Deutsche Bank
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Current Issues
Technology and innovation

More value creation through knowledge (assets)

Implications for regional growth strategies

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Knowledge revolution and knowledge economy: An increasing volume of knowledge is being produced around the globe. This knowledge is giving rise to more knowledge assets in the form of patents, trademarks, and utility models, which are then used to earn income: In 2009, revenue generated from applied innovation activities and trading in intellectual property rights amounted to more than USD 180 bn worldwide, a figure that has doubled since 2000.

Made in Germany, created by Germans: Germany is benefiting from its particular strengths in industry and from the creativity of clever minds focused on practical applications: Germany is being transformed from an importer to an exporter of knowledge. The country earned more than USD 3 bn in 2010 from exporting research and development (R&D) services. It also generates a net gain of some USD 270 m from trading in licenses.

Production of knowledge as a resource gathers pace: Expenditure on education and research is rising sharply, especially in emerging markets; student numbers are also on the increase – particularly those who are internationally mobile and who now total approximately 2.2 m worldwide.

Knowledge-intensive product solutions – a cornerstone of the knowledge economy: Design and fine-tuning work are turning more knowledge into new products, as demonstrated by the sharp rise in the number of registered industrial designs and utility models. The US and Germany are maintaining their position as the frontrunners in this regard.

Structural change in knowledge processing resulting from open innovation and the project economy: Open, project-based types of collaboration and knowledge transfer are gaining in popularity. Public research organizations, universities, and research & development service providers are becoming more influential.

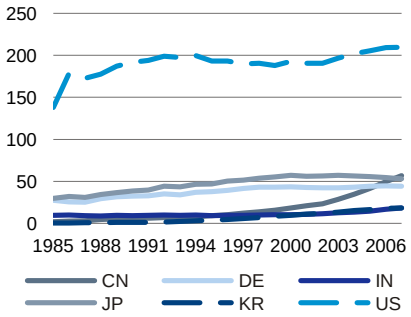
Cluster-based knowledge revolution: The rate at which the knowledge revolution is emerging is varying from region to region around the globe. Existing centers of knowledge in the US (California), Japan (Tokyo, Osaka), France (Paris area), and Germany (primarily Bavaria, Baden-Wuerttemberg) remain important. However, new knowledge powerhouses and clusters, such as South Korea (Seoul), China (Shenzhen), and Singapore, are emerging.

Growth from knowledge and knowledge assets: Regions and businesses can achieve qualitative growth if they support pioneers, continue to refine a range of partnership and collaboration strategies, and develop their own profile. Strategic specialization in the knowledge economy based on an integrated policy covering structure, external trade, education, and research, together with the development of institutional and financial platforms helps to facilitate more collaboration, thereby generating further knowledge assets.

More value creation through knowledge (assets)

The US (still) in the lead 1

Scientific and technical journal articles, '000



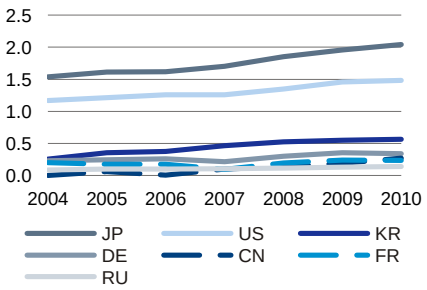
Sources: World Bank, DB Research

Knowledge revolution & knowledge economy – guiding questions 2

It is not possible to cover knowledge as a resource in its entirety, including all cultural and social knowledge as well as the importance of this knowledge for social progress. This review will therefore only use examples of the different types of knowledge generation (input), knowledge processing (throughput), intangible asset development and knowledge marketing/ application (output) to highlight how the knowledge revolution and the emerging knowledge economy is gaining ground around the globe. We ask the following questions: How much (more) knowledge is/will be produced? What trends are evident as far as investment in knowledge is concerned? How does the new alchemy of the knowledge economy work – how is knowledge turned into money? What are the products of the knowledge economy? Who are the main players in this knowledge revolution and knowledge economy? How is the production and use of knowledge changing? Where is knowledge produced? Not least, we ask what the consequences of the emerging knowledge economy will be for businesses and regions, and what they can do to influence developments.

Knowledge increasingly protected - worldwide 3

Patents in force by country of origin, m



Sources: WIPO 2011, DB Research

A knowledge revolution in progress

Knowledge is seen as the cradle of progress and prosperity. Knowledge and innovation are prerequisites for economic and social progress. Our analysis demonstrates[1] that a knowledge revolution is occurring as a result of the interplay between various forces within structural change[2] and that businesses are increasingly generating revenue from knowledge in the form of services.[3]

First, more knowledge, and primarily more specialized knowledge, is being created as a consequence of the education and research activities undertaken by national governments, public-sector organizations, and also increasingly players in the private sector, and as a result of the growing number of open, structured collaborative approaches at an international level.[4] The number of academic publications is rising with a total of almost 1 m such publications appearing in 2008 (see chart 1).

Secondly, new types of open,[5] applied, knowledge-based collaboration between innovative players are helping to generate knowledge assets and stimulate the emergence of the knowledge economy. Inventors and researchers in education and research establishments and in businesses are developing, refining, designing, and transforming knowledge into innovative product solutions in which technologies and services are available to users as a complete package. Within this process, the various players, such as knowledge-intensive businesses, development service providers, public research organizations, and universities, are becoming increasingly important.

The registration of intellectual property rights to protect the knowledge in ideas and product designs is very much on the increase.[6] This creates knowledge assets that – to an increasing degree – can also be sold and traded for financial gain. This is reflected in the growing number of rights over intangible property in the form of patents and trademarks, and in the rising volume of more product-related intellectual property rights (registered industrial designs and utility models[7]) (see chart 3, chart 4, charts 6a and 6b).

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1 We are grateful to colleagues at the OECD, WIPO, and UNESCO for providing ideas for discussion and the background to the data analysis.

2 For a 'map' of the dynamics in structural transformation, see Hofmann et al 2007: 65-67.

3 Given the structural changes in the production, application, and commercial exploitation of knowledge, this paper refers to this transformation as a 'knowledge revolution'. Due to the nature of the available data, we have not carried out separate detailed analyses of the changes in different knowledge areas and disciplines. The proposition that the transformation is tantamount to a knowledge revolution is supported by current trends. These trends indicate that a fundamental change is taking place in knowledge production in favor of more open production methods (based on open source) with closer networking and, above all, more validation. Knowledge is generated via collaboration between more participants and involves a range of different cognitive technologies (Weinberger 2012; Nielsen 2011).

4 The static capture of economic dynamics usually involves some time delay and there is therefore a great deal relating to knowledge assets and the knowledge economy that has not yet been measured or reported. Furthermore, available levels of implied knowledge and skills, for example, are difficult to measure anyway. This being the case, this paper is a selective review of the situation with the aim of generating some strategic foresight and identifying possible implications as far as future action is concerned.

5 For a definition and an overview of open types of innovation, see WIPO 2011: 47-48. This definition distinguishes between four types of open innovation according to the associated cash flows, the focus of collaboration, and whether the innovation is inbound or outbound. All forms of open innovation are structured by means of management and rules, whether formal (via agreements) or informal (via community values).

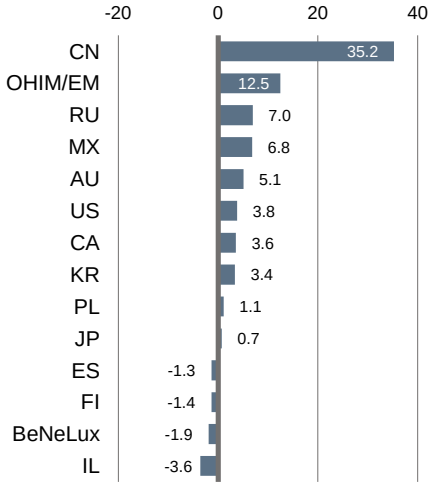
6 Although some discussion is necessary regarding the structure of the system of intellectual property rights and its capacity to promote innovation (the key being patent quality), the relatively solid comparative data on the development of intellectual property rights offers a basis for analyzing long-term trends in knowledge production and in the knowledge economy at an international level, taking account of regional differences.

7 The statistics are now also clearly showing the importance of Europe in terms of product innovations for everyday use and the associated intellectual property rights. Expressed very simply, following the establishment of the OHIM (Office for Harmonization in the Internal Market) and the introduction of a system for registering industrial designs and utility models in and for

More value creation through knowledge (assets)

Trademarks on the rise as a part of the knowledge economy 4

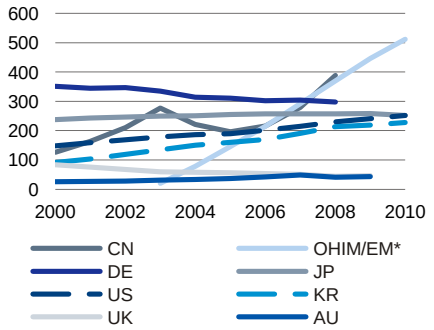
Annual growth rate of trademarks in force by office, in %, 2008-2010 (except DE, CN 2009)



Sources: WIPO 2011, DB Research

More protected product knowledge - worldwide 6a

Industrial Designs in force by office in '000 and reporting year

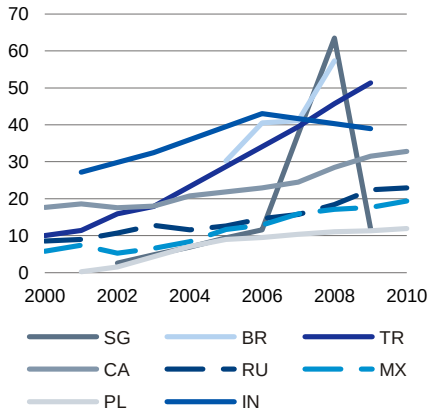


*EM: European Market

Sources: WIPO 2011, DB Research

More protected product knowledge - worldwide 6b

Industrial Designs in force by office in '000 and reporting year



Sources: WIPO 2011, DB Research

Time to ask what defines the new alchemy in the knowledge economy, how it functions, and what the new quality and consequences of the knowledge revolution consist of.

Fundamental definitions relating to the creation of value from knowledge 5

Knowledge assets: Banks of knowledge that are converted into knowledge assets on the basis of the various existing international traditions of intellectual property rights.[8] These knowledge assets are not given a monetary value in themselves. The monetary value attaching to an asset only arises after prospective customers and knowledge providers have arrived at a price on the basis of licensing, other agreements or marketing processes.

Knowledge economy: In the wider sense of the term, all economic activity based on generally highly codified knowledge (knowledge assets). In the narrower sense, economic activity attributable to producing and trading codified knowledge and intellectual property rights; the term may also refer to the development of national intangible assets.

Knowledge revolution: Longer-term structural transformation of knowledge, now accelerating as a result of better opportunities for processing information and knowledge based on advanced information and communications technologies. This structural change, which is occurring over a number of decades with different phases of acceleration, relates first to the nature of knowledge. The specifications for knowledge and non-knowledge are changing based on epistemic further development (see Weinberger 2012). Secondly, there are changes in the number of knowledge producers and knowledge owners. The different knowledge technologies and structural change in the economy also mean that knowledge production is no longer limited to academic institutions and businesses. In addition, other knowledge domains involving non-experts and social and cultural practices, i.e. informal types of knowledge, are used to find solutions for coping with day-to-day challenges. Thirdly, knowledge production is changing: More open forms of collaboration between a large number of players supported by knowledge technologies are leading to faster processes for creating more knowledge (including specialized knowledge) and verifying existing knowledge (see Nielsen 2011).

Knowledge technologies: Knowledge technologies include advanced information and communication technologies and software solutions for storage and knowledge management (database technologies, big data mining, text recognition), next-generation social media, and artificial intelligence solutions. They also include virtual reality and augmented reality applications, which are used to present a visual representation of information and knowledge. On this basis, processes can be simulated, allowing users to feel a state of immersion (i.e. a state in which a user becomes fully immersed and can interact within an information and knowledge environment). Information and knowledge technologies have long been used in data mining and in developing and manufacturing products. Knowledge technologies also encompass learning solutions (online and hybrid courses, massive open online courses (MOOCs), and cloud-based education and research solutions) that will fundamentally transform learning over the next few years.

Knowledge wealth: The proportion of the total wealth of a country accounted for by intangible assets determined in accordance with international statistical agreements.

Knowledge owners and players: Individuals, organizations, and communities who produce knowledge.

Knowledge and value creation networks: Networks of higher education institutions, research establishments, knowledge-intensive service providers, manufacturers, and service businesses of different sizes in a variety of industry sectors. These networks create more knowledge based on complex structures involving financing, collaboration, supply arrangements, and legal relationships. They protect this knowledge, spawn innovation, and distribute this knowledge either individually or together (for example, with umbrella brands) around the globe or on a highly regionalized basis.

Knowledge revolution and knowledge economy to come

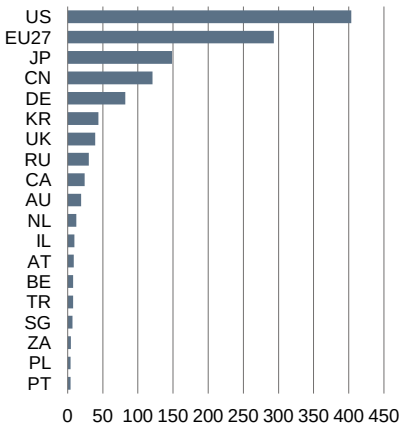
An increasing volume of knowledge is being produced around the globe. The growth in investment in knowledge – with investment in R&D leading the way – indicates that more countries, businesses, regions, and local authorities appear to be recognizing that knowledge and innovation must also be promoted by a

[8] Europe, it is now possible for European and non-European businesses to protect knowledge assets throughout Europe. The establishment of the OHIM means that, from a purely statistical perspective, some countries have dropped back in terms of their positioning based on the number of registered industrial designs and utility models. Some of this is just statistical distortion. For an overview of intangible assets, see Andrews/de Serres 2012: 8.

More value creation through knowledge (assets)

'Knowledge powers' and their investments 7

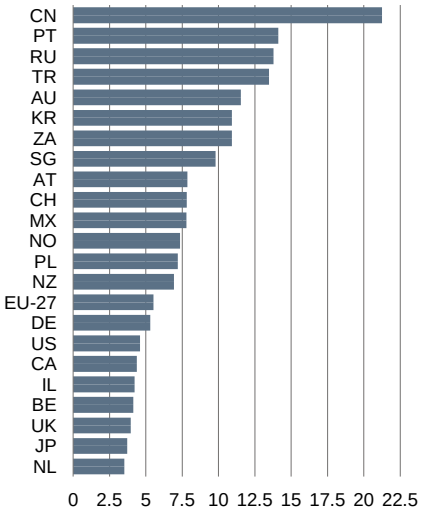
Gross Domestic Expenditure on R&D in USD bn PPP, 2008



Sources: OECD, DB Research

Dynamic knowledge investments 8

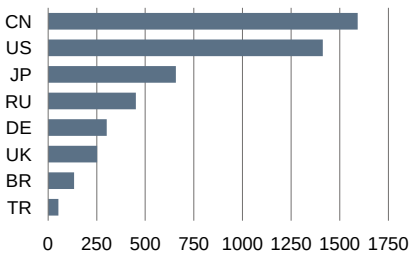
Gross Domestic Expenditure on R&D, growth p.a., in %, 2000-2008



Sources: OECD, DB Research

China - more talents 9

Researchers, '000, 2008



Sources: UNESCO, DB Research

well-financed research environment so that no ground is lost in terms of global competitiveness: R&D expenditure in many countries and businesses is rising, in some cases sharply.

Both well-established and new 'knowledge powers' are increasing R&D expenditure in absolute terms. The US is still way out ahead in this regard (see chart 7). This trend can also be identified from an analysis of the expenditure in relation to growth in gross domestic product.

A more detailed analysis of the growth in knowledge investment – measured in terms of yearly growth rates – clearly shows that this commitment is being significantly increased primarily in emerging markets (see chart 8). This group of countries is very clearly led by China. Russia, South Africa, and Mexico − as well as developed countries such as Australia, Poland, and Austria – are also attaching more importance to R&D and investing accordingly. Particularly in countries such as Poland and Mexico, and also Austria, these aggregate investment figures conceal different growth rates depending on area of knowledge, industry sector or cluster. These more detailed growth rates may be reflected in a better competitive position on the part of the knowledge players concerned. These countries are building up their position in the international knowledge landscape, albeit from a low level compared with developed countries such as the US.

More researchers – new growth in the number of clever minds available for the future

At the same time, the number of researchers is rising in many countries and regions. Clever ideas emerge from clever minds; the training and development of researchers is therefore one of the prerequisites if a country or region is to keep up in terms of global competitiveness. The growth in the proportion of the total number of people in work accounted for by those engaged in research demonstrates that this issue is also a priority for many of the players – countries and private sector businesses alike (see chart 9). Even if the absolute differences are huge, there is a general trend towards an increase in the number of researchers involved in value-adding activities. However, growth in the number of researchers in developed countries has remained relatively steady over the last few years. In view of the investment being made in R&D, many developing countries will probably soon have more researchers at their disposal.

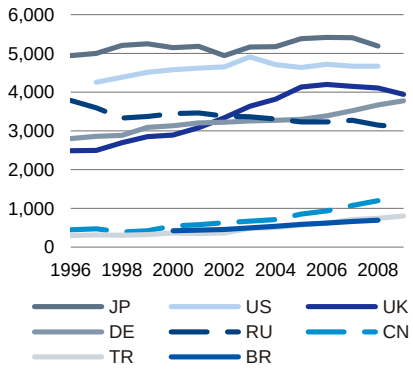
The list of countries investing more heavily in researchers is headed, in particular, by the largest industrialized countries, such as Japan, the US, the United Kingdom, and Germany. However, the trend in China is also striking: In terms of the number of researchers, China overtook the US back in 2007. Today, there are around 1.6 m researchers and academics in China. Over the past few years, the investment in this area has created more than 1 m additional jobs directly focused on knowledge production (R&D). But this trend is not just limited to China (see chart 10). The rising number of researchers in many emerging markets indicates that the regional weighting in terms of both production and use of knowledge will shift increasingly toward Asia.[9] In short: More and more people are earning their livelihood from knowledge and research, which in turn creates the basis for even greater global networking and yet more knowledge production.

[9] Currently, most developing countries have relatively few researchers as a proportion of the total population because these countries only started to invest in knowledge just a few decades ago.

More value creation through knowledge (assets)

More clever people for more knowledge 10

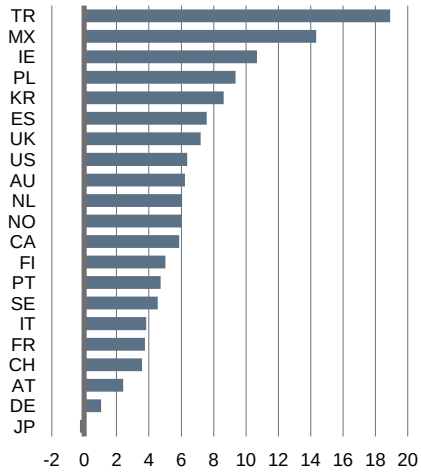
Number of researchers per million of population



Sources: UNESCO, DB Research

Investments in knowledge via education 11

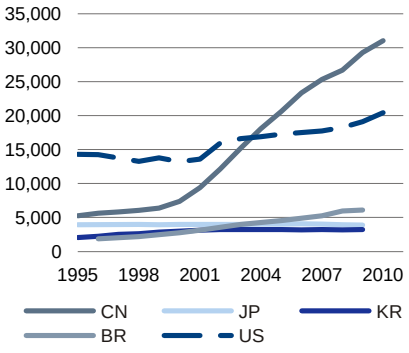
Expenditures on education of private and public institutions, 1998-2008, growth p.a., in %, in local currency



Sources: OECD, DB Research

Student numbers increasing world-wide 12

Total tertiary enrolment, full and part-time, by nation, '000



Sources: UNESCO, DB Research

Knowledge revolution – more investment in knowledge through education

In 2008, the Turkish government stepped up its spending on education by some 19% p.a. on average. Rising education budgets in other countries such as Mexico, Ireland, Poland, South Korea, Spain, and the United Kingdom demonstrate that the relevance of education has been recognized, that knowledge production has been promoted through education, and that the knowledge revolution has been driven forward (see chart 11). These countries are using this investment to enhance their chances of becoming one of the players who shape the knowledge revolution and the global knowledge economy in the future, a development that appears to be more than necessary given their starting positions.

More investment in the next generation of 'brains' – more students …

In the same way that investment in R&D has been interpreted, the growth in student numbers can be interpreted as an increase in the investment in the next generation of able researchers, developers, and therefore knowledge owners. An analysis of the UNESCO data on the number of registered students by country shows that, in 2010, the United States and China had by some distance the greatest growth in the pool of future human capital. At the same time, it is clear that, in past years, China has significantly increased the proportion of its population participating in tertiary education. In 2012, it created the opportunity for more than 30 m students to study in its research and higher education institutions. And this is just the beginning when you take into consideration the plans of the Chinese government and those of other Asian and south-east Asian countries aimed at rapidly raising the current low level of research-based, knowledge-intensive production and the number of knowledge owners (Asian Development Bank 2012: 3 et seq.) (see chart 12).

… who are becoming increasingly internationally mobile

Another factor that becomes transparent from an analysis of the knowledge revolution is that there is a new aspect to the 'global tradition', which has always been a feature of study and knowledge production over the past few centuries[10]: For some time now, study as a path to greater knowledge has no longer stopped at national borders. The next generation of bright individuals has recognized that, in a world characterized by much greater economic globalization, it is also important to experience other countries – and thus acquire local country knowledge, market knowledge, and above all a cultural understanding. This is undoubtedly one of the reasons for increasing international mobility among students. The number of internationally mobile students, i.e. students who are not citizens of the country in which they are studying, has climbed to just under 700,000 in the US, over 360,000 in the United Kingdom, over 280,000 in Australia, and 200,000 in Germany[11] (see chart 13).

A study conducted by the British Council has concluded that China, India, the US, Brazil, and Indonesia will possess the five largest education and research systems in the world by 2020 (British Council 2012). This is hardly surprising as more than half of the global population between the ages of 18 and 22 will be living in these countries by that time. These are vast resources of human capital that will unlock huge potential when activated. The potential for social and

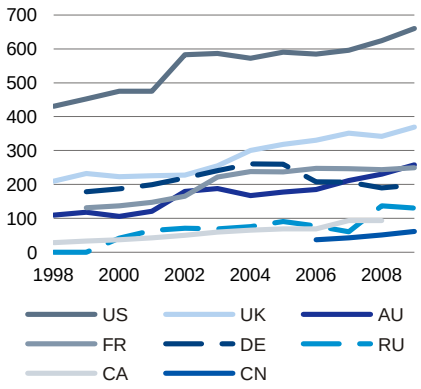
[10] With regard to the globalization of knowledge and implications in historical perspective, we refer simply to the research project of the same name published by the Max Planck Institute for the History of Science. Further information is available at http://www.mpiwg-berlin.mpg.de/de/index.html.

[11] The data for international student mobility varies significantly because the basis of data capture is different from country to country. Despite these differences, the overall trend is unambiguous.

More value creation through knowledge (assets)

Thirst for knowledge quenched abroad - students more mobile internationally 13

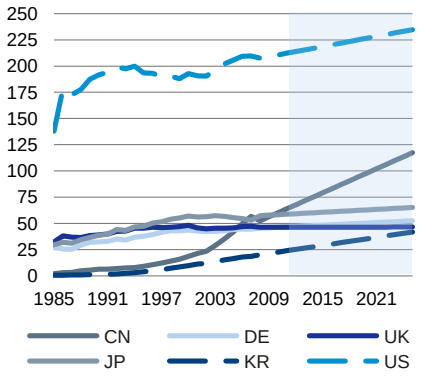
International flows of mobile students at the tertiary level in `000



Sources: UNESCO, DB Research

More knowledge is being produced 14

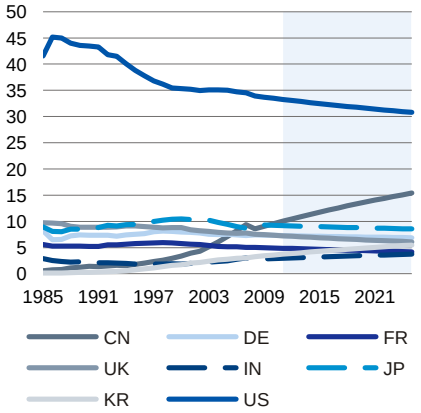
Number of scientific and technical journal articles in '000, nationality of first author



Sources: World Bank, DB Research

Asia catching up through knowledge revolution 15

Share of scientific and technical journal articles, in %



Sources: World Bank, DB Research

economic innovation that can be derived from providing a university education for knowledge migrants has been well demonstrated in the past, particularly by the US, for example with the development of Silicon Valley – ultimately, many of the innovators in Silicon Valley did not originate from the US.[12]

Globally, more output from the knowledge pipeline with country-specific variants

The knowledge revolution can now also be well documented statistically in terms of knowledge output: Over the last few decades, the number of academic research papers published worldwide has risen to reach 960,000 or more than 1.5 m articles (depending on counting method) in 2008 (UNESCO 2011, Royal Society 2011). An analysis of the global proportion of published academic articles accounted for by individual countries highlights that this proportion is characterized by a degree of path dependence and regional circumstances: The current leading research nations remain strong. The US, the European countries, and Japan remain the driving forces in global knowledge production (see chart 14). However, it is also becoming clear that other countries and regions are up-and-coming: There is a shift in knowledge production towards Asia – primarily towards China. Forecasts suggest that this shift will continue: Emerging markets like China are steadily increasing their academic output. As a result, a new knowledge world order is emerging in which the current players are not only being enriched, but also challenged, by the thirst for knowledge and knowledge-related work carried out by people in other regions and countries (see also Royal Society 2011) (see chart 15).

Knowledge economy – more knowledge assets

A knowledge revolution is therefore taking place. But how does the structure differ compared with previous decades? The new feature within the structural change is that more knowledge assets are being created from the knowledge that is generated: The volume and significance of codified knowledge and intellectual property rights is growing, including via more open forms of knowledge production.

Furthermore, more income is being earned from applied innovation activities, such as R&D services, and from trading in intellectual property rights both inside and outside Germany. Since 2010, this has amounted to more than USD 180 bn worldwide with an annual growth rate of 8.8%. But how do you make money out of knowledge? What are the bases on which the knowledge economy is emerging?

Knowledge economy – growth in codified knowledge

One of the bases of the emerging knowledge economy is codified knowledge and the associated intellectual property rights. Just to give some idea of the scale of these developments, there were 7.3 m patents in force at an international level in 2011. Since 2000, there has been a continuous increase in the number of patents issued each year (WIPO 2011: 7.36).

[12] In the period from 1995 to 2005, more than 25% of the technology enterprises in the US were founded by immigrants. In terms of Silicon Valley and the Research Triangle Park (RTP), more than half of the technology companies (52.4%) were established essentially by immigrants who had come to the US from China, Taiwan, India, or Germany in order to study or to complete their studies. Estimates have shown that, by 2005, companies established by these immigrants had been responsible for generating USD 52 bn in revenues and creating in excess of 450,000 jobs (Wadhwa et al 2007: 5).

More value creation through knowledge (assets)

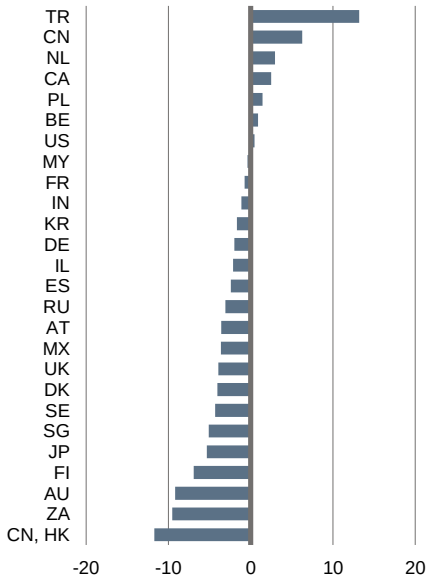
More investment in knowledge, but not always more knowledge assets 16

Given the rise in investment in knowledge, it is interesting as to whether more investment in knowledge also automatically leads to greater production of knowledge assets (codified knowledge). An analysis of R&D intensity, which measures the relationship between the number of registered patents and investment in research and development, shows that there are substantial differences in the utilization of the allocated financial resources. This analysis based on the percentage proportion of patents per USD 1 m of R&D expenditure reveals that a number of countries, primarily Turkey, the Netherlands, and Poland, have been relatively successful in producing knowledge assets from investment in knowledge (see chart 18).

A differentiated analysis of annual growth rates in R&D intensity over the period 2001 to 2009 also shows that some countries managed to increase their 'return on research' over this period: This primarily occurred in Turkey, China, the Netherlands, where the efficiency of the respective research systems was significantly improved on a yearly basis from 2001 onward. These countries were able to increase the production of knowledge assets without having to invest substantially more than previously. This is particularly remarkable in the case of the Netherlands because it would be reasonable to assume that developed countries had already reached a certain level of saturation. The growth in R&D intensity was negative over the same period in Japan, South Korea, and even Germany. Evidently, this saturation can be observed primarily in industrialized countries where investment in knowledge is already at a high level (see chart 17).

Knowledge assets from R&D spending 17

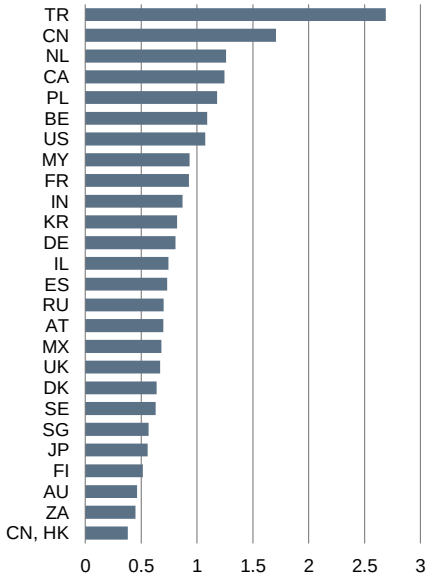
Patents per millions USD of research and development expenditure, growth p.a., in %, 2001-2009



Sources: WIPO 2011, DB Research

Knowledge assets from R&D spending 18

Share of patents per million USD of research and development expenditure, change in %-points, 2009 to 2001



Sources: WIPO 2011, DB Research

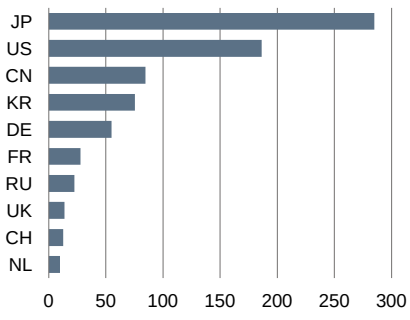
Dynamic growth in knowledge assets – principally in China and South Korea

An analysis of growth in patent applications and patents issued in the last few years highlights that the pace of growth in the protection of intellectual property rights, particularly as regards patents, varies considerably from region to region around the globe. In 2010, Japan, the US, and China could lay claim to by far and away the greatest proportion of codified knowledge based on absolute figures. Japan could rightly claim to be playing a key role in knowledge production with almost 300,000 patents (see charts 19 and 21).

However, Japan is no longer keeping up in the international race for more protected knowledge (knowledge assets) in innovative sectors of the economy, as is demonstrated by the trends in China and South Korea. These trends are reflected in the annual growth rate for patents in important areas of technology (for example, (technical) instruments (MEMS, sensor technology), electrical engineering, mechanical engineering, and chemicals) (see table 20 and chart 21). The high pace of growth in Asia in relation to knowledge assets in core areas of technology and science indicates that China and South Korea have caught up with the club of nations that have previously dominated innovation. It is only a matter of time before China also overhauls Japan and other developed countries in absolute terms, becoming the leading patent power with all the implications that could conceivably entail for the knowledge world order.

Asia starting to set the tone when it comes to protected knowledge 19

TOP 10 countries of origin (patent offices), granted patents in 2010, in '000



Sources: WIPO 2011, DB Research

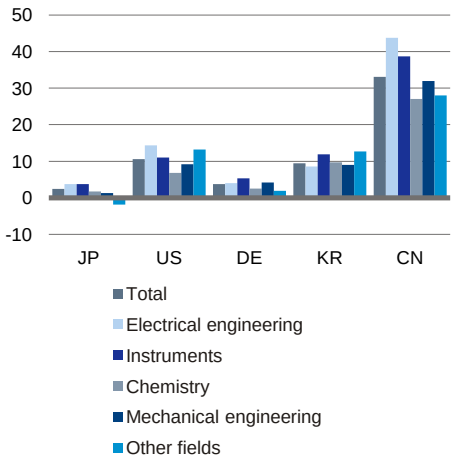
Knowledge assets – more new trademarks and 'Made in Germany'

The slowly emerging knowledge economy is manifesting itself not only in the form of patents as intangible property rights, but also clearly in the growth of registered trademark rights: In 2010, more than 18.1 m trademark rights in force worldwide and this number is steadily growing. In excess of 3.16 m trademarks were registered in 2011 alone (WIPO 2011: 105, 150 et seq.).

More value creation through knowledge (assets)

Dynamic growth in Asia for technically-oriented knowledge assets 21

Patent applications by field of technology, growth p.a., 2000-2009



Sources: WIPO 2011, DB Research

China and South Korea – the sprinters in the race for knowledge assets 20

Patent applications by sector, percentage year-on-year change, 2010

	Total	Electrical engineering	Instruments	Chemicals	Mechanical engineering	Other
US	10.6	14.31	11.02	6.79	9.22	13.22
DE	3.72	4	5.36	2.52	4.16	1.88
KR	9.46	8.55	11.86	9.72	9.05	12.7
CN	33.03	43.79	38.67	27.05	3.,97	27.95

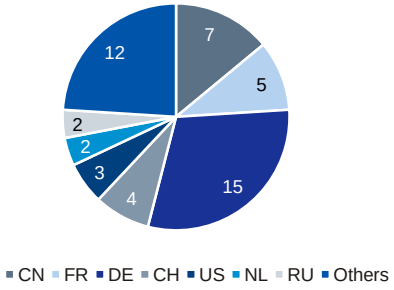
Sources: WIPO, DB Research

German companies are particularly responsible for registering many of these trademark rights: Of the 50 institutions or companies registering the greatest number of trademarks at an international level in 2010, 15 came from Germany (WIPO 2011: 105). 'Made in Germany' is therefore being protected and exploited as a knowledge asset (see chart 22).

When the growth in trademark rights is analyzed more closely, it becomes clear that China is beginning to play an important role in this area of the knowledge economy too. Even though companies and institutions in Europe, Germany, the US, and Switzerland account for a large proportion of the trademarks registered globally, the momentum is also becoming evident in this area of activity: In 2010, every third trademark right was registered by a Chinese company or a Chinese institution (see WIPO 2011).

Made in Germany - an asset 22

Filed Madrid Applications, country of origin of TOP 50 applicants, 2010



Sources: WIPO, DB Research

Knowledge economy: New products and solution-oriented design

New knowledge-intensive products represent another of the key elements making up the foundations of the knowledge economy. Fine tuning and solution-oriented design, together with processes of combining and recombining knowledge, is transforming more knowledge into new products and also increasingly into services. Nowadays, customers – be they retail customers or businesses – are no longer interested in buying technologies alone, i.e. technologies that they then have to adapt to their own processes. Rather, they are looking for ready-made one-stop solutions. In other words, they want to become more efficient and effective through integrated services. For example, this is the case in vehicle manufacturing and associated robotics where the emphasis is now on integrated production lines that have already been planned as such and are fully functioning rather than 'just' on individual machine tools and production robots, i.e. the actual individual technology products themselves.[13] From a statistical perspective, these hybrid products represent a challenge. This is because there is little reliable data relating to these new solutions which represent complex bundles of technologies and services (see Kempermann/Lichtblau 2012).

More knowledge – more knowledge-intensive product design and products

The sharp rise in the number of registered industrial designs and utility models[14] indicates however that product innovation and solution-oriented product design are key activities of today's businesses in the knowledge economy. Some of the industrial designs and utility models that are now registered are no longer simply restricted to products themselves, i.e. individual technical artefacts, but tend to comprise combinations of products and services, as in the case of prefabricated

[13] Similar examples can be found in relation to integrated medical operating solutions (integrated operating theatres in place of minimally invasive devices 'alone') or real estate development solutions (operator models with integrated buildings management services in place of 'just' materials, building technologies, and construction work).

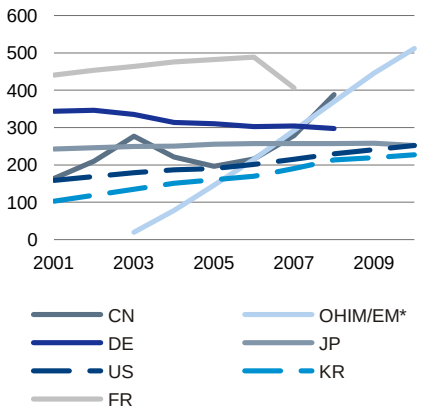
[14] For a detailed definition of industrial designs and utility models, see the WIPO website.

More value creation through knowledge (assets)

"Created in Germany and Europe"
Europe & Germany great in product design

23

Industrial Designs in force by office and reporting year in ´000



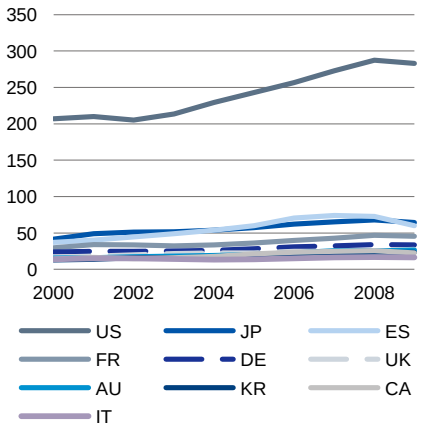
*EM: European Market

Sources: WIPO 2011, DB Research

Top 10 countries by knowledge assets

24

'Fixed intangible assets' in USD bn

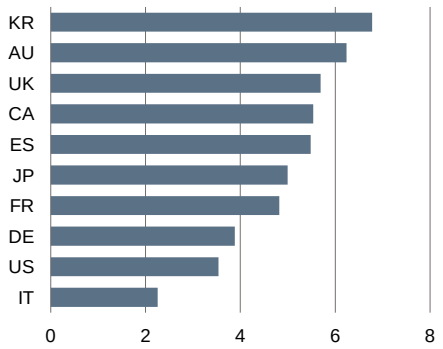


Sources: WIPO, DB Research

Substantial growth in intangible assets

25

Yoy-growth rate of fixed intangible assets, in %



Sources: OECD, DB Research

housing. To a growing extent, businesses are also dependent on being able to market 'hybrid' solutions. This determines their performance to a certain degree.[15]

The frequency of applications for industrial property rights to protect solutions and ideas encapsulated within products is increasing: In 2011, some 1.65 m registered industrial designs and utility models became legally valid worldwide following applications for the protection of intellectual property rights submitted to 56 offices (WIPO 2011: 179). Just as in the case of other types of knowledge assets, this reflects a sharp upward trend in the number of registered industrial designs and utility models. This rise was particularly apparent in 2009 and 2010. In 2010 alone, 650,000 industrial designs and utility models were registered (WIPO 2011: 154). Interpreted a different way, more and more products are being developed on the basis of new knowledge or as a result of recombining existing knowledge. This solution-oriented knowledge converted into products and services is then also protected.[16]

The growth in product-oriented knowledge assets demonstrates that some countries, such as the US, some European countries, and first and foremost Germany, are maintaining their current role as trailblazers in the knowledge economy: There is an overall trend in favor of 'Designed in Germany' and 'Created in Germany' as well as 'Made in Germany' across all categories of products (see chart 23). Of the 50 largest companies that register industrial designs under the system established by the Hague Convention on the International Registration of Industrial Designs, 17 originate and have their head offices in Germany (WIPO 2011: 176-177).

From knowledge to intangible assets

The production and commercial exploitation of innovative ideas is increasingly becoming an important economic factor.[17] The methods for capturing data on this economic factor are still in their infancy because most businesses and public-sector organizations do not comprehensively record or account for their investment in knowledge, that is to say in education, research & development, and/or in knowledge technologies (software and process engineering). Nevertheless, statistical data on trends in the trading of licenses and intellectual property rights does point to growth in the knowledge economy (see WIPO 2011: 60-63).

Knowledge economy – more international trade in knowledge

Indications that growth in the knowledge economy is gathering pace and that knowledge-based activities, together with human skills and expertise, are becoming an important (and measurable) means of value creation are provided

[15] Given the highly complex nature of the data on registered industrial designs and utility models (in terms of the diversity of product categories, and in relation to the issue and the enforcement of registered industrial designs and utility models), it is not that straightforward to offer any statements on the relationship between (product) design activity, the protection of these designs, and commercial exploitation. Some studies indicate that (product) design activity makes a significant contribution to the value creation process in national economies. This seems plausible but it is not something that we intend to examine in more detail here.

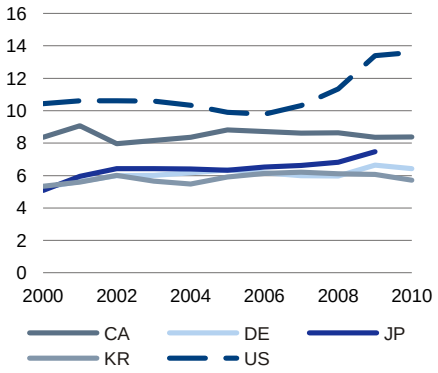
[16] Unfortunately, only a small number of statistically measurable conclusions can be drawn in relation to the development of hybrid products based on the growth in utility models. Given the specific nature of hybrid solutions in terms of the associated intellectual property rights, these solutions fall between different protection systems and areas of protection. In the context of this study, we can only state that the system of intellectual property rights will have to be subject to significant further development over the next few years and this development will very much depend on the innovations in technology and business practices that come about in this time.

[17] International, economic comparisons of intangible assets are only possible with severe limitations because of the substantial differences in the methods used for gathering, recording, and assessing asset data.

More value creation through knowledge (assets)

Growing significance of intangible assets in the US 26

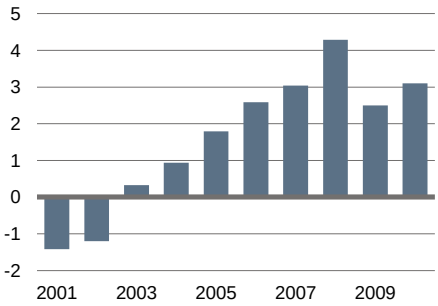
Share of 'Intangible assets' on gross fixed capital formation, in %



Sources: OECD, DB Research

Germany a net R&D exporter 27

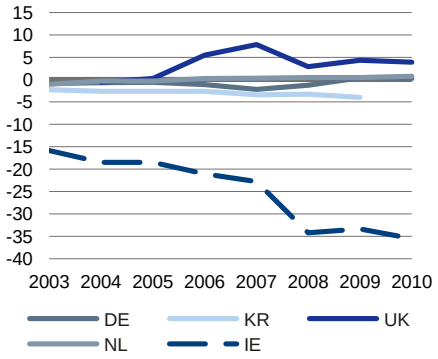
Balance of trade in R&D services , USD bn



Sources: UN, DB Research

Knowledge imports and exports 28

Balance of trade in royalty fees, USD bn



Sources: UN, DB Research

by an analysis of financial statements published by businesses, principally the figures covering income and expenses related to licenses: Many businesses are now selling more licenses abroad or are increasingly buying in license rights.[18]

International royalty and licensing fee receipts (recorded on a nominal basis) have risen faster than global economic growth (from USD 27 bn in 1990 to more than USD 85 bn in 2000 and more than USD 180 bn in 2009).

Knowledge economy gains a foothold worldwide

It is interesting that the knowledge economy is extending to cover an increasing number of countries: In 1990, only 62 countries were behind the use of intellectual property rights, but by 2007 this number had already increased to 147 countries. Whereas only 43 countries received license payments in 1990, this number had swelled to 143 by 2007. In the period from 2000 to 2009, the most significant development in this area was seen in Brazil, Russia, India, China, South Africa, Ireland, South Korea, and in eastern European countries.

Although the developed countries still continue to be the primary beneficiaries, accounting for over 99% of the cash flows from intellectual property rights, the other countries are slowly catching up. There is still a good deal of impact from path dependency because, as yet, the vast majority of license payments continue to be derived from growth in manufacturing industry. However, this growth is now being replaced by the increasing trade in knowledge-based or knowledge-intensive services (see WIPO 2011: 63).

Germany – from knowledge importer to knowledge exporter

Germany is benefiting from this growth in the knowledge economy: Whereas the German balance of trade at the start of the new millennium still showed a deficit in R&D services, since 2003 Germany has consistently exported a greater value of licenses, trademark rights, and R&D than it has paid to import foreign expertise in a variety of forms (see chart 27).

Germany is profiting not only from its industrial strength but also from the application-oriented creativity of its smart minds: In 2010, the country earned more than USD 3 bn from exports of R&D services, in contrast to 2001 when Germany still had to pay out USD 1.4 bn to import these services. It also generates net receipts of some USD 270 m from trading in licenses.

A similar trend from importer to exporter of knowledge can be seen in the United Kingdom since 2005, in the Netherlands since 2006 (see chart 28), and in France since 2007, with Finland in the vanguard of these developments since back in 2001. To date, other countries such as India, Ireland, South Korea, Australia, and Canada have remained net importers. Germany's excellent positioning in the market for knowledge-intensive services has also motivated non-German companies to invest in R&D in Germany (see Lehnfeld 2012).

Accumulation of wealth through knowledge assets

Besides direct license income measurable as a monetary amount, knowledge and knowledge assets also give rise to other wealth measurable in monetary terms that is included in macroeconomic statistics.[19]

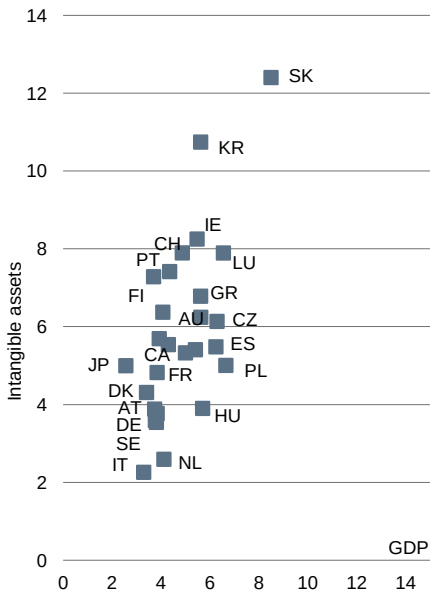
[18] Unfortunately, the United Nations only reports data from a few countries under the 'royalties and license fees' indicator, which is why it is difficult to draw any conclusion about the global growth in the volume of knowledge exports and imports.

[19] Given the lack of data on knowledge assets and their monetary value, these figures from the macroeconomic statistics of various countries only offer a general pointer, of course. It is reasonable to assume that the accumulation of wealth through knowledge assets is already more significant than indicated by the data.

More value creation through knowledge (assets)

Intangible assets growing faster than GDP 29

Scatterplot of GDP-growth rates and fixed intangible assets, in % p.a., 2000-2009



Sources: OECD, DB Research

Knowledge-intensive service providers – winners in the knowledge economy 30

In the structural change involving knowledge and the knowledge economy, a number of sectors are becoming more important. These sectors include the service providers who act as researchers & developers on behalf of businesses or other customers and offer architecture and other inspection and testing services. These service providers are the 'new alchemists'.

This upward trend is reflected by the revenue growth in the knowledge-intensive segments of R&D, architecture and engineering consultancy, and technical, physical, and chemical inspection services.

In 2009, Germany generated revenue of approximately EUR 9 bn from knowledge-intensive R&D services. This represents almost a threefold increase on the equivalent figure for 2000. Revenue growth in architecture and engineering consultancy, and in technical, physical, and chemical inspection is also relevant. Germany generated revenue of more than EUR 50 bn from services in these segments. Even though these segments are cyclical, the average annual growth rate in the period from 2005 to 2009 was 6.7%. As the growth rate was sustained at a high level over an extended period, it would be reasonable to assume that this alchemy in which profitable services are created from expertise, i.e. knowledge and skills, will continue to grow in economic importance (see chart 31).

An analysis of the global growth in intangible assets (based on OECD data) clearly highlights that the value of knowledge production worldwide measured in terms of intangible assets is increasing steadily. For example, the value of the stock of knowledge held by the US (measured on the basis of intangible assets) amounted to EUR 283 bn in 2009. This equated to almost 50% of the aggregate intangible assets for the entire world.[20] In 2009, the value of national intellectual property was USD 64 bn in Japan, USD 33 bn in Germany, and USD 23 bn in South Korea (see chart 24). The knowledge revolution in conjunction with the emerging knowledge economy is therefore not only making countries richer in knowledge. Rather more significantly, it is also allowing these countries to build up assets with a monetary value.

Almost all countries are accumulating a greater wealth of knowledge, this development being most noticeable in nations specializing in high-tech products (such as South Korea) and in the other industrialized countries (see charts 24 and 25). One point particularly worthy of note is that intangible assets have been growing faster than the economy. Chart 29 shows a comparison between the average annual growth rate in the value of intangible assets and the average annual growth rate for GDP in selected countries over the period from 2000 to 2009. The chart clearly shows that intangible assets grew faster than the rest of the respective national economy in almost all cases.

New types of collaboration are helping to foster the knowledge revolution and knowledge economy

What is helping to nurture the growth in the knowledge economy and what are the vehicles for this growth? The knowledge revolution and the emergence of the knowledge economy is being promoted primarily by the fact that new information, communication, and knowledge technologies are allowing very many more people, researchers, and organizations to collaborate closely with each other around the globe. They are in a position to create more knowledge and knowledge assets through this interaction and collaboration. The spread in internet usage and methods of disseminating information and knowledge that are now practically free of charge, together with the increase in the number of options for processing knowledge, will continue to drive forward this structural change in knowledge as a resource.

Global academic collaboration propels the knowledge revolution

At the beginning of the second decade of the 21st century, researchers from different continents are able to work together on academic publications and in this way create knowledge. The number of academic publications with more than one author is therefore increasing steadily.

At the same time, we are seeing the publication of a much greater number of articles arising from collaboration between researchers in different countries and parts of the world (see Royal Society 2011 and Schneegans 2011). It is estimated that more than a third of all the articles published worldwide result from collaboration between researchers from different countries (see British Council 2012).

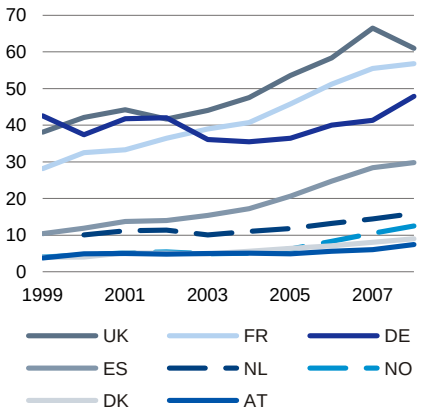
Furthermore, studies by the British Council indicate that international collaboration between researchers in teams aimed at publishing an article also have a very positive effect on the academic impact of this article: Around 80% of a country's research impact – measured on the basis of citation frequency – can

[20] This is the aggregate figure for all countries for which data is available. No pricing adjustments have been applied.

More value creation through knowledge (assets)

Experts in converting knowledge into services and money 31

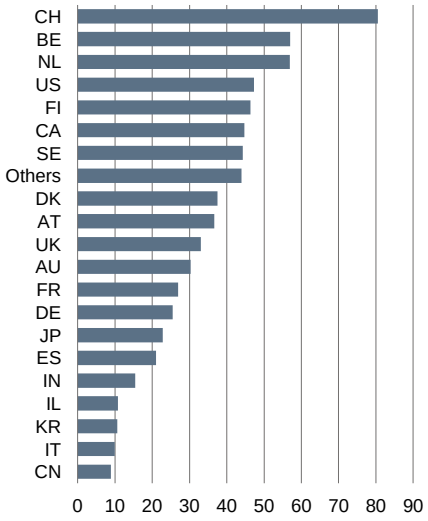
Turnover in EUR bn of architecture- & engineering offices; techn., phys., chem. research



Sources: Federal Statistical Office, DB Research

Patents with international teams of inventors are widespread 32

Share of patent cooperation treaty applications with at least one foreign inventor 2010, in %



Sources: WIPO, DB Research

be directly attributed to the extent of their international research collaboration. In addition, research papers from international co-productions generate a significantly higher citation rate than research from 'just' one country. This also indicates that papers arising from international collaboration are of a higher quality (see British Council 2012).

More knowledge assets from more global collaboration

The impact from international collaboration and from better communication and networking opportunities for researchers is not just limited to academic article output. Global academic collaboration is also increasingly leading to more knowledge assets. This is reflected in the number of patent applications in which at least one of the inventors is from a different country. For patents submitted under the PCT (Patent Cooperation Treaty), the proportion of patent applications with at least one foreign co-inventor increased from 9.2% in 1990 to 25.3% in 2010.

A more detailed analysis shows that researchers from countries such as the US, but also primarily from smaller countries – with Switzerland leading the way – are focusing on international collaboration. A country can strengthen its innovative capabilities by exploiting international networking opportunities and actively encouraging its own researchers and students. International collaboration can ensure that materials in short supply are used more efficiently, but also provide new stimulus and ideas. All the parties involved therefore gain from this collaboration. Many of the countries benefit from the mobility of researchers, students, ideas, and innovations. This international exchange allows knowledge owners – individuals and institutions – to achieve a degree of excellence such that the knowledge produced can be protected as a knowledge asset, that is to say in the form of a registered patent (see chart 32).

Knowledge economy driven by collaboration and project-based activities involving business, academics, and policymakers

An analysis of the vehicles for the knowledge revolution and knowledge economy reveals that the growth in this sector is being stimulated by close and more open project-based types of collaboration between businesses (companies), academics (public research organizations, universities), and in some cases also policymakers.[21]

The political players become highly significant in this process primarily when there is a need to shape the financial and organizational frameworks – which is best done in accordance with the principles of democratic legitimacy, subsidiarity, and proportionality – and also provide the momentum (in accordance with the same principles) for funding and implementing education, research, and development activities. They can provide a sound statutory basis so that the various players can act independently, knowledge-oriented, and with an entrepreneurial approach in the knowledge economy.[22] However, the real driving forces are, in particular, the universities, public research organizations,

[21] By some way the most difficult area of the knowledge revolution and the knowledge economy in which to capture data is the area of application or knowledge processing (throughput) because data capture relating to the procedures, working methods, and thinking of the relevant players is still in its infancy. For example, there is no end-to-end data capture relating to the projects undertaken by the various players. For this reason, our statements in this paper should be treated as an illustration of a trend identified by anecdotal evidence and a small number of proxy indicators.

[22] Higher education institutions, for example, can only work successfully over the long term in close, project-based collaboration with businesses and generate more knowledge if they are also given the necessary degree of autonomy and flexibility by their political masters. This also applies in respect of the instruments for funding and development.

and other knowledge pioneers who shape knowledge production and the speed of knowledge creation with the organization of their research activities.

The structure of the knowledge revolution in each country, region, or area depends on the types of collaboration between these driving forces and the other players, such as businesses, public-sector organizations, or social institutions.

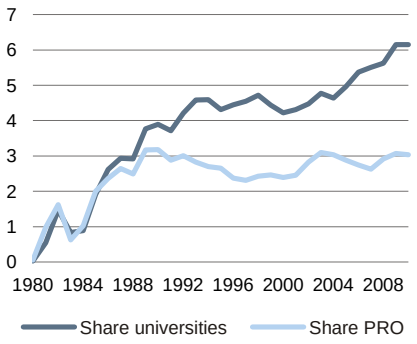
Innovative enterprises in the knowledge revolution focused on knowledge assets and the knowledge economy

Whereas the traditional players in the area of knowledge – universities and public research organizations – are fueling the knowledge revolution through their research and publications, it is evident that it is innovative enterprises that are primarily advancing the knowledge economy itself. Although businesses also carry out research to an increasing extent – and businesses also play an important role as a provider of investment and impetus for new research process innovations, for example in the refinement of knowledge technologies[23] – it can be stated in general terms that businesses are focused first and foremost on creating more knowledge assets and knowledge-intensive products in line with the purposes of the businesses concerned. This is also reflected in the high number of applications for intellectual property rights submitted by businesses (see WIPO 2011).

Production of knowledge assets by higher education institutions and public research organizations

Public research organizations (PRO) & universities gain relevance 33

Percentage share of total patent cooperation treaty applications, TOP 30 countries of origin



Sources: WIPO, DB Research

However, an analysis of patent registration activity highlights that higher education institutions and research establishments are starting to play a more important role. This is particularly true in the US and other developed countries (such as Germany, France, and Finland), but does also apply in newly developed countries (China) and emerging markets. Universities and research organizations are also being forced to take patenting and knowledge-protection activities more seriously as a result of changes in the overall political requirements (such as the need to furnish greater evidence of productivity by registering patents) and the close, project-based types of collaboration with businesses and other academic players.[24]

A cultural shift is taking place in higher education institutions and research organizations in which these institutions are beginning to attach greater value to knowledge assets. This is partly due to the collaboration with businesses on the basis of projects and contractual agreements. The production of knowledge assets, i.e. patenting and standardization strategy, is becoming an urgent strategic issue that university managers are now attempting to address. This is also reflected in the statistics, which show that there is a worldwide increase in the importance of creating knowledge assets by public research organizations and universities. Universities and public research organizations are beginning to expand the range of their impact in the knowledge economy and, although this is still at a modest level, the growth rates and potential are significant (see tables 34 and 35).

[23] Many businesses are having to cope with steadily increasing volumes of data and more specialized knowledge, so they are continuously investing in, developing, and/or using new knowledge management and learning solutions for their businesses. They are also sharing these knowledge process innovations with partners (universities, research establishments, and others) and are therefore helping to improve the production, processing, and dissemination of knowledge.

[24] It should be noted that almost all German federal states have established in some form or another (and with varying degrees of success) institutions for the commercial exploitation of patents. These institutions have been set up in universities and/or for the benefit of universities. In this context, the universities are expected to exploit knowledge and create knowledge assets that have not yet been protected.

More value creation through knowledge (assets)

As demonstrated by the proportion of patent applications submitted either individually or jointly by universities and public research organizations (such as Fraunhofer and the Max Planck Society in Germany, see table 35), both public research organizations and universities are becoming more important as regards innovative activities and the knowledge-based (production) economy (see chart 33).[25]

Universities – one of the cradles of knowledge assets 34

University	Country	Number of patent applications in 2010
University of California	US	306
Massachusetts Institute of Technology	US	145
University of Texas System	US	130
University of Florida	US	107
The University of Tokyo	JP	105
Harvard College	US	91
Columbia University in City of NY	US	91
Johns Hopkins University	US	89
University of Michigan	US	79
University of Pennsylvania	US	75

Knowledge assets generated with the view to commercial and societal gains 35

Public research organization	Country	Patent applications in 2010
Fraunhofer-Gesellschaft	DE	298
Spanish National Research Council (CSIC)	ES	126
Netherlands Organization for Applied Scientific Research (TNO)	NL	116
National Institute of Advanced Industrial Science and Technology	JP	91
SNU R&D Foundation	KR	86
Mayo Foundation For Medical Education and Research	US	60
Max Planck Society	DE	57
Council of Scientific and Industrial Research	IN	56
Battelle Memorial Institute	US	50
VTT Technical Research Centre of Finland	FI	48

Sources: WIPO, DB Research

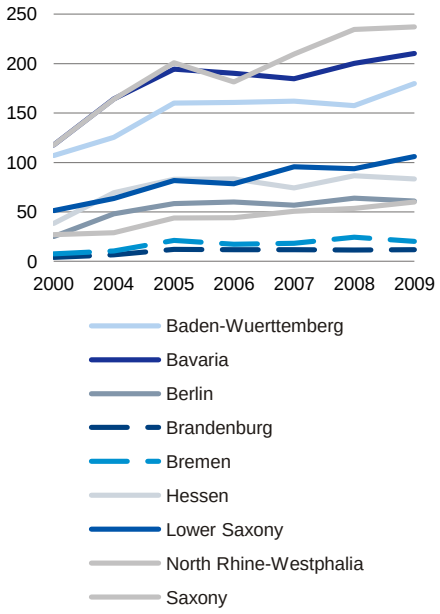
Public research organizations and higher education institutions are becoming one of the integral components of the international knowledge revolution and knowledge economy, whereby they are becoming more important as an economic contributor to the locality concerned (be that a country, region, city, or area) in addition to their role as contributors to a greater wealth of knowledge from a cultural and social perspective. In many cities, public research

[25] The proportion of total patenting activity accounted for by universities and public research institutions appears to be relatively modest at under 10%. When interpreting this data, care must be taken to note that, first, it does not include patent applications submitted jointly with businesses. Secondly, many of the patent applications submitted by researchers and higher education/university faculties in their spin-off activities or other posts are not included either. Thirdly, many universities in Germany for example, together with their political masters (the German federal states), only began to develop expertise in the commercial exploitation of patents from the middle of the 1990s onward. Finally, when classifying the data, it should be borne in mind that many academic players in the knowledge market decide – as do many small and medium-sized companies – not to apply for protection of their intellectual property rights because of the high costs involved in patent applications, the issue of patents, and also the enforcement of patent rights. They transfer these rights to partners such as businesses (in return for or without compensation for this transfer of rights). The actual trend should therefore be interpreted more in terms of its structural significance, rather than focusing on the particular figures showing the proportion of patents accounted for by academic institutions.

organizations and establishments and universities are now already major employers and centers of economic and social value creation because they are undertaking research and development activities as part of the project economy, including such activities based on contracts and third-party funding. In addition, their programmatic focus on innovation and their education and training activities are ensuring that the next generation is well prepared to reap the potential rewards and take on its responsibilities in the knowledge economy.

Business2Science increasing in Germany 36

Third-party funds from industry to universities
EUR m



Sources: Federal Statistical Office, DB Research

'Open', project-based knowledge transfer drives the knowledge economy

Since businesses can often no longer promote innovation alone owing to the steadily growing intensity of knowledge and the increasing specialization of knowledge and skills, businesses are now increasingly following the US model and integrating universities and research organizations of different kinds into their development, testing, and marketing processes if they want to develop marketable knowledge-intensive solutions quickly. They open up their innovation processes and now develop new products and processes in close collaboration with partners, even in some cases on the basis of structured, project-based knowledge transfer.

Using third-party funding, they issue research and development contracts to universities and public research organizations or, in some cases, even outsource entire research and development tasks to these players (see chart 36).[26] This closer form of collaboration leads to cross-fertilization between public research organizations (which are in any case focused on long-term innovative activities), higher education institutions, and businesses.

When innovation processes are opened up in this way, the result is that more players become involved in knowledge production, more knowledge is produced faster, and this knowledge is then also converted into knowledge assets. Innovation processes are opened up by running competitions and awarding prizes, with ideas for solutions being suitably rewarded. Businesses also create platforms with other businesses (partners and suppliers) or customers so that they are able to work in closer collaboration even as knowledge and knowledge assets are developed.

Close correlation between knowledge assets and open collaboration

One of the points that is clearly evident from an analysis of open innovation processes is that, in all the cases we have described and also in other methods of open innovation (see WIPO 2011: 47-49), there is a close correlation between the protection of intellectual property and the creation of knowledge assets; indeed, the two are complementary. In the case of competitions or awards, the terms and conditions of participation include assurances or transfers of rights and quasi-contractual agreements covering any knowledge assets that potentially may arise. Prior contractual or other arrangements are also included in contractual provisions, such as those in agreements with other players covering the purchase or outsourcing of knowledge-intensive services. Platforms on which various players join forces in order to allow the reciprocal use of their knowledge assets by others and thereby design new customer-focused solutions do not work without some kind of provision addressing the recoverability of the value of the knowledge production and a breakdown of the gains. Even well-managed open innovation communities (for example, primarily communities of practice) are based on a complementary relationship between knowledge assets and intellectual property rights (see WIPO 2011: 49). In these

[26] For an overview of open innovation, forms of knowledge transfer, and their advantages and disadvantages, also as regards patenting and licensing activities, see Athreye/Yang 2011: 5, 11 et seq., and WIPO 2011: 47-49.

communities too, contractual provisions or even informal rules govern the distribution of the future expected gains derived from the knowledge assets that are created (gain-sharing models). It appears that, above all, it is faster and more efficient to develop and successfully market solutions in close collaboration with other players as part of projects and programs if there are clear rules covering the issue of the knowledge assets and how the income derived from the knowledge is to be treated.

Emerging networks as a cornerstone of the knowledge revolution and knowledge economy

This rise in collaboration among businesses themselves, with customers, and also increasingly with public research organizations and universities is leading to the creation of global knowledge and value-creation networks. Often, the players in existing global production and innovation networks, i.e. the long-term forms of supplier relationships and collaboration between various players,[27] are now no longer able to avoid the need to closely integrate universities and research-based institutions. The advantage of involving these knowledge-intensive players is that, particularly in the early phases of product development processes, businesses can integrate very specialized knowledge and skills (e.g. in the area of materials research) into the production processes. They are thus able to develop new categories of products faster and better than before. With increasing frequency, innovative universities and research organizations within these newly emerging associations focusing on knowledge production and value creation provide the momentum for businesses to step up their involvement in the development of new solutions and products. In this way, it is possible for universities – based on long-term research funding and project-oriented collaboration, together with access to the training of talented young people – to continue to develop the foundations of the knowledge economy and help regions to prosper (see Rollwagen 2010).[28]

Cluster-based knowledge revolution in knowledge powerhouses

A more detailed analysis of the patterns followed by the knowledge revolution and the current spread of the knowledge economy based on the creation of knowledge assets at a regional level shows[29] that regions are involved in a knowledge race at the level of commercial enterprises and research organizations. As a result of this race, the extent to which the knowledge revolution is taking hold in different regions of the world varies considerably and activity is concentrated in regional clusters. Some astonishing changes are taking place. Whereas Japan was previously the trailblazer, this role is now being taken over by the US and increasingly also by China and South Korea: In the period from 1983 to 1990, 60% of the global growth in patent registrations was accounted for by Japanese developers and inventors, but this proportion then fell to just 12.3% between 1995 and 2008. Over the same period, US research and development establishments steadily increased their number of patent applications, as did businesses and institutions in China and also South Korea.

[27] In particular, studies carried out by Ernst on models of production and value creation in the electronics industry have demonstrated that advances in informatization have been accompanied by the dawn of a new phase in global collaboration, in which collaboration is taking place using worldwide production and innovation networks (see Ernst 2009).

[28] A prestigious international example of this is the German public research organization Fraunhofer, which has enjoyed a huge amount of success in developing new technology fields and solutions in joint research, piloting, and development projects with businesses and non-commercial players.

[29] This analysis broken down by regions and agglomerations with major cities as focal points was carried out on the basis of patent data from WIPO because a regional analysis of issued and patents in force, published articles, trademarks, and utility models would have extended beyond the limitations of this investigation.

One of the most noticeable features in these developments is how the speed of growth varies from country to country and within countries themselves. This is leading to the emergence of a group of standout regions, which are ahead of the pack as far as knowledge assets are concerned.

Knowledge revolution concentrated in individual countries and regions

In order to assess the varying regional growth in the production of knowledge assets, we have analyzed the regional distribution of patents. This analysis highlights that existing centers of knowledge remain important even today.

In terms of the production of knowledge assets, regions of particular significance are as follows: in the US, the 'Golden State' of California; in Japan, principally the metropolitan areas of Tokyo and Osaka; in Germany, first and foremost Munich and Bavaria together with Stuttgart and Baden-Wuerttemberg; in France, a cluster around Paris; and also Taiwan.

However, the increase in knowledge-based, structural collaboration between players from politics, business, and academia in a large number of regions around the world is also giving rise to new 'knowledge powerhouses'. New centers for the production of knowledge assets are emerging, for example, in China in Shenzhen (Guangdong province), South Korea in the Seoul agglomeration, in the city-state of Singapore, in Poland around Warsaw, Wrocław and Kraków, and in Turkey in the metropolitan area centered on Istanbul.[30]

More 'small knowledge powerhouses': a new 'world order of knowledge' is emerging

As the knowledge revolution advances, more regions are securing a long-term share of the growth in the knowledge economy. An analysis of the growth of regions accounting for more than 100 patent applications reveals that more 'small knowledge powerhouses' are being created:[31] In China, South Korea, and Canada some regions, for example, are developing rapidly to become new centers of knowledge asset production. This is leading to a noticeable transformation in the world order of knowledge. Emerging economies such as Malaysia, Mexico, Indonesia, and some South American and African regions are becoming more important based on the high level of dynamic growth in the region concerned; individual agglomerations are becoming established as small, regional knowledge powerhouses with a significant spillover effect into their respective surrounding areas.

Growing through knowledge and knowledge assets

As demonstrated by the previous analysis, more knowledge is being created worldwide on a collaborative basis and in different ways. Some of this knowledge is also being transformed into knowledge assets more quickly, on the basis of which businesses and institutions are earning income. Sustained investment in

[30] The degree of centralization in the production of knowledge assets varies substantially from country to country depending on how research policy and the promotion of research is organized; it is also a function of the regional, structural, and economic circumstances of the country concerned, and the path taken by the country as a result of industrialization. Germany, for example, has a multifocal approach with patents registered and knowledge assets created in many of its regions or federal states, whereas the growth in China and Turkey, for example, is concentrated in just a few regions, provinces, and cities.

[31] It should be noted that any such assessment is subject to limitations because only a small amount of reliable data is available for many of the emerging regions. Furthermore, countries with potential as far as the knowledge economy is concerned, such as Mexico, Indonesia, Brazil, Malaysia, and Turkey, do not yet stand out in the statistics because patenting activity by businesses, public-sector research institutions and universities is only just beginning and these countries are still very much catching up in converting knowledge to knowledge assets.

Regional knowledge powerhouses 37

Region	Country	Number of patent applications in 2010
Tokyo	JP	8914
Osaka	JP	4821
California	US	3586
Bavaria	DE	3240
Baden-Wuerttemberg	DE	2793
Seoul	KR	2335
Paris	FR	2334
Singapore	SG	2017
Shenzen	CN	1914
Amsterdam	NL	1435

Sources: WIPO, DB Research 2011

R&D, training and professional development as well as changes in the forms of knowledge production and in the transformation of knowledge are now resulting in a shift in the world order of knowledge, a process that will continue over the next few years. Businesses, regions, and countries now have the opportunity to benefit from their investment in their knowledge pioneers – students and researchers in education and research organizations – and in public-sector organizations as well as in the businesses themselves, thereby improving their positioning in the knowledge economy. They are benefiting from the fact that they are encouraging the various players to collaborate and that they are creating the foundations for this collaboration with robust policy-making focusing on the long term.

Against this background of changes taking place around the globe, it is conceivable that business people, businesses, education and research organizations, regions, or countries ought to develop an even greater range of strategies in relation to their partnerships and collaboration with other players and countries in order to make the most of the opportunities presented by the knowledge economy.

Knowledge revolution continues through new knowledge and learning technologies

As information and communications technologies, together with knowledge and education technologies, continue to develop, there will be further fundamental changes over the coming years in the general parameters applicable to the range of different knowledge development and knowledge exploitation strategies and 'smart growth' in regions.

It is clear that an increasing proportion of the prosperity of regions, the ability of these regions to adapt, and their capacity to innovate depends on knowledge, education, and research. Project-based education and research organizations often turn into multinational conglomerates operating at local, regional and global levels, creating value by generating ideas and transforming them into assets. Regions, businesses, and investors can make use of these trends to achieve faster growth in qualitative terms. Businesses should be mindful of the knowledge content of their products and develop new products using project-based methods. Given the rise in knowledge content and the increase in the number of hybrid product solutions, the various players depend on being able to develop new knowledge-based strategies. First and foremost, regional decision makers must develop – together with the various other players with political responsibilities – strategies and tools for an integrated policy covering structure, external trade, education, training and research. Coordination, primarily the

Successful knowledge policy: the example of South Korea 38

One of the best examples of the emergence of a regional and national knowledge powerhouse based on a policy focused on the knowledge economy, research, and technology is South Korea. This example demonstrates that a clear political focus on the development of particular locations, as carried out by South Korea over the years 2008 to 2011, can lead to the establishment of high-performance clusters, the restructuring of existing industrial complexes, and the successful conversion to a knowledge-based economy. The outcome is that South Korean companies are now leaders in many knowledge-intensive sectors, such as display production, semiconductor technology, and information and communications technology (primarily cellphones). The example of the South Korean growth shows that continuity in financial support from the public sector, the planning of political activities over a number of years, the clear definition of development mechanisms, coordination between regional, local, and national development plans, and the preferential development of a small number of regions with special instruments, such as technology parks or special economic development zones, can deliver a huge amount of success in terms of improving regional knowledge-based competitiveness (OECD 2012: 98 et seq. and 140 et seq.).

synchronization of activities in the knowledge economy, is paramount. In addition, some attention should be paid to the differing speeds of knowledge-based development in the European regions and elsewhere around the globe. If more knowledge is to be produced, more collaboration between governments, business people, and academics will be on the agenda. The knowledge economy is driven by close collaboration between knowledge owners and by the targeted application of research results and knowledge assets in solutions that are tailored to the needs of customers and regions.

Opportunities presented by the knowledge economy: more (regional) value creation through smart specialization

Against the backdrop of the emerging knowledge economy and the paradigm shift towards stronger knowledge-based growth, the policy aimed at local development and growth in various regions must be reorganized according to the starting position. This also depends on a region's existing infrastructure capital, i.e. its connection to trading, logistics, and transport networks, as well as its energy and information technology infrastructure. Depending on a region's political, social, intellectual, business, and financial capital, regional policymakers can structure general parameters to help the players in the knowledge economy to develop a range of particular knowledge assets from specific spheres of knowledge. It is inevitable that, both within and beyond Europe, the pace of growth resulting from the emerging knowledge economy will vary. Some regions will be able to benefit from the knowledge-based economy faster and to greater effect because they have a better starting position or 'smart' approaches.

With this in mind, it is imperative that individual European countries and regions identify potential and solutions for partnerships involving highly efficient regions and agglomerations with a huge amount of potential, other regions, their businesses, and networks focused on value creation from knowledge. Even regions with forms of structural capital offering little potential can be turned into small knowledge powerhouses by using integrated approaches for developing the knowledge economy and by adjusting the policy mix to incorporate measures from almost all areas of policy (energy, structure, research, education, and labor market). If regions start to encourage businesses, higher education institutions, and other players to work together to create new integrated products and services using regional platforms and value creation networks, they will be able to exploit the opportunities for dynamic growth presented by the knowledge revolution. Simplified bureaucracy, for example related to the procedures involved in establishing businesses, also helps this process.

'Smart growth' from knowledge and knowledge assets

Regions can exploit this structural change in knowledge if they put in place a suitable structural and regulatory framework that encourages the various players in the knowledge economy to take an active role, each providing their own channel of momentum. Businesses, regions, and national governments are faced with a variety of challenges in their efforts to position themselves more actively in pursuit of 'smart growth': These challenges are arising, first, from the structural policy offensive (and the positive impact from this action) in Asian countries such as South Korea and China, and, secondly, from the paradigm shift that is now looming in the structural, regional, and research policy of the EU as part of the Horizon 2020 program.

Regions should grow 'on a smart basis' through knowledge and knowledge assets. To this end, they should look ahead, be proactive in terms of structural policy, and invest with a view to promoting the knowledge economy so that they stand out as a location of choice in the international knowledge race. It is

particularly imperative that businesses and regions support key individuals and pioneers, encourage appropriate partnerships and help these partnerships to achieve a suitable position and profile in the market, improve the integration of philanthropic investment in the growth of the regional knowledge economy, provide incentives for the application of knowledge and its transformation into products, promote the creation of knowledge assets at a strategic level by adopting a more open approach to knowledge, use platforms to improve knowledge transfer and create better knowledge assets, and establish clear parameters that encourage the development of knowledge assets.

Supporting key individuals and pioneers: To survive in the knowledge economy, first and foremost you need clever minds, i.e. key individuals and pioneers. If regions fail to attract suitable specialists and key business people who will seize the opportunities presented by the knowledge economy, these regions will lose ground. Of course there will also be increasing opportunities, for example, to outsource R&D services to other locations abroad. Nevertheless, regions still need to make sure that they have, as locally-based entrepreneurs, those people who are prepared to provide a stimulus for the region and beyond. If a region is to have a basic focus on the knowledge economy, this should start with an integrated investment policy for education and research establishments and the networking of these establishments with locally based businesses as well as international companies with links to the region concerned. Important components of this policy include not only R&D investment but also investment instruments that allow businesses themselves to invest in professional development and (technical) training.

These key individuals and pioneers will therefore only find local conditions to be favorable if a highly effective system of education and continuing professional development is present in the region. Given the background of a knowledge revolution, some knowledge is becoming obsolete more quickly. The half-life period in which knowledge and skills can be applied is becoming shorter owing to innovation and improvements in the knowledge base. This also means that regional decision-makers, key individuals and pioneers must offer even more opportunities so that a region can continue to enhance its status quickly and efficiently. Furthermore, regional players should, in particular, pay much more attention not only to attracting talent from other countries and increasing the number of foreign students, but also to developing business resources for knowledge-based entrepreneurs, an essential requirement in the age of global knowledge circulation. To date, in contrast to other countries, relatively few knowledge pioneers have set up companies in Germany, even though Germany has many foreign students, especially in technical and science subjects. There is still a great deal of unexploited potential here to generate more regional growth by providing development support for knowledge pioneers.

Appropriate partnerships, helping these partnerships achieve a suitable position and profile: As demonstrated by the details of the knowledge revolution described earlier, collaboration between researchers is becoming increasingly important. It follows therefore that companies operating at regional level and regions themselves should 'beef up' and regenerate their existing partnerships to sharpen up their knowledge focus. They should collaborate closely in pilot projects and programs with other players in the knowledge market, be these universities or other regions. It is particularly important to set up international collaborations and establish programs or institutional partnerships to continue projects that have hitherto been driven by individual professors or researchers in companies.

Partnerships that are both international and region-specific: As the knowledge economy continues to become established on the basis of existing and emerging clusters, it is particularly imperative for businesses to establish partnerships rather than simply outsourcing research work. This includes the need, especially

for technology and knowledge-based companies, to play a much greater role than hitherto in the project-based training and professional development of people and development of knowledge in the relevant regional markets and regions. In an example from Denmark, pump manufacturers have become closely involved in regional network solutions for training skilled workers so that their suppliers have a pool of high-quality employees available over the long term, and at the same time the quality of the region as a center of business and employment is improved. In turn, this is also allowing the companies to improve their own position in various international knowledge and value creation networks. Of course, it is also essential that regions – as part of their overall strategy focusing on external trade and economic structure – pay much closer attention to the volume of knowledge content, define a clear strategy with target regions and anchor countries, and implement this strategy with structured projects.

At the focus of knowledge production with 'knowledge flagships': It is clear that there continues to be differentiation between regions based on integrated models covering education, training, research and value creation from knowledge. The knowledge-based development strategy instigated by the Mayor of New York City is just one of the examples of new differentiated strategies that can be found around the world in the age of smart growth. The objective of this forward-looking strategy is to give New York a particular position and profile by developing new institutions, education and research establishments, and businesses based on co-financing solutions. Other similar examples can be found in the UK (London and Manchester), Singapore, South Korea, Malaysia, the United Arab Emirates, and even in the Russian Federation (Moscow/Skolkovo). These examples demonstrate that, in the ongoing knowledge revolution, the old PR principle of 'do something good and tell everybody about it' should perhaps be modified to become 'continue your research and professional development, and initiate (pilot) projects to make sure everybody knows about it'. This is also connected with the need to send a signal to investors that it is worth investing in a particular location because of the excellent development of the knowledge economy base at this location. In this regard, it is important to make use of the existing knowledge infrastructure and develop 'knowledge flagships'. Universities and research institutions are in the vanguard of this process. They should be supported with suitable funding instruments and given more of a free hand (autonomy) so that they can position themselves at both regional and international levels.

Better integration of philanthropic investment: It is not only institutional partnerships that are required to help regions become established in the emerging knowledge economy, other types of partnerships are required too, primarily partnerships with benefactors or sponsors (philanthropists). Particularly in the case of investment in knowledge, there is always a proportion of this investment that has less prospect of having any direct financial impact for an individual investor or region. However, investment in better professional development, for example, allows more people to obtain new skills and qualifications. This then also provides new opportunities for more people. Regions need to cultivate partnerships with benefactors or sponsors especially where they wish to generate fundamental investment in areas of knowledge that are of a more general nature or are concerned with cultural literacy. An increasing number of philanthropists and charitable foundations are becoming involved in funding knowledge production or – in what is becoming an increasingly clear trend – in the transformation of knowledge into projects and products.[32]

Promoting the creation of knowledge assets at a strategic level by adopting a more open approach to knowledge: As the use of cloud solutions in education

[32] Philanthropists are providing an increasing proportion of the funding for knowledge production. The latest figures for the US covering 2011 show that educational establishments received donations of approximately USD 39 bn. The bulk of these donations are used to support the means of conveying knowledge and/or aid the further development of knowledge.

and research continues to develop, and the presence of businesses (including small and medium-sized businesses) as producers and processors of knowledge continues to grow, the ways in which knowledge is produced, processed, and made available will also continue to change. Technical options, in particular, now mean that businesses and regions also have much to gain – in addition to the protection of knowledge – if they take a different approach to their knowledge and share their own knowledge with others in order thereby to produce new knowledge (see Dapp 2011). To benefit from the knowledge revolution, businesses, regions, and research promotion organizations at national level should develop new platforms that allow knowledge to be openly disseminated and shared. The trend towards open access is clear to be seen: A number of European countries have now reached an agreement that the results of research carried out with public-sector support should be openly accessible.

Application of knowledge and transformation into products: Many companies already make use of the opportunity to differentiate their products and make them more competitive by developing and manufacturing them at different research and development sites. They join forces with other businesses in order to advance product development and then protect the resulting products. In the context of a knowledge revolution, the nature of which varies from region to region, it is now essential that a business concentrates on building up knowledge with some regional differentiation and on drawing up a knowledge protection strategy for the business in close cooperation with each region concerned. The strategy should not simply consist of facilitating knowledge-based growth by establishing patents or knowledge assets. Utility models, trademarks, and standards are also important. All this amounts to nothing less than the need for a differentiated strategy for patents, intellectual property rights, and standardization in close collaboration with research organizations, universities, and knowledge-intensive service providers for each region and for businesses.

Using platforms to improve knowledge transfer and create better knowledge assets: This differentiated strategy for the knowledge economy also includes the requirement that businesses and regions take a differentiated approach to partnerships and collaborations, whereby some types of collaboration may be very close, and others more open. The most important thing, however, is to set up platforms. As the relevance of knowledge assets and payments for licenses continues to grow, it is becoming important for businesses and regions to join together with other players and organize the transfer and sharing of knowledge via platforms (see WIPO 2011: 49). These platforms provide the basis for organizing barter transactions (for example in connection with the early stages of product development) and other activities, primarily profit-oriented activities related to the knowledge economy. If knowledge owners and companies are faced with high transaction and licensing costs every time they develop a product, this acts as a constraint on further development. The establishment of these platforms – factoring in the expected commercial value of knowledge assets – is an important prerequisite for setting up sustainable models.[33] In this respect, it is particularly important that businesses operating at a regional level and regionally-oriented universities set up more and better managed platforms in order to initiate projects. These regional platforms, having achieved a critical mass of knowledge production capacity, then also offer the opportunity for the participants to become collaborators at an international level.

These regional platforms have one other advantage. The long-term collaboration between the players means that it is also easier to identify the (joint) long-

Fostering the knowledge economy – platforms count, as shown by the example of Silicon Valley 39

As demonstrated by a study of the circumstances in which Silicon Valley emerged as a knowledge hot-spot carried out by Professor Mark Granovetter of Stanford University, players were required from at least twelve different areas – covered by the financial sector, education and research, the legal and administrative sector, and (local) politics – to encourage innovative business start-ups and the creation of innovative, knowledge-intensive products. Platforms for information sharing were extremely important in allowing the players to collaborate with each other so that the pioneers could provide mutual support in terms of money, knowledge, facilitation of procedures, and networks in the various phases of the innovation life-cycle. Granovetter describes how ten universities, 40 private and public-sector research centers, 8,718 major companies (each with more than 100 employees), 180 venture capital companies, 3,152 law firms specializing in corporate and technology law, 329 recruitment organizations, 1,913 registered accountancy firms, 311 advertising and PR agencies, approximately 700 commercial banks, 47 investment banks, around 100 newspapers with almost 500 journalists, and other key players worked together in Silicon Valley and continue to do so. Furthermore, the number of players and specialties is continuing to increase as a result of additional business start-ups and new activities (Granovetter 2009: 335).

[33] Further advances are being made in the valuation of knowledge assets using platforms, as demonstrated by the example of a platform in which each of the participants no longer has to acquire full licenses, but can instead acquire 'just' the rights to commercially exploit part of a development (see The Economist, May 12, 2012: A new financial exchange hopes to make it easier to trade patent rights).

term funding requirement. It is then more straightforward to create solutions and instruments for investing in knowledge-based growth. Organizing investment in knowledge development or start-up funding for projects aimed at new solutions and products is often difficult. It is therefore also particularly incumbent on regional players to set up the financial framework for the knowledge economy at a strategic level. In this case, regional players, together with national development banks, other financial institutions, and private sources of funding, can review the various co-financing opportunities and develop new instruments for knowledge-based growth. A variety of options is available as regards funding, which may involve external-trade-based development and investment strategies with public-private partnership or crowd-funding models, impact investments, or even various types of corporate venturing programs.

Establishing clear parameters that encourage the development of knowledge assets: The successful positioning and profiling of companies and regions in the emerging knowledge economy also requires the development of different benchmarks and transparent, sound (development) parameters to be used by regional decision-makers for the purposes of structuring the knowledge funding. Before these benchmarks and parameters can be determined, the knowledge and value-creation drivers in companies and regions must first be investigated; increasingly, projects must also be analyzed in terms of their knowledge production efficiency.

Knowledge economy specialization in networks for creating value from knowledge

The emerging global knowledge economy opens up the opportunity – primarily for regions – to generate an additional stimulus for growth by specialization. Now it is up to all players to develop a range of different partnership and collaboration strategies matched to the potential available in each region for exploiting this opportunity. These strategies may include forms of very close collaboration with the partners bound by tight contractual provisions as well as more open-ended ventures (‘expeditions’) to explore uncharted territory: Particularly if innovative products and solutions are to be developed, knowledge-based entrepreneurs need latitude and the opportunity to fund their ideas, for example by means of more intense collaboration between the public sector and other players (who may include philanthropists).

Regions can gain a great deal if they specialize on the basis of an integrated policy covering external trade, education, training and research as well as participate in platforms allowing their higher education institutions and knowledge-intensive players to collaborate in projects at an international level. This enables regions to create both more knowledge and more knowledge assets, which they can then market.

If the transfer of knowledge is advanced by structured forms of project collaboration and the application of knowledge is driven forward – even with apparently simple and low-cost technical solutions – more people in many regions of the world can benefit from the stimulus that these activities provide.

Regions in Germany and Europe, in particular, are now presented with a great number of opportunities from a structural policy perspective to position themselves as part of global knowledge and value creation networks by specializing in the knowledge economy (smart specialization) and to continue to develop their position of excellence and potential in projects operated in collaboration with other regions.

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More value creation through knowledge (assets)

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