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Making ideas work for society:
University cooperation in knowledge transfer

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"Making ideas work for society. University cooperation in Knowledge Transfer"

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“**Making ideas work for society.** University cooperation in knowledge transfer”

Abstract.

Sustainable economic growth is more brought about by ideas, knowledge and human capital than by physical capital, like machines, buildings or land. Universities are one of the sources of ideas and of human capital. We focus on the third function of universities, next to education and research, in particular on knowledge transfer. Knowledge transfer is highly visible in agglomerations like Silicon Valley. Many countries nowadays have strategies to step up knowledge transfer as a source of sustainable economic growth.

Knowledge is recognised to have its strongest potential impact close to the place where it is generated. This makes a university attractive to the region in which it is located. The university contributes to sustainable economic growth not only through the expenditures associated with the running of the university, but perhaps more by the knowledge transfer. This involves amongst others partnerships with business.

Knowledge transfer does not come by itself. It requires action and strategy on the part of the university, the region and local public or private actors (businesses and public organisations). It appears that US and UK top-universities are more prominent not only in realising cooperation with business, but also among each other.

JEL Codes: I21, I25, O31, O32, O33, O34

Keywords: Knowledge transfer, innovation, university-business cooperation, triple helix

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1. Introduction: KT as an imperative for a university

1.1 It's ideas that count for progress.

It was a shock when economists (in the 1950s) realised that economic growth could only partly be accounted for by investments in buildings, machines and land ("physical capital"). The "wealth of nations" (Smith, 1776) was apparently not only in physical capital as Smith (and with him most economists) had believed for some 200 years. The part of economic growth not explained by physical capital, the "residual", was attributed to ideas, knowledge, derived from research and incorporated in people (Denison, 1962). The 2018 Nobel Prize for economics was awarded to Paul Romer in recognition of his contribution to deepening our understanding of the role of ideas and well-trained (wo)manpower as drivers of (sustainable) economic growth (see for example: Romer, 1990).

Ideas arise everywhere, but they are more likely to be the result of organised research as happens in universities or other research institutes. The ideas and the new knowledge, however, may easily remain in the confines of the university halls and rooms. Making them work for society is the topic of this chapter, with an emphasis on how university cooperation can contribute in this respect.

1.2 KT as an imperative for a university.

Beyond the goals of providing education and doing research, universities should pursue, according to their charters, "KT" or "knowledge valorisation".

Universities can have a substantial impact on the economy of the world, of their country and in particular of the region, through the "valorisation of university research" or "Knowledge Transfer" (henceforth termed KT). KT is a term used to encompass a broad range of activities to support mutually beneficial collaborations between universities on the one hand and on the other businesses and the public sector. These collaborations tend to enhance first and foremost the economic growth of the region, as most of the benefits of the new knowledge, whether patented or not, contribute most close to places where the knowledge is generated.

Minshall (2018) describes KT of a university as a 'contact sport'; "it works best when people meet to exchange ideas, sometimes serendipitously, and spot new opportunities". Technology transfer is a subcategory: it concerns transfer of innovative solutions of problems that are protected by different intellectual property rights.

Unlike in education and research, collaborations in KT over long distances are mostly among the top-universities in the world. For other universities, the collaborations are mostly in the region or are in the form of "learning from each other's experiences"

1.3 Content of this chapter.

Making ideas work for society: that is the role which universities have –in addition to education and research. Section 2 presents the development of the awareness of KT in universities and in society at large. Most universities world-wide have recognised the importance of contributing to society through KT - often with the universities in Silicon Valley as shining examples. The awareness of KT as one of the drivers of innovation has been increasing in the past decades. Innovation itself is increasingly recognised as an important driver of sustainable economic growth. Countries strive to be high up on the international innovation ranking index.

In section 3 we explore more in detail KT at the level where it happens: the individual university and its impact on the region. In section 4 we consider the crucial factors which contribute to valorisation and how to organise KT in a university. In section 5 we look into the existing cooperation and 6 is a section with conclusions.

2. Competitiveness through innovation; innovation for less oil-dependency.

2.1 Valorisation and innovation.

In 1938, one of the first university spin-offs was created by Bill Hewlett, a student of Stanford University, encouraged by his professor Fred Terman to start a company based on an idea from his own master's thesis. He then founded together with his colleague David Packard, Hewlett-Packard Company. HP became a huge success: it was ranked 24th in 2004 and 48th in 2018 out of 500 best prospering companies in United States (Fortune 500, 2018).

HP was the beginning of Silicon Valley: the notion that the proximity between university knowledge (of top universities) and business could create high technology agglomerations, with high economic growth as a result. However, being a top-university does not automatically imply a high contribution to the region through KT: several high-quality universities such as Berkeley, Cal Tech, Columbia, Chicago, Harvard and Johns Hopkins have hardly played a vital role as incubator for high tech industry in the region. Varga (1997) concludes: “The same university research expenditure was associated with dramatically different levels of innovation”.

Learning from the success stories on links between business and universities, is high up on the policymakers’ wish lists. Governments call on university leadership to take up the “third goal” of the university (KT) with the same dedication as the first (education) and second (research) goal. This was even more so as policymakers were searching for cures to the stuttering growth seen in many Western nations since the global financial crisis or as in the Arabian Peninsula Governments are seeking less dependency on oil.

Continental Europe has had a mixed experience with knowledge-transfer. In the post war period (after 1945) the universities, in particular the technical universities, were important to regain a competitive edge in production in the electronics sector, in the chemical sector, in car manufacturing and in mechanical equipment, only to mention examples. However, in the period of the rapid expansion of universities from 1965 onwards, the relations with industry as well as with the region became looser. The period of the 1990 presents a turning point. It was felt that the economies of had lost their comparative international strength and that this needed be mended by increased innovation. Knowledge driven innovation became a key-word.

At that time the European continent was recognised as having comparative *advantage in creating* knowledge, and comparative *disadvantage in transferring* it to other sectors and turning it into innovation and growth. Europe produces comparatively large amount of basic research (around 30% of the world's scientific publication) with less than 8% of the world's inhabitants. At the same time it used to be unable to get much industrial innovation and economic growth out of it. This phenomenon was widely known as "European paradox". The "European paradox" was explained as resulting from "institutional factors"(European Commission, 2017), like the communication between scientists about current research, sharing information ahead of wider publication, networks of people in companies, universities, research institutes and elsewhere. The limited university autonomy in many EU countries is also a factor in less than possible KT (Hoareau et al., 2013).

The EU set up the Horizon 2020 programme (see website Horizon 2020) to promote smart, sustainable and inclusive growth for EU states through research and innovation. The scale and scope of the Horizon 2020 program expanded the past EU frameworks by funding a wide range of diverse activities along the whole value chain, from basic research through to market uptake.

The importance of industry-academia links is evident university strategies in countries like Finland, Germany, Ireland, Norway, the Netherlands and the UK. However, in many EU countries the challenge to make university ideas work for society has hardly (as yet) been taken on.

2.2. Country's ranked by level of innovation.

KT contributes to the competitiveness and the level of innovation of the country. Countries are keen to see themselves high on the ranking of innovation. Rankings on innovation make the headlines in the financial and economic newspapers. The general pattern of rankings of countries is well illustrated with the Bloomberg (2015) ranking of countries and sovereigns based on their overall ability to innovate. This ranking identifies the top 50 countries by level of innovation with the metrics presented in Figure 7.1.

[Table 7.1 here]

Other rankings (like that of the World Economic Forum –henceforth WEF-ranking) are more sophisticated (Cornell, INSEAD and WIPO, 2018). In 2018 the top 10 ranked economies over the last four years are: 1. Switzerland 2. Netherlands 3. Sweden 4. United Kingdom 5. Singapore 6. United States of America 7. Finland 8. Denmark 9. Germany 10. Ireland. Northern Africa and Western Asia with 19 economies shows that Israel (11th world wide) and Cyprus (29th) achieved the top two spots in the region for the sixth consecutive year. Third in the region is the United Arab Emirates (38th). By the way: the WEF report does not include KT from universities as one of the main drivers of sustainable economic growth.

2.3 Innovation and oil-dependency.

Oil rich countries, in particular those in the Arabian Gulf have almost since their inception strived for innovation as a way to become less dependent on oil, both in terms of GDP, or as a percentage of Government Revenue or as a Percentage of Exports. Albassam (2015) documents that these efforts have not been very successful in the period 1970-2015, while at the same time countries like Norway (oil), Chili (copper) or Botswana (diamonds) and even the UEA (oil) have become less dependent of their natural resources.

The road towards less oil dependency is paved by innovation, in which KT from universities is an essential part. Yet, KT still has a long way to go in many of the oil rich countries in the Arabian Gulf.

3. Knowledge and the region.

3.1. The distributed impact of knowledge

The first study to show that investments in new knowledge have by and large local effects is from Jaffe (1989)[1]. He demonstrated empirically the effects of public R&D on innovation in relation to the distance between the spot of origin of the new knowledge and its economic impact. The number of patents was used as the indicator for the production of new knowledge. He shows that public R&D has a strong locational impact: the higher public R&D in the region, the more patents in that region. This is explained by the "spill-overs" of knowledge towards that region. His findings are corroborated on a large number of other studies, for Austria, France, Germany, Italy, Spain, Sweden as well as the EU as a whole. However, the impact of (new) university knowledge on the region differs substantially between sectors: it appears to be substantial in sectors like pharmaceuticals and medicine, or optics, electronics and nuclear technology, but less so for chemical products or metal products.

R&D investments not only lead to more patents in the region, but also to more product innovations (patented or unpatented) (Acs et al., 1992). That effect is even stronger than on patents. This and other studies confirm the hunch that the application of new knowledge, is more likely to happen close to the place where it is originated, simply because of the contacts between the people who invent

[1] This section draws on a study of the Central Planning Office (CPB) of the Netherlands (Braam et al. 2017).

and those who apply. Of course, this does not exclude the application of new knowledge on a long distance. For example, international firms realise new knowledge through central research institutions or countries with central research facilities in selected areas. The personal factor in generating innovation close to the university is borne out by the larger number of partnerships between firms and universities close to the university (d'Este et al., 2013, Hong and Su, 2013, Hülsbeck and Pickavé, 2014).

In general one expects smaller firms to benefit more from the proximity of (new) university knowledge. Yet at the same time, larger firms may prefer to locate their research intensive production or their research labs close to a university with a comparative edge in their sector. It is then not surprising that Audretsch and Vivarelli (1996) for Italy and Ponds et al.(2010) for the Netherlands find that both large and small companies in the region benefit from the presence of a university. Also Ghinamo (2012) finds from an analysis of 44 papers on the impact of the university on the region that these support the existence of a genuine spillover effect of university research on regional innovation. To be sure, the studies quoted above are just examples of a large number all with the same conclusion: the region benefits substantially from KT.

3.2 Measuring impact.

Impact is part of the “performance” indicators of KT. The other two are: inputs, and outputs. Table 7.2 gives an overview of these three categories of performance indicators.

[Table 7.2 here]

Horizon 2020 Programme of the EU uses 23 similar performance indicators. They add the leverage of venture funding as well as relation with of KT with *societal challenges* to the performance indicators.

3.3 Evidence on the impact of universities on the region.

Regional scientists have extensively studied the economic impact of universities to the community (see for example: Maskell and Törnqvist, 2003, Siegfried et al., 2007, Jager and Kopper, 2013 or Goddard and Valance, 2013). The impact of the university on the region goes far beyond KT as Wylie (2018) and the contributors to his book show. “Universities can affect the lives of many members of the community via their applied research and aspiration raising activities. They create new knowledge, realise it commercially and fix it locally”. Lambooy (1996) gives an overview of the different types of economic effects as in Table 7.3.

[Table 7.3 here]

Originally the impact on the region was mostly assessed through employment in the university and the expenditures from students, using regional multipliers (see for example: Garrido-Iserte and Gallo-Rivera, 2010 or Kotosz et al. 2015). Subsequently Biggar economics (2017) included also KT activities. The total economic impact of LERU (League of European Research Universities with 23 participating universities) was computed at 71.2 billion Euros, of which almost one third by KT (technology licensing, consultancy, contract and collaborative research, spin-outs and start-ups, research and science parks, workforce training and staff volunteering).

In evaluating the role of KT it turns out that it is often the combination of the supply of well-trained youngsters and knowledge valorisation which makes the difference (see for example Winters, 2011 for the US or OECD, 2010 a and b for European examples). Knowledge valorisation enhances the chances that the graduates of the university remain in the region. This is of course relevant in regions with expanding universities while the population of that region is shrinking (see for example for Finland: Hapaanen and Tervo, 2012). Universities can be important for the investment climate which in turn might seduce firms to locate near to a university.

Grant (2015) analysed 6,679 impact case studies of the 2014 Research Excellence Framework (REF) in United Kingdom and finds that larger institutions make large contributions to topics such as ‘Clinical guidance’ and ‘Dentistry’, while small institutions make a greater than anticipated contribution to topics such as ‘Sports’, ‘Regional innovation and enterprise’ and ‘Arts and culture’.

DeVol et al. (2017) have made a ranking of the best US universities for technology transfer, with the University of Utah heading the list. The research done at Global University Leaders Forum (GULF) (made up out of the leaders of 27 top universities from 11 countries) is mostly connected to business in the fields of life sciences and computing. The list of the 20 companies that co-publish the most papers with academics is dominated by major IT firms such as Microsoft, IBM and Google and by large pharmaceutical companies such as GlaxoSmithKline and Pfizer [2](see Figure 7.1).

[Figure 7.1 here]

Worldwide the WEF has made the ranking of the regions which score highest in international patent filings and scientific publishing. These are as in Table 7.4.

[Table 7.4 here]

Notice the close correspondence between countries by level of innovation and the regions of innovation.

[2] At the background of the strong links between university research and industry in the pharmaceuticals sector may have been the downsizing of the research capacity in the drugs industry in favor of an investment into putting new drugs into clinical trials, while they are looking for smaller biotech firms and universities for the early-stage innovation.

4. Organising innovation systems: making KT work.

4.1 Institutional setting: triple helix.

KT does not happen by itself, but requires an institutional setting, in which the different actors (knowledge suppliers and knowledge users) find each other easily, or are even partners. In general one may say that KT has the best chances for success in a compact between the university and the region, often termed: the triple helix with the three parties: (local) Government, the university and both the public and the private sector. A compact ensures joint strategies. Increasingly universities and regions learn from each other or cooperate in realising the economic and social benefits from KT from the universities through joint research between universities and industry, start-ups, scale-ups combined with other forms of cooperation (for example in the education area), as well as with a social commitment of the university towards its setting: the region in which it located. This requires an engagement of the university in incentivising KT (as we see in 4.2). But it also needs an engagement from the region. This applies not only to the regional government, but also to the business community and the public sector in the region. An important element to make the cooperation succeed is the availability of angel and venture capital. Regions in which these compacts have been agreed upon clearly show substantially more socio-economic progress compared to regions in which there is little connection between the different partners.

KT goes substantially beyond the patenting of university innovations. Patents can be a source of valorisation if they can be applied either by third parties or by university start-ups. But the majority of the valorisation comes through new products, improvements in products or in production technologies which are difficult to patent. The use of new knowledge contributes a comparative advantage for the first mover. This is also relevant in the context of Open Science (see section 4.4).

The size of public research is clearly recognised as contributing to innovation. All of the top clusters in innovation of Table 7.4 receive substantial amounts of public funds (Mazzucato, 2013). Yet these funds are often targeted as a result of "industrial policy" towards knowledge creation in university which is closely related to the business sectors in the region. This underlines that the triple helix not only involves the region. It is best suited for innovation if the national level is included as well.

Hoareau et al. (2013) point out that the institutional framework for KT requires university autonomy – in close harmony with accountability of public universities to their funding agent: the public (i.e. Government).

4.2 Readiness of universities for innovation.

The EU and OECD have analysed what it takes for a university to be successful in KT. This happens to resemble closely the insights of Pertuzé et al. (2010).

The combined EU/OECD analysis has resulted in a self-assessment tool: HEInnovate (European Commission, 2018). Eight key areas are distinguished for the capacity of the university to contribute to innovation in the region and beyond:

1) Leadership and governance; strategically strong governance and good leadership are required for entrepreneurship.

2) Organisational capacity (funding, people and incentives), such that institutions minimise their formal structure which often are adverse to entrepreneurship.

3) Entrepreneurial teaching and learning.

4) Preparing and supporting entrepreneurs in students and staff.

5) Acknowledging digital transformation and digital capabilities as the key factors for entrepreneurship and innovation.

6) Building and sustaining good relationships with a wide range of stakeholders such as the public sector, regions, businesses, alumni, professional bodies.

7) Internationalisation as essential for entrepreneurship.

8) Monitoring and measurement of the size of KT.

The EU and OECD offer to review the engagement of universities in KT (the so-called Regional Innovation Impact Assessment, RI2A). Universities prepare their own case studies which will be then assessed by international experts.

4.3 A practical example.

Here we present a to-do list for a university which desires to be "entrepreneurial": This is by and large derived from the practice at Maastricht University (the Netherlands).

1. Leadership

- Embed the university strategy in a triple helix. Involve the region in the development of the university strategy.

--It is important that the university leadership (Board and deans) have ownership for KT as part of their performance agreements.

-Set goals in terms of the number of start-ups, scale ups and other forms of KT.

-Reward deans for success in entrepreneurship of students and graduates, in patenting. Reward successful entrepreneurs from university incubators with a substantial part of the shares. Set up clear and trustworthy guidelines for this.

2. Entrepreneurship education.

-Research based teaching (as part of problem based teaching) to be enlarged to start-up based teaching: using the examples of start-ups as part of the learning experience;

-Bachelor and master thesis can also be devoted to business plans for start- ups;

-PhD theses have (compulsory) a section on "validation", indicating the relevance of the research done to society. These validations are stored in an open access depository which can be consulted by the public and business at large, as a way to "unlock the knowledge safe".

-A course in entrepreneurship in all disciplines, striving to catch at least 10% of the students; making it part of the compulsory part of the curriculum in economics and business.

-Involving alumni who have successfully started companies in public university lectures or in the regular teaching programme is one of the ways in which a stimulating environment for entrepreneurship is built.

- Have a small number of "entrepreneurs in residence" at the university to be involved in teaching and research in entrepreneurship.

3. Supporting structures.

-Develop an incubator for start- and scale-ups, supported with angel and venture capital (supplied or organised by university). Support in the incubator new businesses with marketing and administration.

-Create an entrepreneurship centre for delivery of the entrepreneurship courses. -The entrepreneurship centre leads pre-incubation services (with angel funding from the university). Students can start a business as part of their credits in the entrepreneurship centre. The university will own only a small percentage of the shares of the start-up.

-Organise annually one or two entrepreneurship weeks to inspire students on entrepreneurship and to discuss successful practices of start-ups including how to find funding.

-Establish master courses in engineering and science on industrial sites related to the master courses, making research facilities of businesses part of the university campus.

-The returns to start-up of spin-off should accrue mostly to the individuals who have supplied the entrepreneurship.

-Recognising entrepreneurial achievement/patents on par with academic publications for the academic career.

-Set up a department of the economic analysis of innovation.

-Four faculties should take the lead: economics (financial and business services), medicine, science and engineering.

- Have an annual university entrepreneurship prize for the most promising start-up of that year.

4.4 Open science

At present there is a substantial drive to work to do research as "Open Science". In this mode intellectual property rights remain absent; so that all research findings are accessible. The main purpose of open research is to spread knowledge and allow that knowledge to be built upon by giving free access to the information so it can flow without restriction.

Open science allows researchers to apply each other's findings without costs and expands the access to students to new knowledge. However, it is questionable whether these advantages are sizeable; accept by reducing costs of peer reviewed publications for the academic community at large, if fees to be paid by authors for publishing are less than the present subscription costs of journals.

The impact on entrepreneurship is undecided. On the one hand intellectual property rights were established to create an incentive for new knowledge. On the other open science allows for a higher speed of application.

One notices a move towards more open innovation models involving larger multinationals, like the Structural Genomics Consortium. All the results from this research – into the three-dimensional structures of human proteins – are open access. Firms can still see the long-term potential of using the discoveries for later-stage commercial benefit by being close to the new knowledge generated.

In information technology, open innovation and the sharing of discoveries are more established. Firms recognise the benefits that accrue from that dissemination, including more thorough review, consideration and critique, and a broad increase in the scientific, scholarly and critical knowledge available.

The bottom line is that Open Science will increasingly get hold of society, definitely when public research is involved. Open science, if anything facilitates KT.

5. Cooperation in innovation.

Cooperation in KT goes hand in hand with cooperation in research. Existing forms of cooperation are mostly through three channels:

- The region. This was exemplified in the Table 7.4. In terms of the size this is presumably the largest cooperation worldwide in KT/research. The region lends itself well to cooperation in KT as it can be embedded in a triple helix, connecting universities, regional administration and the businesses in the region.
- Top universities. The cooperation in KT of the "Gulf"-universities has been well documented. Figure 7.2 gives an overview.

  [Figure 7.2 here]

  Notice that the kernel of worldwide cooperation universities/industries is in the US and the UK. The impact of this inter-group collaboration on research citations is massive: the darker hue of the lines in the network map shows that the field-weighted citation impact of work co-authored by academics from the institutions is consistently high. On the hand many companies are often attracted to large institutions with a wide breadth of excellent research, but on other companies may simply choosing to work with their nearest higher education institution.

  Continental Europe is still not highly visible in this context, despite the EU efforts. This might be the result of a lesser entrepreneurial spirit among academics on the continent, but also due to too little autonomy for the universities (Hoareau et al., 2013) and too little infrastructure in terms of incentives within the university (as mentioned in section 4.2). .

- . Other forms of university cooperation. There are many university networks, like LERU, in which universities search for joint interests and joint commitments in education, research and KT. In contrast to the GULF universities, there is little information available on the size of the KT or the research cooperation in these networks. In this category "other" also fall the cooperation between universities through mutual Memoranda of Understanding (MOU). To say it blandly: MOUs generally appear to be little more than a license for the university administration to travel and to learn about experiences elsewhere with little translation to the work-floor and little actual cooperation in KT.

University cooperation in KT is hard work, carried out by the work-floor: the active researchers. Encouraging and incentivising researchers is generally to best way forward, with the university administration in the seat of encouragement and possibly door-opener.

6. Conclusions.

Sustainable economic growth is more brought about by ideas, knowledge and human capital than by physical capital, like machines, buildings or land. Universities are one of the sources of ideas and of human capital. We focus on the third function of universities, next to education and research, and in particular on KT. KT is highly visible in agglomerations like Silicon Valley. Many countries nowadays have strategies to step up KT as a source of sustainable economic growth. Countries strive for a good position on the rankings of countries by innovation. Generally the countries which are high on the list are also actively pursuing KT strategies for their universities.

Knowledge is recognised to have its strongest potential impact close to the place where it is generated. This makes a university attractive to the region in which it is located as there is a substantial knowledge spillover from the university to the region. The university contributes to sustainable economic growth not only through the expenditures associated with the running of the university, but perhaps more by the KT. Smaller firms tend to benefit more from the proximity of university knowledge, while larger firms choose to locate their research close to top-universities. KT appears to be substantial in sectors like pharmaceuticals and medicine, optics, electronics and nuclear technology, but less so for chemical products or metal products.

KT does not come by itself. It requires action and strategy on the part of the university, the region and local public or private actors (businesses and public organisations). This is captured in the "triple helix" notion: universities, businesses and regional Government should engage in a regional compact which allows for strategies which are closely tuned to each other. National Government should also be included. KT is better facilitated if universities have the freedom/autonomy to act without too much red tape. The readiness of universities to engage in KT can be deduced from the commitment of the leadership, from the orientation of the university towards entrepreneurship and from the organisational structure, with attention for an incubator, for systematic study of innovation and for rewards for success in KT.

Open science (without protecting intellectual property) is increasingly the mode of operation, because it increases the speed of KT. Large firms in pharmacy and ICT see the advantages of Open Science.

It appears that US and UK top-universities are more prominent not only in realising cooperation with business, but in cooperating with each other in KT. This is clearly a challenge for universities on the European Continent and for universities elsewhere in the world.

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Table 7.1 Metrics for innovation ranking.

Six equally weighted metrics were considered and their scores combined to provide an overall score for each country from zero to 100.

1. Research & Development: Research and development expenditure as a percentage of GDP

2. Manufacturing: Manufacturing value-added per capita

3. High-tech companies: Number of domestically domiciled high-tech public companies—such as aerospace and defense, biotechnology, hardware, software, semiconductors, Internet software and services, and renewable energy companies -- as a share of world's total high-tech public companies

4. Postsecondary education: Number of secondary graduates enrolled in postsecondary institutions as a percentage of cohort; percentage of labor force with tertiary degrees; annual science and engineering graduates as a percentage of the labor force and as a percentage of total tertiary graduates

5. Research personnel: Professionals, including Ph.D. students, engaged in R&D per 1 million of the population

6. Patents: Resident utility patent filings per 1 million of the population and per $1 million of R&D spent; utility patents granted as a percentage of world total

Source: Bloomberg (2015).

Table 7.2 Classification of indicators of KT performance.

Categories	Indicators
Inputs	**Resources:** R&D expenditure; university's governmental income; non-government donations, grants and contracts; industry sponsorship of university research; scholarships; number of researchers. **Researchers' capabilities**: number of publications, citations, projects, reports or patents done in the past. **Researchers' motivation**: number of previous industry contracts in the department/university; number of strategies concerning industry-university cooperation in the department/university; amount of resources dedicated to support cooperation in department/university; perception of researcher about the benefits from the cooperation with industry. **Firms' absorptive capabilities**: quality certificates (ISO); previous collaboration with academia; membership of some association or research group; number of scientists; structure of employees by occupation and education. **Firms' motivation**: number of previous contracts with universities; involvement with university (e.g. alumni, lecturer); perception of the firm about the benefits from the cooperation with university.
Outputs	Patent applications; patents; license revenues; publications; joint publications; postdoctoral or doctoral positions offered within alliance; joint supervision; master and/or doctoral theses; secondment of researchers; intensity of

	collaboration; spin-offs; meetings; seminars; workshops.
Impact	GDP per capita; total factor productivity; productivity renewal indicator; number and share of high growth enterprises; renewal rate of enterprises; share of inward FDI per GDP; knowledge intensity of production; success of spin-off companies; productivity growth; turnover growth, export growth, the increase in exports created by new inventions; net increase of jobs, employment growth; recruitment of graduates; science citation index.

Source: Seppo and Lilles, 2012, p.2013.

Table 7.3. Economic effects of a university.

	Example
Employment at the university	Number of jobs at the university and related institutions
Income of the university	State contributions, tuition fees, financial a.o. benefits e.g. from book sales & merchandising
University spending	Purchase of goods and services by the university
Income and spending of university employees	W ages, salaries, and social security costs. Expenditures in shops, on entertainment and culture, and on public transportation
Labor market effects	Delivery of educated labor. Heightened productivity effect.
Spin-off business	Companies founded by (former) students and university employees, whether employing academic knowledge and technology
Marketing of knowledge	The sale of knowledge in a variety of forms: from ideas and courses, to patents.

Source: Lambooy (1996)

Source: Lambooy (1996)

Figure 7.1 Connection between GULF Universities and Industry.

Node colour = institution FWCI (Field-Weighted Citation Impact); Node size = number of publications; Thickness of line = number of co-publications; Colour of line = collaboration FWCI

Source: Baker (2018)

Table 7.4 Top cluster of economies or cross-border regions within the top 50

1	Tokyo–Yokohama
2	Shenzhen–Hong Kong
3	Seoul
4	San Jose–San Francisco
5	Beijing
9	Paris
15	London
17	Amsterdam–Rotterdam
20	Cologne
22	Tel Aviv–Jerusalem
28	Singapore
29	Eindhoven
30	Moscow
31	Stockholm
33	Melbourne
37	Toronto,

38 Madrid

44 Tehran

45 Milan

48 Zurich

Source: Cornell et al. 2018, p. xii

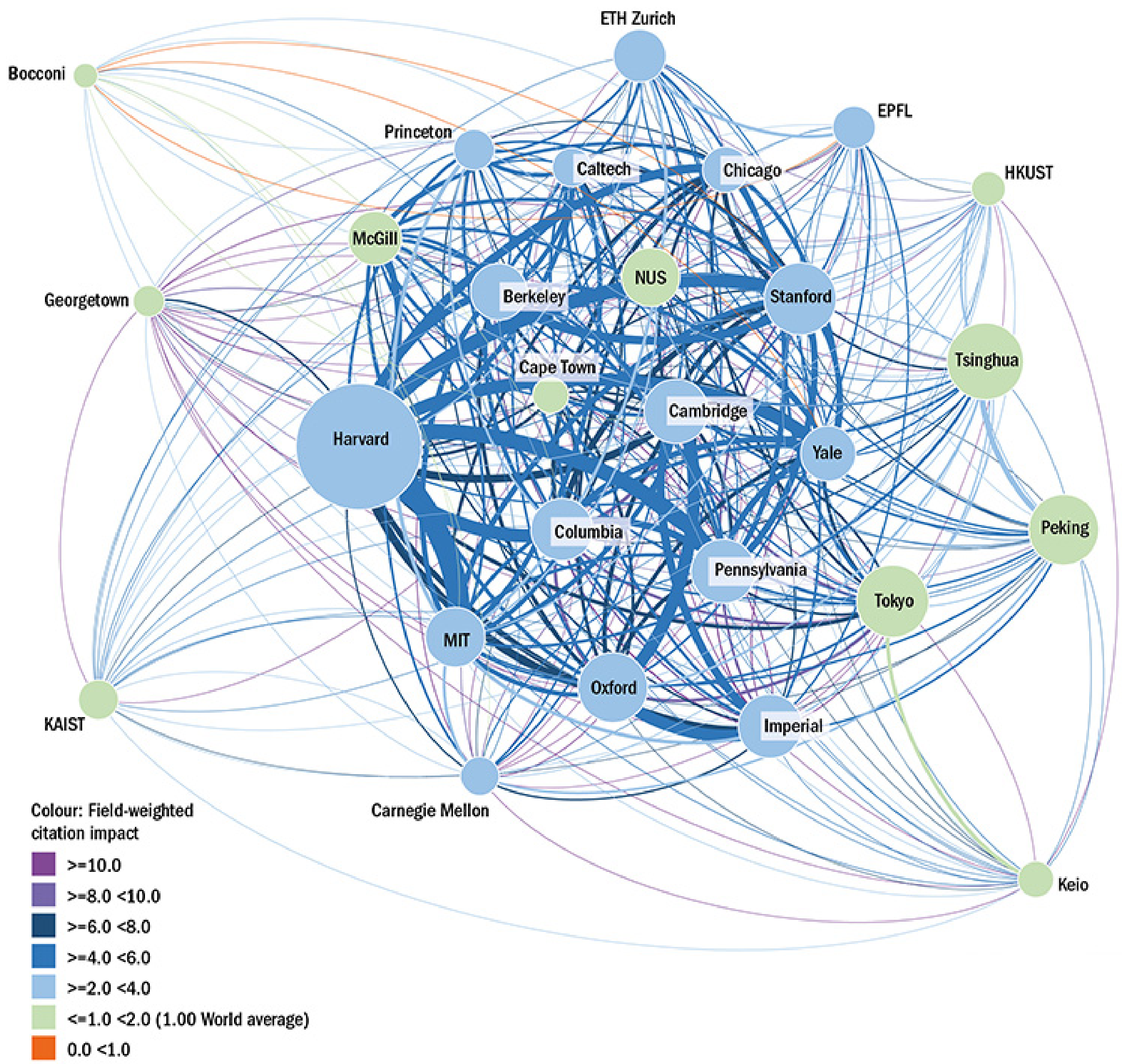

Figure 7.3 Cooperation in KT (co-publications university-industry).Node colour = institution FWCI**;** Node size = number of publications

Thickness of line = number of co-publications; Colour of line = collaboration FWCI

Source: Baker (2018)

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