provided to them). These can be interpreted in a natural language; for the indicator leadership, for example, experts provided the following feedback:

Leadership/ Governance
Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)
Expert 1 Rationale: outside-in knowledge/expertise flows => it should facilitate collaboration and the generation of new ideas Senate/Council/Gvt body/Faculty/Consultative Board Too many different organisational units which may have different control systems Maybe simplify it? Industry experience of the man in charge (e.g. Vice-chancellor)? Do you expect this indicator to have a reasonable variability? i.e. Most HEIs may simply have a very low value Amount of sponsorship obtained by alumni/industry? Clear and tangible recognition of the impact that attending the Uni has had on the career of leaders
Expert 2 Weak indicator and technically difficult to implement. Does not fully cover leadership and governance. Many universities get involved in sitting on regional bodies promoting regional bodies, how do they take that knowledge out, how does that help to promote innovation in the sectoral bodies, more outward-looking.

It is therefore important to seek to use those indicators for which there is a sufficient level of expert support[31].

- If the experts immediately indicate critical flaws in the variable then that variable can be discounted from further consideration.
- If there are some criticisms but mixed with positivity, then, if the other indicators are strong, it can be included.
- If the experts are primarily positive, then that would be evidence that would help make the case that that variable should be included.

Input for other elements of the external validity of the indicators was provided through the qualitative fieldwork and survey. In this, stakeholders were asked to comment on the appropriateness of each of the variables, and to propose alternative variables that could potentially be used in their place. The results of the stakeholder consultation are set out in Chapter 5, and these have been used in distilled form in the optimisation process (see 6.3). In contrast to the experts, the consultees' familiarity with the indicators was far more limited and there was a risk that some of the feedback on the indicators was primarily an opinion and a 'gut feeling', rather than a well-ordered justification. We therefore focused primarily on the **arguments** advanced by stakeholders.

In the case of the Leadership variable, the following feedback was incorporated:

Leadership/ Governance
Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)
Stakeholder feedback on the variable • Define applicable university bodies and management level • Define external members (background) • Focus on externals with a business background may be more indicative of an entrepreneurial culture • Take into account the role and degree of involvement of external members in university bodies • Consider impact of externals' involvement • National legislation on HEIs' governance affects this indicator and may have a significant impact on it • Focus on HEI bodies with real decision-making authorities

As with the experts, the stakeholders' evidence can be interpreted based on natural language as corresponding to three levels of support for the indicator

- If there are substantive criticisms of the variable, or a series of minor issues that cannot be satisfactorily mutually resolved, then that variable can be discounted from further consideration.
- If there are primarily superficial/ cosmetic criticisms but mixed with positivity, then, if the other dimensions are strong, it can be included.
- If the comments are primarily positive, and from a number of perspectives, then that would be evidence that would help make the case that that variable should be included.

From this basis, we adopt two further rules as the basis for our optimisation approach.

[31] In this case, we interpreted the experts' evidence as primarily negative (and taking the practical consequence in line with Rule 3, we excluded the indicator from further inclusion in any of the indicator sets).

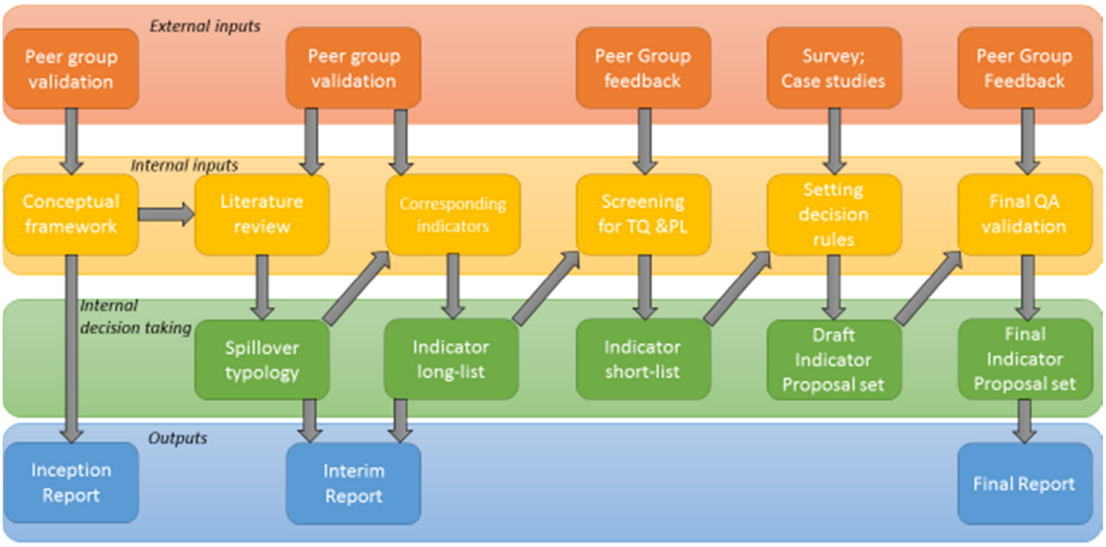
Rule 6: seek to use indicators for which there was a strong expert consensus that they had a sufficient degree of validity (as defined by the experts' own language).

Rule 7: seek to use indicators for which there was a strong stakeholder consensus that they had a sufficient degree of validity (positive, converging comments on validity in their response to the consultation).

Annex 6.3: Generating prototype indicator proposals

Developing indicator sets to provide valid policy-making information is an inherently subjective task that seeks to balance principled and pragmatic considerations, ensuring that information is produced on the correct mechanisms but within an overall resource envelope of affordability and ease of effort. When dealing with indicators for a concept, there is the additional problem of complexity, with potential simplifications at one point potentially leading to inadvertent problems later on in the selection process. A good indicator development process therefore continually zeroes and cross-references the choices made to avoid unnecessary channelling, and this is particularly important in making the final choice for a set of indicators. In 6.2, we have set out how we have gathered information on the 19 long-listed indicators in order to make an indicator selection. This information serves as the basis for the selection process, described in 6.4; in this section we explain how we bring the potential indicators together to make a selection of a set. This fits within the overall development workflow as shown in the diagram below.

EUNIVATION INDICATOR DEVELOPMENT VALIDATION WORKFLOW



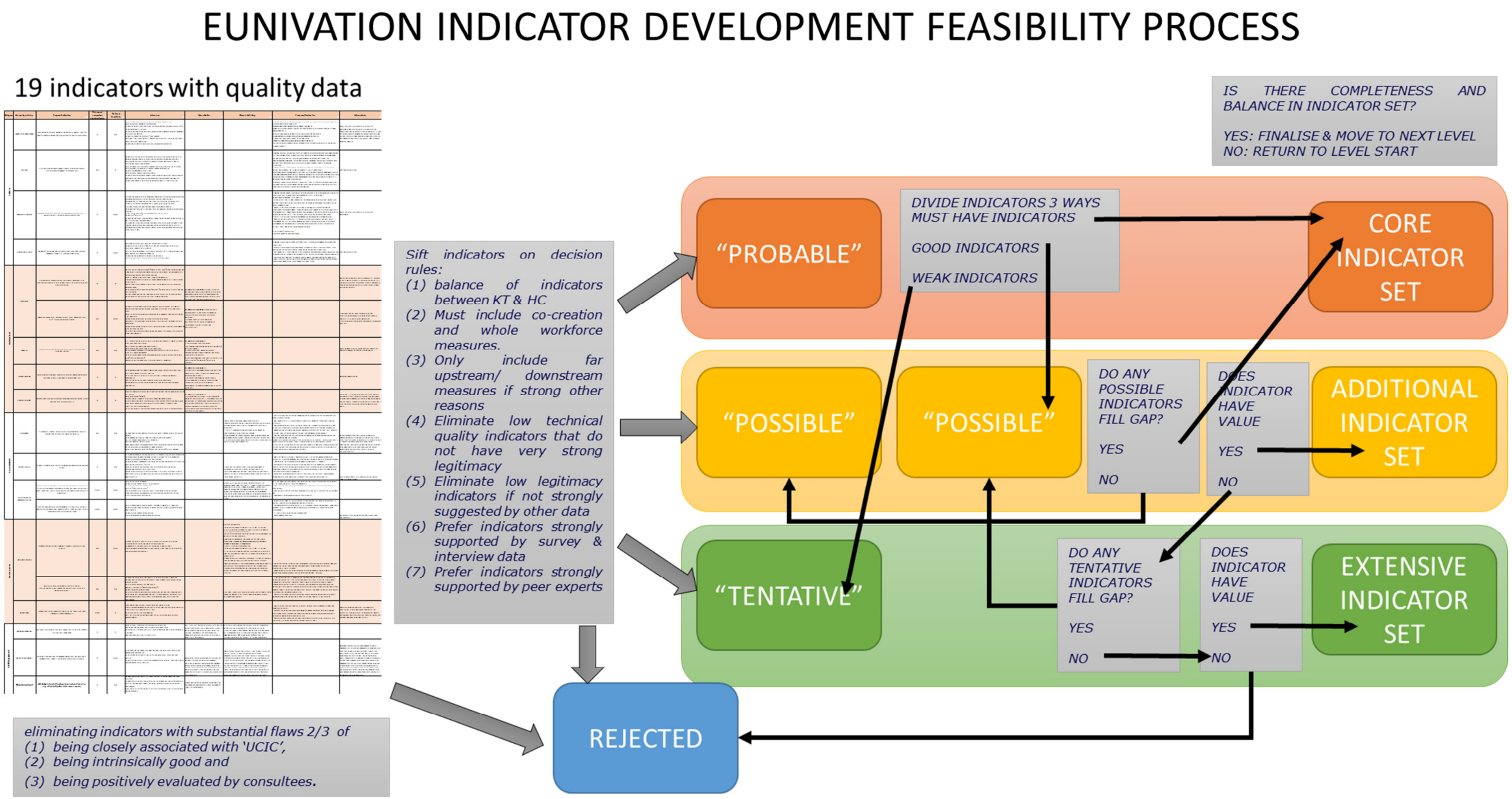
Developing sets to minimise policy effort

The purpose of this indicator set is to disaggregate university contributions to innovation capacity to a territorial level to improve the policy management of those contributions. The indicator set prototype therefore seeks to make distinctions between different units of aggregation and therefore there need to be sufficient indicators to guarantee that the important distinctions are visible in the indicator set with sufficient resolution for the purpose necessary. The Regional Innovation Scoreboard distinguishes for example between four performance levels (innovation leaders, innovation followers, moderate innovators and modest innovators). The distinction we make in UCIC also suggests that some level of distinction need be made by the primary source of the contribution (whether knowledge transfer or human capital or a mixture of both).

The absolute minimum requirement for the indicator set is that it should capture the most important contributions for knowledge transfer and human capital, and that there should be a reasonable expectation that the differences between units will be sufficiently high to give a clear resolution. In practice, we expect this will involve 1-3 indicators from each of the two categories, reflecting the indicators that are both intrinsically optimal but also regarded by the external consultees as being the 'best' or least problematic. This will provide a very crude overview of UCIC, that we refer to here as the **core indicator set**[32].

[32] These percentage figures are *ex ante* indications of the kind of coverage that would be produced by the set; determining what the *actual* coverage provided by these indicators would be, would require *ex post* validation and an analysis of the extent to which the indicators were converging towards a stable UCIC measure. More information is provided on this in 6.4.4 below.

Figure 24: An overview of the feasibility optimisation process – from short-list to indicator sets



More resolution can be acquired from an indicator set that includes indicators that provide more information regarding the internal composition of the overall variable UCIC. These additional indicators will therefore relate to mechanisms that are strongly complementary to the indicators already developed (so both do not relate for example to co-creation or the human capital pool), and will also be rated as good in terms of their intrinsic suitability and their external consultee support. This will provide a relatively simple but more nuanced overall picture of UCIC at Europe's different territorial levels: we refer to this as the **additional indicator set**.

Additional analytic capacity can be gained by adding additional complementary indicators that cover additional mechanisms without great overlap with the additional indicator set. The purpose of these additional indicators is not to shift the relative ranking between units, but rather to provide additional analytic insight into why some units are performing better than others. These indicators will either therefore cover complementary mechanisms or relate to mechanisms for which the existing indicator omits a degree of coverage. This is an extensive indicator suite, and is most use for developing unit profiles, making differences between the units on the basis of their performance; we refer to this as the **extensive indicator set**.

Making a choice of indicator relevance

The second step of indicator selection is in exploring the ways that a set of indicators fit together to create an indicator set that fits the descriptions in 6.3.1 above. Our overall approach has been constructive, seeking to firstly build the best core indicator set, and then, by adding additional indicators, to provide further resolution for understanding internal composition and performance management information respectively. We approached this as an experimental process, testing different configurations of indicators to identify the indicator sets that optimised the overall 'goodness' of the indicators and the set, whilst ensuring as much information was contained in as few indicators as possible.

For each of the nineteen short-listed indicators, we have gathered three kinds of information about their suitability and derived seven decision-rules in order to distinguish between them. Choosing an indicator set is not just a question of choosing the 'best' indicators, because these indicators may together provide insufficient balance. However, it is possible in the first instance to eliminate the worst indicators from further consideration. The first step in the selection of indicator relevance was therefore in eliminating any indicators which had substantial flaws in two of the three main dimensions (as regards (1) being closely associated with 'UCIC', (2) being intrinsically good and (3) being positively evaluated by consultees).

The second step of the selection criteria was in taking the indicators that remained, and assessing their overall quality level (using the decision rules set out in 6.2 above). The indicators were divided into three main groups, tentatively termed "probable", "possible", and "tentative". The indicators assessed as being probable were then scanned to identify which were the best indicators (following the decision rules) and that indicator set was considered as a core indicator set. The set was then assessed for potential 'white spots' in coverage, while looking to the possible and tentative indicator sets to provide additional complementary information. Once the indicator set was judged to provide enough resolution, the set was considered in its entirety for redundancy, with redundant indicators being removed. A number of these cycles were performed until the process converged around a stable indicator set, this then being adopted as the core indicator set.

The process was then repeated for the other two indicator sets in an additive way – each set adds to it the indicators from the preceding set. In each of the following two processes, the first question asked which of the most important areas are not adequately covered by the more limited set, and then potential indicators are sought firstly from the "probable", then the "possible" and finally the "tentative" indicator set. Indicators are added until there is sufficient coverage to give the desired resolution (6.3.1) and then there is a cycle of removing and adding indicators to the set until the indicator set converges around a single optimal arrangement.

The final step in the process is validating the determined indicator sets, and reflecting on whether they are plausible as indicator sets seeking to measure UCIC.

A comparative indicator selection process

This indicator selection process involves a high degree of judgement-making by the project team. There is a potential risk therefore that the selection outcomes reflect *the way the judgements are made* – interpreting consultee responses for example – rather than the needs of producing a 'good' indicator set. This process is inherent in any performance indicator development process, but is particularly challenging when developing indicators for a concept that has only been operationalised at the stage of the policy process. A number of steps were taken in the indicator selection process to ensure that the judgements were as 'fair' as possible.

1. Grading scales were used to make the different dimensions more explicit. Creating grading scales was useful to allow comparability of the quality across these very different dimensions, and in particular to identify those that were very good or very weak in particular dimensions.
2. Different kinds of information about the potential indicators were brought together in indicator overviews, including their conceptual suitability, the way consultees regarded them and the extent to which they measured technically and in UCIC policy terms (see below).
3. The indicator selection was played out in a selection workshop in which three team members came together to make their own selections and then cross-reference, discussion validate and challenge those selections.

Figure 25: The indicator selection information fiche – the Leadership example.

University activities	Proposed indicators	Relevance/ conceptual appropriatenes	Technical Feasibility	Interviews	Francesco Rentocchini	Adrian Healy
Leadership/ Governance	Percentage of external members on university bodies (senate/ council/ governing body/ oversight/ faculty/ consultative Board)	✓	✓✓	• Define applicable university bodies and management level • Define external members (background) • Focus on externals with business background may be more indicative of an entrepreneurial culture • Take into account the role and degree of involvement of external members in universities bodies • Consider impact of externals' involvement • National legislation on HEIs' governance affects this indicator and may have significant impact on it • Focus on HEI bodies with real decision making authorities	**Rationale**: outside-in knowledge/expertise flows => it should facilitate collaboration and the generation of new ideas **Senate/Council/Gvt body/Faculty/Consultive Board** Too many different organisational units which may have different control systems **Maybe simplify it?** Industry experience of the man in charge (e.g. Vice-chancellor)? **Do you expect this indicator to have a reasonable variability?** i.e. Most HEIs may have simply a very low value **Amount of sponsorship obtained by alumni/industry?** Clear and tangible recognition of the impact that attending the Uni has had on the career of leaders	Weak indicator and technically difficult to implement. Not fully cover fully leadership and governance. Many universities get involved is sitting on regional bodies promoting regional bodies, how do they take that knowledge out, how does that help to promote innovation in the sectoral bodies, more outward looking.

The indicator selection was made in a workshop involving three team members who were each presented with the same information relating to all the indicators. In this workshop, each team member made a provisional selection and then the selection process proceeded through discussion between team members. This ensured that the judgements that were made by individuals were subject to challenge and reflection. The workshop participants sought to achieve a consensus about the correct indicator selections, which is necessary in order to fulfil the seven rules set out in 6.2 above. The judgements that have been made on the basis of the gathered information and the optimisation rules are presented in 6.4 (below).

Annex 6.4: <u>The final proposition for an indicator prototype set</u>

Core indicator set

The first consideration in choosing a core indicator set was the balance between the most important dimensions of the model. From our composite model developed in chapter 2, the most important areas to cover were the contributions to the human capital via skills and knowledge, and through knowledge transfer via collaborative research activities with external users.

Two knowledge transfer indicators have been selected, namely collaborative R&D and consultancy income, as these are both areas where an external user is showing immediate interest in the knowledge emerging from universities. These were also variables that were strongly supported by interviewees and experts, although some concerns were raised that a financial measure was not necessarily optimal for comparing between different disciplines.

Three human capital indicators were selected. One of them was selected because it reflected both human capital and knowledge transfer, that of PhD positions undertaken with non-academic partners. The other two indicators reflect university contributions to facilitate the uptake of skills by non-academic agents, firstly in lifelong learning by academics providing wider teaching, and secondly the involvement of non-academic agents in defining curricula.

Dimension	University activity	Indicator
HC: workforce pool	Lifelong learning	Percentage of academics teaching in courses required by non-academic agents (firms, public sector, NGOs,…)
HC: workforce pool	Mobility	Percentage of PhDs undertaken jointly with a private (non-academic) partner
HC: skill pool	Curricula	Participation of non-academic agents in the definition of curriculum development (level measure)
KT: academic engagement	Collaborative R&D	University research funded by industry and by charities/foundations (number of projects, total value and percentage of total)
KT: academic engagement	Consultancy	Income, total value, number of contracts (by: SMEs, large firms, commercial, non-commercial)

Additional indicator set

The first consideration in choosing an additional indicator set is sustaining the balance between the main dimensions, and including the key elements not already included in the core set. The lacuna in the human capital indicators was in overall student throughput, and in this case the strongest indicator was students enrolled in entrepreneurship courses, capturing one element of the 21^{st} century skills that universities provide to students to facilitate deploying their knowledge in new ways, and improving innovation.

For knowledge transfer, the areas not covered by the core data set were commercialisation and public engagement, and two indicators emerged as strongest in the process. Firstly, university commercialisation infrastructure provided a good indicator of commitment, even if slightly upstream, but clearly related to later outcomes. Secondly, public outreach expenditures were seen as a good way of capturing the efforts that universities make to ensure that other kinds of research that are not immediately commercialisable are also made publically available and can therefore contribute to engagement activity.

Dimension	University activity	Indicator
HC: skill pool	Teaching & Learning	Number of students enrolled in entrepreneurship courses as a percentage of all students/ percentage of ECTs)
KT: commercialisation	Infrastructure for commercialisation	Services provided within the commercialisation infrastructure; Seed corn investment (Y/N); Venture capital (Y/N); Business advice (provided by the infrastructure) (Y/N)
KT: public engagement	Education outreach	HEI budget allocated to educational outreach activities (e.g. school and public talks, career events)

Extensive indicator set

The fundamental consideration in proposing an extensive indicator set is whether there are other dimensions that are not adequately covered by the existing chosen variables, and whether there are indicators that provide additional useful management information proportional to the overall additional effort required in their gathering.

The indicator for internationalization provides an additional dimension measuring the way that skills are activated and taken up within society. The optimal data set looks at lifelong-learning, collaborative learning, external curriculum input and joint Ph.D. training as the main mechanisms by which skills are used to create novelty.

The indicator for student start-up activity provides information on the extent to which the university environment is creating the raw materials for innovation and supporting its uptake in business. What it adds to the existing indicators is that it is a proxy for 'informal innovation contributions', and therefore contrasts with activities specifically arranged by the university, and formal contractual relationships between universities and innovators.

The one area that is not covered at all adequately in the indicator set relates to research engagement; there are indicators covering shared research and public engagement, but there is nothing that adequately captures the non-formal ways that research flows to create innovation capacity. More work would be needed to propose a prototype indicator for this area, but there appear to be potential benefits in exploring this area.

Dimension	University activity	Indicator
HC: skill pool	Internationalization	Number of ECTs awarded to international exchange students (ERASMUS student) as a percentage of ECTS
KT:	Student start up	Student start-ups (total active start-ups, turnover, private funding raised)

commercialisation	activity	
KT: academic engagement and public engagement	*Research/ Engagement*	*There is a lacuna around research engagement by universities*

The relative coverage of the proposed indicator sets

The issue of the aggregate degree of coverage provided by the indicator set is an important element of the feasibility set, in order to understand whether the proposed set provides a fair indication of a complex real world phenomenon involving multiple overlapping effects. However, it is also important to avoid false precision, and it is not possible at this stage to say in a meaningful way what percentage of coverage is provided by the indicator sets. This would require the construction of the indicator set and then its comparison against recorded overall performance levels over time to understand what share of the desired performance could be attributed to the processes covered by the indicator.

To give a sense of the order of magnitude of the variables' coverage, we therefore attempt to gain a sense of the extent to which the indicators selected provide coverage of the diversity of the elements. From a first order perspective, the indicators cover all five of the sub-dimensions, the main processes by which universities contribute to innovation capacity. The core indicators relate to processes by which universities most directly contribute, i.e. creating knowledge in ways that ensure that potential users will be involved in its use, and educating students in ways that activate them to use their human capital to stimulate innovation.

A second order perspective is provided by looking at how closely the indicator set corresponds to the overall 'shape' of the construct we have identified, covering the most important elements of the mechanism[33]. In order to get an indication of the congruency of the indicator set with the construct, it is possible to consider what information is missing in the indicators from the picture presented by the indicator set (and hence dimensions that have been excluded from inclusion in the main indicator set). The indicators proposed relate to 10 of the 19 sub-dimensions of the model[34]. For the remaining 9 indicators:

- 4 carry almost no relevant information because what can be measured does not readily correspond to the scale along which a characteristic can be measured (IP income, media engagement, community engagement, leadership & governance).
- 3 carry some useful information of a relatively small scale and are associated with UCIC despite not being particularly significant in the creation of innovation capacity (incubators, intermediary institutions and talent attraction/ retention).
- 2 are reasonable indicators but are excluded because they duplicate other, better indicators that are already chosen (contract research and graduate numbers – both are indicative of innovation but not as closely associated with innovation capacity as the ultimately selected variables).

It is clear with the extensive indicator set that there is a diminishing amount of information being captured, with more information given on sub-processes –international exchanges are

[33] Distortions can arise in this coverage from two main sources. Firstly, it can be the case that a particular element is missing in the model, and therefore it is under-represented in the indicator set. Secondly, it can be the case that one particular element is covered by multiple indicators and therefore it is over-represented in the indicator set.

[34] spin-offs, business suppy, R&D collaboration, consultancy work, public reach out, curriculum, teaching and learning, internationalisation, mobility and life-long learning

another indicator of activation of student creativity alongside entrepreneurship and practical embedding, whilst spin-off companies have a degree of overlap with the knowledge outplacement mechanism already captured by business support. However, both those indicators provide useful additional information and therefore the decision about their inclusion is an emergent outcome. That decision should be taken specifically related to the additional burden that gathering that information would impose on the chosen methodology, rather than being something that can be decided *ex ante*.

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