Deutsche Bank Research

November 3, 2009

Your country needs innovative minds!

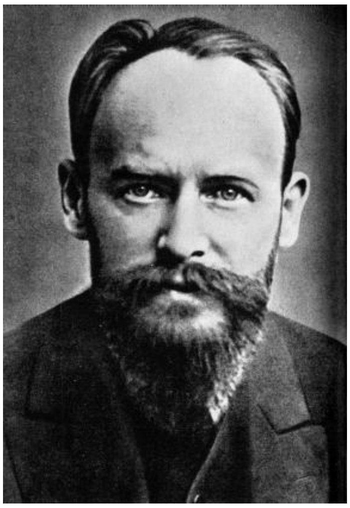
Innovation is all around us and is at the core of many products and services. Innovations thus constitute the foundations for employment, productivity, international success and prosperity.

Every innovation has its origins not only in human curiosity but also in human needs and the ideas conceived to satisfy them. Ideas in turn are based on knowledge and the creative potential of individuals. Generating and pooling fragmented items of knowledge are among the key elements of the innovation process.

The innovation process extends from the conception of an idea right through to the delivery of a marketable product. It is a complex system of varying factors, interactions, feedbacks, loops and tempos and is subject to irregular change.

Innovation cannot be measured directly. The entire innovation process is like a black box. Researchers therefore conduct studies that attempt to estimate the innovation performance of an economy by examining the indicators of the (upstream) inputs and (downstream) outputs in the innovation process.

According to the findings of such research, Germany boasts one of the most innovative economies. This success cannot, however, be taken for granted. To maintain this success all those involved in the innovation process need to redouble their efforts, also in light of the impact of demographic change. The strengths and weakness profile for Germany flags up this necessity.



"Every creation is a risk"

Christian Morgenstern, German author (1871-1914)

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Content

1. Innovations – the drivers of economic success

ISO country codes

Code	Country
AT	Austria
BE	Belgium
BG	Bulgaria
CH	Switzerland
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GR	Greece
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
JP	Japan
KR	Korea
LT	Lithuania
LU	Luxemburg
LV	Latvia
MT	Malta
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
SE	Sweden
SI	Slovenia
SK	Slovakia
UK	United Kingdom
US	USA

Source: Int'l Organization for Standardization 1

We are surrounded by innovation: from toothbrushes and music-playing, navigation-equipped mobile phones right through to insurance policies, innovation is to be found in many places and forms the basis for nearly all products and services. Without innovation there would be no progress and no new or improved products. Innovations are key economic factors, generating growth, employment and prosperity. Innovations also make a major contribution towards ensuring competitiveness. It is precisely during those times of protracted crises, deep recessions and great uncertainty among economic agents that creativity and innovative flair are needed.

2009 is the European Year of Creativity and Innovation

In its Lisbon Strategy approved in the year 2000 the European Union set itself the ambitious objective of becoming the most competitive and dynamic knowledge-based economy in the world. In the intervening years many reforms have also been set in train to achieve this objective. Nevertheless, despite a number of successes there is no prospect of attaining the targets that were actually set for 2010. All the same, the EU is sticking to its strategy and has underlined this symbolically, too: the year 2009 has been designated the European Year of Creativity and Innovation.[1] The objectives declared in association with this year include, for example, the creation of an innovation-friendly environment, the emphasis on openness towards cultural diversity, the development of a sense of the importance of creativity, innovation and entrepreneurial spirit as well as the support for openness to change, creativity and problem-solving capability.

The importance of innovations for the economy is manifested in the creation of new economic opportunities, for example, in the form of not only products and services, but also new business models and production processes. On account of its highly open economy Germany's innovative vigour is subject to huge pressure. This will be intensified further by demographic change: Germany will see its population not only shrink but also age heavily, which could have an adverse effect on productivity.

Germany is one of the leaders in innovation capability

To date, Germany has given a good account of itself. Despite criticism of the reluctance to invest venture capital and the looming skill shortage[2] the German economy managed to rank among the leaders in comparative international studies on innovation performance in 2008.[3] But what actually is innovation and how can the innovation capability and the innovation potential of an entire country be measured? In answer to the foregoing question, the innovation process is highly complex and similar to a black box.

Innovation process is a black box

A wide range of definitions of innovation can be found in the relevant literature. The word "innovation" is derived from the Latin terms

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[1] This was approved by the European Parliament and the Council after being proposed by the Commission on December 16, 2008.

[2] Expertenkommission Forschung und Innovation (EFI). Gutachten 2009.

[3] INSEAD (2009). Global Innovation Index and Report 2008-2009 as well as European Commission (2008). European Innovation Scoreboard 2008.

"novus" (new) and "innovatio" (renewal or some new creation). The European Union, for example, defines innovation as "the successful production, assimilation and exploitation of novelty in the economic and social spheres".[4] The term is commonly used non-specifically to describe new ideas and inventions and their commercial application. Innovation thus ranges from the idea right through to the marketable product, with the path to completion defined as the innovation process. The innovation process is extremely multi-faceted and can be more accurately compared with the complex network of roads in a city than an absolutely straight motorway that leads directly to the destination. Also, many ideas do not lead straight to the desired success. Consequently they have to be reconsidered, adjusted and revised. Accordingly, feedback or loops form part of the innovation process, which itself is also undergoing permanent change. This brief description alone shows how difficult it is to describe the innovation process for a new good or a new service. Doing this for an entire economy appears to be virtually impossible.

Since it is impossible to measure innovation performance directly we look at variables that can provide indications about a country's innovation performance via the inputs and outputs of the innovation process. However, these indicators provide only a vague outline of the desired information. After all, innovations come in many guises. They can be new technologies, products, services, types of organisation, process techniques as well as production or process methods. Innovations are also influenced by societal and social changes as well as economic policy in particular, and they in turn trigger organisational innovations. They are therefore more than simply technical solutions to concrete problems.

Which are the steps to teach us more about innovation?

The following chapter describes the elements and functions of modern innovation processes. Attention is focused on the factors involved and how they collaborate. There is also a discussion about knowledge generation and its economic significance for a national economy. This is followed by explanations of several phenomena which ensure that the innovation process is subject to permanent change.

Chapter 3 addresses the approaches, findings and criticisms of the studies conducted to estimate innovation performance at the macroeconomic level. These studies present the comparison of innovation at the international level in the form of country rankings.

In Chapter 4 a profile is drawn up of the strengths and weaknesses of the German economy. For this, we use selected indicators that can influence the input phase of the innovation process. This enables Germany's strengths and weaknesses to be compared internationally.

The strong significance of the societal climate for innovation with regard to technology and science is emphasised in the closing chapter. Man is the central figure of the innovation process and this will remain the case.

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4 Commission Communication of 11 March 2003 "Innovation policy: updating the Union's approach in the context of the Lisbon strategy".

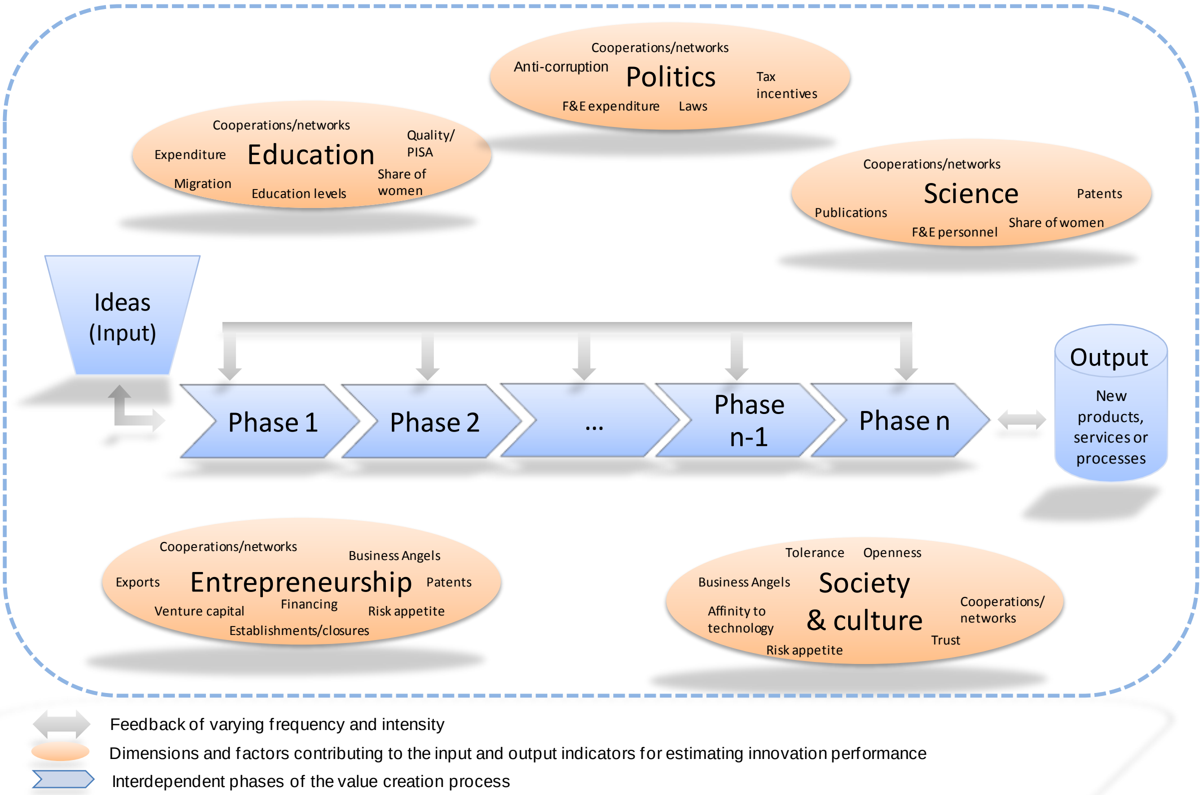
2. Modern innovation processes – a simplified description

The innovation process – from the conception of the idea to the finished product

The following figure provides a simplified illustration of the basic structure of an innovation process. Key elements are the individual phases of the innovation process that are required for the transformation of ideas into marketable products and services. The diagram is based on standard process models found in the relevant literature and enhances these with additional dimensions containing potential input and output indicators.

The innovation process begins with creative ideas and first drafts. The following individual but closely linked innovation phases represent subprocesses from the organisational business units such as development, purchasing, production, sales and all upstream and downstream links with suppliers, official bodies, research institutes, competitors and clients. Test or pilot phases designed to provide pointers to the likelihood of success and customer acceptance remain standard elements of the process.

Schematic illustration of the innovation process



Source: DB Research

The innovation process is not a one-way street

The innovation process consists of a number of subprocesses, some of which are consciously managed and operate informally while others occur spontaneously. Accordingly, feedback and interdependencies of differing frequency and intensity do occur between the individual phases.[5] Feedback can, for example, come from ideas failing to be implemented as planned within individual subprocesses during the creation of the product or service. In this case the steps in the preceding phases have to be revisited, and where necessary, modified and/or changed, or the idea may even have to be completely abandoned. It is also possible that during the innovation process new ideas are spawned which ultimately give rise to products and services that are completely different from what was originally conceived.

Depending on the respective path dependency the development during the process influences and restricts the future possibilities. Path dependency makes some objectives in the innovation process no longer attainable on account of the development stage already reached, because the number of alternatives decrease at each key stage of the advancing innovation process, i.e. at the juncture at which a decision has to be made about the further course of action. Feedback loops ensure that processes remain on certain paths. The plotting of an alternative path – i.e. returning to a preceding decision-making stage – does, however, become increasingly difficult due to the above-mentioned feedback effects and presents innovators with huge challenges not only of a technical nature, but also in terms of costs.

This carries with it the risk of incalculable time delays. But this learning process is part of the innovation process. The above-mentioned forces at work reflect the highly complex nature of the innovation process. Its transparency is low, which implies considerable measurement problems. Nevertheless, feedback and feedback loops are among the most important elements of the innovation processes, because they result in the rectification of errors and the improvement of processes.

Innovation processes not restricted to the corporate level

Increasing global interconnectedness means that a successful innovation process is reliant on active cooperation between business, science, politics, society and culture. It is therefore inadequate to focus solely on companies. Companies do of course perform a key role in the innovation process. They often initiate and implement ideas. But there are far more factors and decision-makers involved in the innovation process who share the responsibility for fundamental activities. They include:

— Research and science, which develop new methods and methodologies,

— The education sector, which produces the required highly qualified personnel,

— Investors, who provide the necessary (venture) capital,

— Lawmakers who create an innovation-friendly environment, and

— Consumers themselves, whose consumption habits prompt product developments from manufacturers or who even become involved in the development process themselves (interactively).[6]

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5 Rollwagen, Ingo (2008). Zeit und Innovation: Zur Synchronisation von Wirtschaft, Wissenschaft und Politik bei der Genese der Virtual-Reality-Technologien.

6 Lead-user theory developed by Eric von Hippel (1986). Lead users are consumers whose needs precede the demands of the mass market. They are

The participants from the ranks of education, politics, science, entrepreneurs, society and culture enter the innovation process in different combinations and they collaborate with differing levels of intensity. At every single step in the process the participants make contributions that impact the innovation process. A more precise differentiation between product and process innovation is not made as there is hardly any difference between the procedures and the participants in the innovation processes.

Cooperation promotes innovation

It emerges that innovation involves dimensions from both the supply side and the demand side. Today, hardly any innovations are produced by a single person. Networks and different forms of collaboration are required to bundle innovative resources. Together all participants spin an innovation web that is characterised by creative and interactive (often only temporary) collaboration.[7]

But what makes cooperation between the participants so interesting and how can this cooperation generate increased benefits? One possible explanation was supplied by Hayek as long ago as 1946 in a book in which he described spontaneous (market economy) arrangements, which can certainly be compared with the dynamics and the complexity of innovation processes "[...] it is the problem of using knowledge that no-one possesses in its entirety".[8] The individuals collaborating with each other, who in their work environments and their social relations participate in the innovation process, have according to Hayek's theory, "special knowledge of the particular circumstances of time and place".[9] Every single participant thus possesses unique, special, situation-based or local knowledge that improves the entire innovation process by bringing together fragmented knowledge. Collaboration becomes faster, more specialised and more productive. The result is more efficient resource deployment, cost-saving synergy effects and bringing together of competencies. Moreover, collaboration enables entrepreneurial risk to be diversified.

Multidisciplinary cooperation …

The linkages between different sectors result in more frequent changing of sides between the individual process dimensions by personnel. Multidisciplinary cooperation leads to the respective decision-makers understanding and learning to apply methods and approaches from an alternative perspective. This learning effect boosts the problem-solving potential of all those involved.

The better the expertise of the individual players, and the greater the integration, transparency and trust that characterise the collaboration, the higher is the quality of the national innovation systems. The term "National Innovation System" was popularised by

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described as trendsetters. They expect to derive a particularly great benefit from the satisfaction of their needs and/or the solution to their problem. They therefore often act as innovators and problem solvers and use their "expert knowledge" to help companies in the innovation process. If they participate directly in the innovation process, they become prosumers.

7 See Hofmann, J. et al. (2007). Germany 2020 – New challenges for a land on expedition.

8 Hayek (1946). The Use of Knowledge in Society. He also writes: "[…] how much we still have to learn in each job after we have completed our theoretical studies, what a large part of our working life we spend acquainting ourselves with a specific activity and what a valuable asset in all occupations is the knowledge of people, of local conditions and special circumstances.

9 Hayek (1946).

Lundvall[10] and Freeman who defined it as "[…] the network of institutions in the public and private sector whose activities and interaction initiate, import, and diffuse new technologies".[11]

… requires increased management effort ...

Collaborative working arrangements, however, require increased coordination and organisational input. Necessary evaluations of the partial process results, modern management styles, non-hierarchical communication as well as a genuinely implemented feedback culture and/or "innovation from below" [12] are helpful foundations for successful multidisciplinary collaboration. Despite their collaboration those involved can, for example, possess differing project-based knowledge and also be at differing stages in achieving their objectives. Opening up the innovation processes and collaborating with stakeholders speed up the learning effects. The feedback loop in particular is an especially effective process instrument. The entire innovation process requires an active feedback culture across all subprocesses due to the embedded feedback and loops in order to continually optimise by eradicating errors.

… as well as a high degree of flexibility

The opening up of processes and the willingness to collaborate, however, generate demands for a great deal of flexibility, which always has a negative impact on planning certainty. This means that all participants have to react faster and need to increase their adaptability. Active cooperation and multidisciplinarity can make this increased workload an obstacle in the innovation process. More time is required especially in the early planning phases, which can cause higher initial costs. This extra workload does decrease, though, as the cooperation process progresses. With high-quality planning this could ultimately lead to a more cost-efficient innovation process than going it alone without collaboration.

Core element of the innovation process: knowledge

Besides curiosity and the joy of breaking new ground, the origins of every innovation also lie in the insatiable needs of mankind and in the resulting ideas on how to satisfy them. Spontaneity is also a source of innovation. An apposite quote from Wilhelm Busch in this respect is: "Each desire once fulfilled immediately begets another."[13] Ideas are based on the knowledge and the creative potential of specific individuals. Consolidating fragmented sources of knowledge is thus one of the key areas of the innovation process. Knowledge generation stimulates technological progress and is increasingly shaping the structure of modern economies. According to modern growth theory, technological progress is primarily the product of the skills and/or the training of the workforce as well as research and development (R&D) and its diffusion.[14]

10 Lundvall, B.-A. (1992). National systems of innovation. Towards a theory of innovation and interactive learning.
11 Freeman, C. (1987). Technology policy and economic performance; lessons from Japan.
12 Palfrey, J. and U. Gasser (2009). Generation Internet, Chapter 10, Innovation.
13 Wilhelm Busch – German poet, painter and artist (April 15,1832 – January 9, 1908).
14 See Romer, P. (1990). Endogenous technological change.

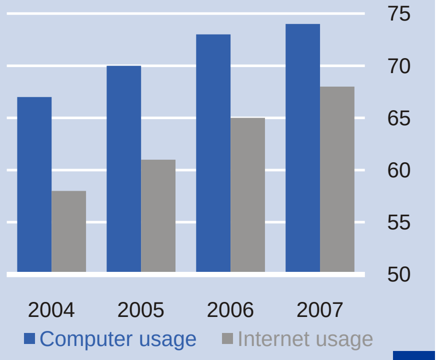
Knowledge diffusion via digital and virtual media

Knowledge diffusion is being promoted via digital and virtual media using information and communications technologies. The availability of technology and content has increased considerably. More and more people, and especially younger people, have access to computers and the internet.

Whereas in 1998 only 12% of households used the internet, by 2008 it was nearly 80%. In addition, the costs of creating, disseminating, storing and utilising digital content, such as written material, music, videos and photos, has fallen sharply and the prices of the technology required continue to decline. This societally desirable effect materialises in the form of spillovers in many creative processes of an economy.[15]

PC and internet usage

Persons in Germany aged 10 and over as a percentage of the population



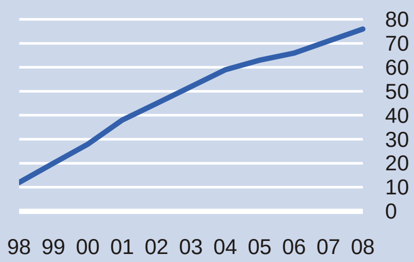
Source: Federal Statistical Office 2

“Knowledge commons”

Unlike other factors of production such as capital, raw materials or labour, knowledge possesses an economically exceptional property: the use of knowledge is non-competitive in its impact, i.e. the use of the knowledge of one person does not preclude its simultaneous use by a different person. If physical products are exchanged, then the owners of these objects change as well. If, however, ideas are exchanged, each party has two ideas after the exchange has been concluded. This could be one of the reasons why the growth of leading economies in the past decades has been mainly attributable to increased knowledge and its increasing dissemination.

Household internet usage in Germany

Share of the population aged 14 to 64



Source: Allensbacher Computer und Technik-Analyse 3

Innovation processes are subject to constant change

Innovation processes are not static but are the outcome of the changing approaches adopted by the parties involved. The environment in which the innovation process occurs is also subject to constant change that can directly influence each participant and compel him to adapt. This is a reference not only to short-term cyclical fluctuations but in particular to long-term structural changes. Innovation processes are thus subject to constant change which can be characterised roughly by the following developments: [16]

Probably the most economically influential trend remains the increasing *global integration* between the fields of information, technology, capital (direct investment), human resources as well as goods and services with the pace of technological progress accelerating, the importance of the service economy growing and the volume of digital and virtual goods, services, processes and business models increasing.[17]

Furthermore, the speeding-up of the innovation process (shrinking product life cycles and shorter reaction times) in recent years points to a growing tendency among participants towards greater *collaboration* and thus the *opening up of innovation processes*. An OECD survey of the internationalisation of private-sector research and development projects also showed that most collaborative ventures in the scientific and technological sphere were the result of

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[15] Depending on the degree of openness, standard of education, mobility of the labour force (brain circulation), multinationality of companies, deregulation of capital markets and infrastructure level of an economy, technology diffusion results in a positive externality in the national innovation system (standing-on-shoulders effect).

[16] A detailed description of the trend-like dynamics can be found in Hofmann et al. (2007). Germany 2020 – New challenges for a land on expedition.

[17] OECD (2009). A stocktaking of existing work.

initiatives and contacts established by individual researchers and companies, regardless of political strategies and initiatives.[18]

The growing importance of intellectual capital, lifelong learning, greater citizen sovereignty as well as demographic change are influencing the innovation process via the *individual as a bearer of knowledge and a source of ideas*. This means that there are some companies with a small number of employees and few tangible assets whose market capitalisation is higher – in relative terms – than that of other companies with more employees and bigger balance sheets.[19] Knowledge-intensive and knowledge-driven companies often have just one money-making idea whose implementation exists in the minds of the employees.[20]

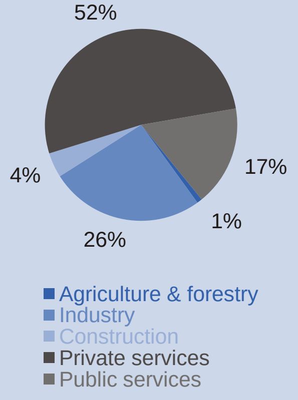
Creative economies

In this connection, Richard Florida talks of a "creative economy" that developed over time especially after 1950 thanks to increasing technological progress, expansive R&D spending and patent filings into a knowledge-driven and information-based economy.[21] Apart from a rising service sector share[22] another phenomenon that is indicative of the post-industrial society is the observation that knowledge will become the key resource for action.

With their advanced production methods *creative economies* are in most cases also those countries with the largest international market shares.[23] Specialisation in the high quality, high-tech goods and services markets in particular enables correspondingly high revenues to be generated.[24] Another feature of such economies is that the incentive mechanisms and institutions required to promote innovations are relatively broadly developed. Above all, it is the investment in knowledge-intensive information and communications technologies (ICT) in all OECD countries that has become considerably more important. This enables companies to produce more efficiently. Companies that have also succeeded in linking their information and communications technologies with other research-intensive technologies, organisational processes or business models achieved better results than those which concentrated solely on ICT, according to an OECD report.[25]

Input side of GDP: services are dominant

Share of GDP in %, 2008



Source: Federal Statistical Office 4

Germany as a case in point

The above description is particularly true of Germany. The service sector dominates the German economy, generating nearly 70% of GDP (2008), followed by manufacturing which accounts for 26%.[26] This is also reflected in the labour market. In 2008 the German service sector employed 29 million people and thus over 70% of the

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18 OECD (2008). The internationalization of business R&D: evidence, impacts and implications.

19 The expectation-dependent market capitalisation of Apple totals some USD 111 bn with a workforce of 32.000, whereas Daimler AG with 263,819 employees has a market value of USD 37.67 bn. Source: Bloomberg, May 13, 2009 at 11:04.

20 Picot, A. and M. Fiedler (1997). Der ökonomische Wert von Wissen.

21 Florida, R. (2002). Chapter 3. "The Creative Economy".

22 According to the ZEW (Zentrum für Europäische Wirtschaftsforschung) definition, knowledge-intensive services include the credit and insurance sector, data processing and telecoms services, technical services (R&D services, engineering consultants, technical laboratories etc.), management consultancies and advertising.

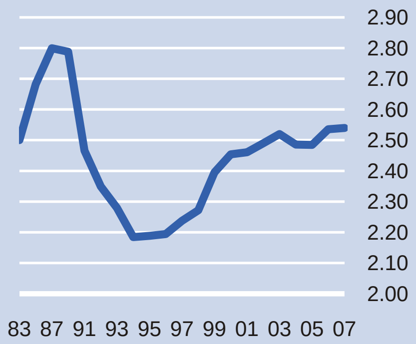
23 Porter, M.E. (2004). Building the Microeconomic Foundations of Prosperity: Findings from the Business Competitiveness Index.

24 Legler, H. and R. Frietsch (2007).

25 OECD (2009). A stocktaking of existing work.

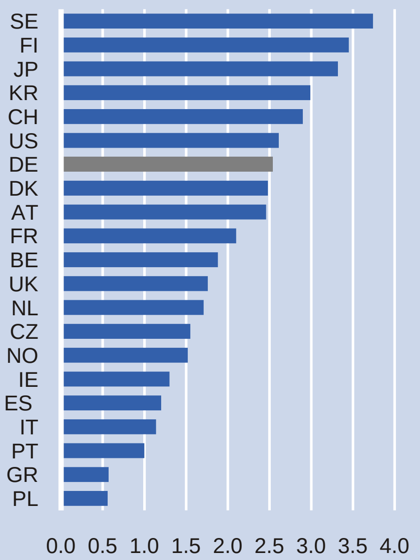
26 Ehmer, P. (2009). Services in the throes of structural change.

German R&D spending
Private and public, in % of GDP



Source: Federal Statistical Office 5

International comparison of R&D spending
% of respective GDP, 2006



CH: 2004, KR: 2005, JP: 2005
Sources: Eurostat, Ministry of Education, Science and Technology of Korea 6

workforce. Germany also has a high export share (goods and services) in GDP of nearly 50% and by capturing 10% of global trade in 2008 it was the world's leading exporter for the sixth year in a row.

Germany's strengths do not lie in naturally occurring minerals or other labour-intensive activities but in capital and knowledge-intensive resources like education, science, research, technology and of course its innovation performance. Concentrating on these activities provides Germany with the key comparative advantage in international competition and is one of the reasons why Germany also does relatively well in comparative international surveys of innovation performance.

For example, German research and development (R&D) expenditure, which is equivalent to more than 2.5% of gross domestic product (GDP), is relatively high by international standards and is almost on a par with that of the US. The only countries that spend more are Scandinavia's Sweden and Finland as well as Japan, Korea and Switzerland, which spend 3% or more of their GDP on R&D.

3. Comparing innovation – findings, methods and problems

Germany's innovation performance is one of the best compared to other nations

One look at the most recent innovation rankings reveals that Germany's performance is good by international standards. According to the Global Innovation Index (GII) computed by INSEAD, Germany ranked second out of 130 countries and according to the European Innovation Scoreboard's Summary Innovation Index (SII), the German economy was the third best performer out of the EU's 27 member states.

According to a report published by the German Institute for Economic Research (DIW) in November 2008, the German economy ranked eighth out of the seventeen countries surveyed. In the country ranking of the Global Competitiveness Report of the World Economic Forum[27] (WEF) Germany landed in seventh place out of a total of 130 countries assessed, while the most recently published report from the Information Technology & Innovation Foundation[28] (ITIF) placed Germany 15th out of the total of 40 countries.

The above-mentioned reports represent a small selection of the available research. One interesting aspect of the reports is that the US economy, which is usually regarded as being highly innovative, is not always to be found occupying top spot.
For example, Sweden tops the country rankings of both the DIW and the European Innovation Scoreboard. In the Global Innovation Index the US ranks right behind Germany in third place. Denmark, Finland, Switzerland and the UK are also among the highly innovative economies and are ranked in the Top Ten.

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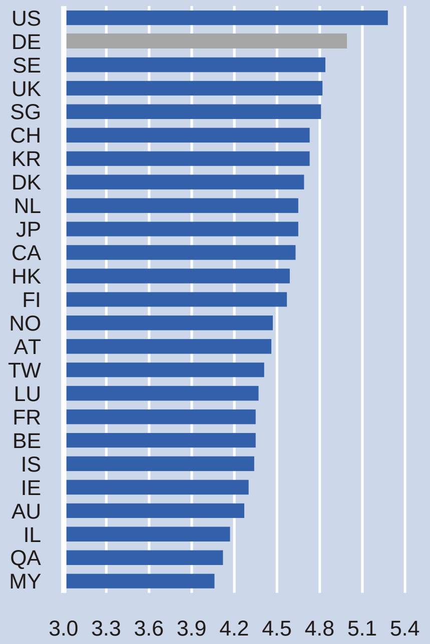
[27] Although the WEF report's title contains the word competitiveness, the individual indicators cited in the report show that it also focuses on a country's innovation performance. The countries surveyed are also divided into three clusters: factor-, efficiency- and innovation-driven economies.
[28] The Information Technology & Innovation Foundation, published in February 2009.

INSEAD Innovation indicator

Global Innovation Index (GII), ranks 1-25, rescaled [1;7], 2008-2009



Source: INSEAD

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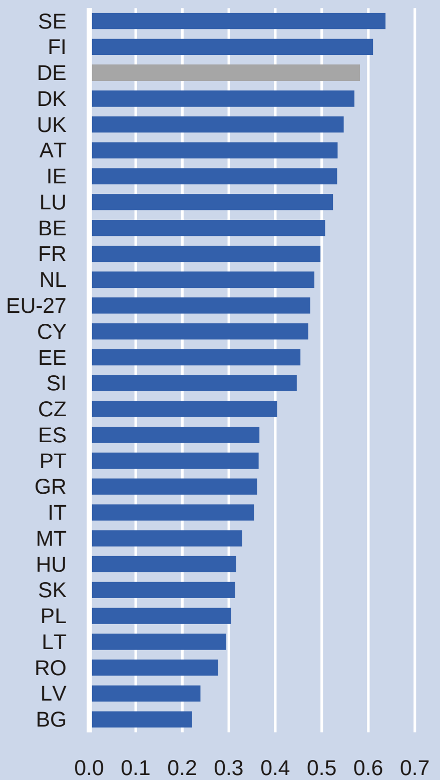
European Innovation Scoreboard innovation indicator

EU-27, rescaled [0;1], 2008



Sources: Pro Inno Europe, Inno Metrics

8

But how do the different surveys rate the innovation performance of a country when the innovation process is extremely complex and intransparent and cannot be measured directly?

An estimation using input and output indicators

Since it is impossible to directly measure a country's innovation performance, attempts are made to estimate it via input and output indicators of the innovation process.[29] The indicators used come from the most diverse areas of an economy. There are indicators to describe policy and institutions, infrastructure, macroeconomic stability, educational attainment as well as goods and labour markets. Indicators relating to sources of funding, technological capability, market size, entrepreneurial activity and linkages are used along with indicators concerned with social capital.

Input indicators

The input-side indicators used are innovation drivers which provide partly mutually dependent stimulation of the innovation process. The selection of these input indicators is based on assumptions about potential causal links between the innovation capability of an economy and its determinants. Since research presumably has a positive effect on national innovation performance the R&D spending of both the private and public sectors in absolute terms and relative to economic output are appropriate input indicators. Other input indicators are, for example, the risk appetite of individuals, the standard of technical equipment at companies, for example with broadband connections, or the access to funding (in particular venture capital). Other particularly important input indicators are education spending, the number of graduates or the share of the population that has completed vocational training.

Output indicators

Output indicators are variables that characterise the success of the innovation process after its completion. Variables suitable for this purpose are, for example, export shares, especially in technology- and knowledge-intensive segments. Patents can also be selected as outputs of the innovation process, as can the number of papers published in academic journals or royalty fees.[30] Sales figures can also help conclusions to be drawn about the marketability of new products and services.

A multi-faceted selection of indicators

A broad range of indicators are selected for the estimation process: while the Summary Innovation Index is a composite of just 29 indicators, the Global Innovation Index uses 94 indicators to generate a country ranking. And even more indicators – well over 100 – are used by the German Institute for Economic Research and

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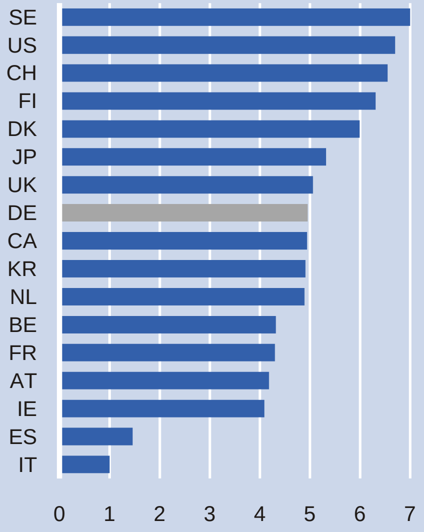
[29] For easier comprehension and to simplify the illustration, a distinction is made between innovation influence (input) and innovation product (output). The distinction between innovation capability (input) and innovation pattern (output) can also be explained in this context.

[30] Patents or copyrights are required before royalty fees can be charged. They allow the inventor or the owner to charge fees for the use of his idea or his protected intellectual property over several years. These also include franchise fees, such as those charged by McDonalds or Starbucks. In 2002 more than half (53%) of all royalty fees headed to the United States.

DIW innovation indicator

Leading industrial nations, rescaled [1;7], 2008



Source: DIW 9

the Global Competitiveness Report of the World Economic Forum 2008-2009.[31]

Scaling and weighting of the raw data

The aggregation of the individual data into one index is conducted in two steps:

Firstly, the data have to be made comparable. To do this they are first converted to a common scale, for example between 0 and 1, that is to say they are standardised.[32] The range of the raw data extends from per-capita units, for example education spending, via percentage figures relative to GDP through to soft data from surveys.

In the second step the problem is aggregating the converted data into a composite indicator.[33] This requires the individual indicators to be weighted. A variety of methods can be used to do this. They range from equal weighting by utilising principal component analyses[34] right through to determining the weighting from expert estimates.

A survey done on behalf of the European Commission showed that the order of the country rankings changes only marginally, though, when differing weighting methods are used.[35] This prompted the Committee for the European Innovation Scoreboard to assign equal weightings to all indicators.

Similar methodology – different indicators

While there is barely any difference between the methods used in the reports, the type and the number of dimensions and the indicators used are very different. This explains the differing results for the country rankings.

But although the results of the innovation reports differ, they provide a relatively timely picture of the innovation patterns and the innovation capability of individual countries. By deliberately uncovering strengths and weaknesses the surveys also provide a basis for economic and innovation policy recommendations to the decision-makers in national innovation systems.

Extensive criticism of the methodology for estimating innovation

Given the fact that the innovation performance of a country cannot be observed or measured directly the concepts used are at best approximations of reality. The criticisms made of it are correspondingly extensive.

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31 In the case of the Global Competitiveness Report 2008-2009 of the World Economic Forum two-thirds of the indicators are soft data from an executive opinion survey. The WEF surveyed more than 12,000 managers from 134 countries for its report.

32 First, the difference between each country and the lowest value on the original scale is calculated. Then the country-specific difference is divided by the difference between the top value and the bottom value.

33 The so-called composite indicator presents the key findings of the report in a condensed form.

34 The purpose of principal component analysis (PCA) is to condense the information contained in a set of indicators. To do this, an analyst calculates the smallest possible number of new, overarching variables – i.e. the principal components – that explain as much of the total variance as possible. Factor analysis produces a similar outcome using a similar methodology.

35 European Commission (2005). Methodology Report on the European Innovation Scoreboard 2005.

Interdependencies not taken into account

One of the most frequently expressed criticisms of the innovation indices is that they take no account of the interdependencies between the individual indicators. Many of the indicators used are undoubtedly correlated. The result is that a single innovation driver can be illustrated by several indicators in parallel. This leads to overweighting, which in turn can result in distortions of the highly aggregated composite index.[36] For example, education is of above-average significance in many dimensions. Education expenditure (input) presumably has an influence on the number of graduates (input) and thus also on the number of employees in the high-tech sector (input), which in turn probably has an impact on the export share (output) of this segment.

Input indicators thus influence not only the output, but also other input indicators used in the surveys. This could play a part in those countries that do relatively well specifically on education indicators also gaining better rankings in the overall presentation of their innovation performance.

In order to arrive at an empirical answer to this question of how much individual indicators are correlated we took 13 standard indicators[37] (8 input and 5 output indicators) commonly used by the research institutes and carried out a correlation analysis[38] for 29 countries for the years 1999 and 2005.

Indicators for assessing innovation performance at national level

Input indicators	Sources
(1) Graduates from tertiary education in science and technology aged 26 to 64	Eurostat
(2) Expenditure on tertiary education as % of GDP	OECD
(3) Public R&D expenditure as % of GDP	Eurostat
(4) Private R&D expenditure as % of GDP	Eurostat
(5) Venture capital as % of GDP	Eurostat/ EVCA
(6) Percentage of enterprises with broadband connections	Eurostat
(7) Employees in knowledge-intensive services as % of the workforce	Eurostat
(8) Anti-corruption index	Transparency International

Output indicators	Sources
(1) Exports of knowledge-intensive services as % of total exports	Eurostat
(2) Exports of high technology as % of total exports	Eurostat
(3) Global market share of trade in high technology, in %	Eurostat
(4) High-tech patent applications filed with the EPO[1] per million inhabitants	Euroatat
(5) Royalty fees as % of GDP	IMF/Weltbank

[1]EPO = European Patent Office

Source: DB Research 10

[36] In this context this phenomenon is also referred to as multi-collinearity. It occurs when there is a very strong correlation between two explanatory variables.

[37] Apart from one exception in the inputs the indicators refer to “hard” data. The Corruption Perceptions Index supplied by Transparency International (TI) is based on “soft” survey data from the respective countries.

[38] The correlation analyses were conducted for 1999 and 2005, and the percentage change between the two dates. The latter analysis examines potential interdependencies in the innovation process over a period of 6 years. All the raw data was converted to a single scale between 0 and 1, which means that the country with, for example, the highest venture capital expenditure relative to GDP is assigned the maximum value of 1 in the correlation analysis. The poorest performing country thus has a value of 0, which ensures that the actual differences between the individual countries remain.

Knowledge (education) is the foundation

Correlation coefficients for 29 countries for the indicator:

	Tertiary graduates aged 25 to 64
Input:	
Tertiary graduates	**1.0**
Employees in know ledge-intensive services	0.9
Priv. R&D expenditure	0.8
Corruption Perceptions Index	0.8
Enterp. w ith broadband connect	0.7
Public R&D expenditure	0.6
Venture capital	0.4
Education expenditure	0.3
Output:	
Global share of high technology market	0.7
Royalty fees	0.6
Exports know ledge-int. services	0.5
High-technology patents	0.3
High-technology exports	0.2

Source: DB Research 11

Stimulate private R&D

Correlation coefficients for 29 countries for the indicator:

	Private R&D expenditure as % of GDP
Input:	
Priv. R&D expenditure	**1.0**
Tertiary graduates	0.8
Public R&D expenditure	0.7
Enterp. w ith broadband connect	0.7
Employees in know ledge-intensive services	0.7
Corruption Perceptions Index	0.7
Education expenditure	0.6
Venture capital	0.4
Output:	
Global share of high technology market	0.8
Royalty fees	0.6
Exports know ledge-int. services	0.4
High-technology exports	0.3
High-technology patents	0.2

Source: DB Research 12

Strong correlation between input and output indicators …

The table included in the appendix shows the correlations between the indicators for 2005. The closer the correlation coefficient is to 1, the stronger the correlation. Zero signifies statistical independence.

As expected, the correlation between all input indicators and output indicators is relatively strong, apart from two exceptions. The correlation is actually negative between the input indicator *public R&D expenditure as a percentage of GDP* and the output indicators *exports of knowledge-intensive services* and *high-technology exports*.[39]

In particular the input indicators *tertiary graduates (figure 11), private R&D expenditure (figure 12)* and *employees in knowledge-intensive services (figure 13)* display significant correlations between the individual output variables.

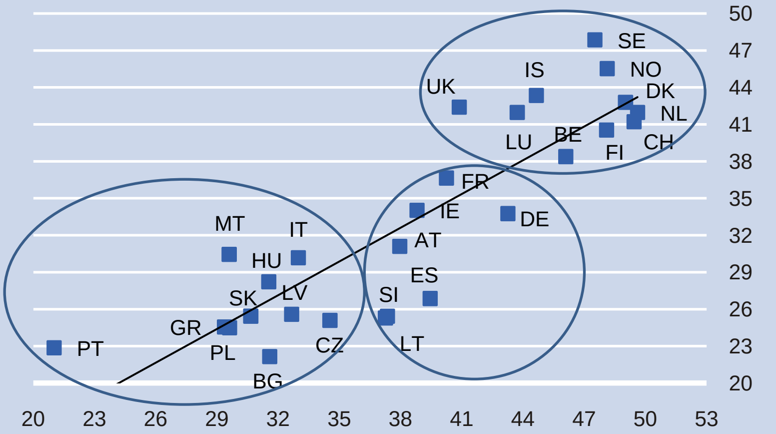
Our analysis also shows that the coefficients of the output indicators *high-technology patents* and *royalty fees relative to GDP* correlate relatively strongly with all input indicators, whereas the correlation with *high-technology exports* is surprisingly weak.

… but also within the input area

Apart from a few exceptions the correlation between the individual input indicators is, however, also relatively strong, which is shown for example by the correlation coefficient of 0.9 between the indicators *educational attainment* and *employees in the knowledge-intensive services sector*.[40]

Educational attainment and employment in knowledge-intensive services

X-axis: Tertiary graduates in science and technology as % of 25 to 64-year-olds; Y-axis: Employment in knowledge-intensive services as% of workforce, 2005



Sources: Eurostat, DB Research 13

[39] This probably has more to do with statistical collection problems.

[40] The correlation analysis for 1999 produces similar results. The correlation matrix on which it is based can be found in the appendix. The interdependencies are generally slightly weaker than in 2005, but overall the deviations are on the low side. Those indicators that were correlated in 2005 also reveal similar interdependencies in the past. This suggests that the correlation is stable.

Promote knowledge-intensive services

Correlation coefficients for 29 countries for the indicator:

	Employment in knowl.-intensive services
Input:	
Employees in knowledge-intensive services	**1.0**
Tertiary graduates	0.9
Corruption Perceptions Index	0.8
Priv. R&D expenditure	0.7
Enterp. with broadband connect	0.7
Public R&D expenditure	0.6
Venture capital	0.6
Education expenditure	0.5
Output:	
Global share of high technology market	0.7
Royalty fees	0.7
Exports knowledge-int. services	0.5
High-technology exports	0.3
High-technology patents	0.3

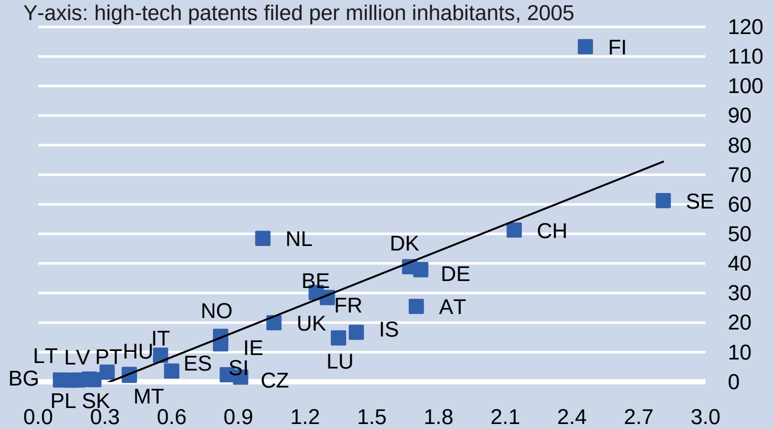
Source: DB Research **14**

Figure 15 illustrates this close correlation for the individual countries surveyed and shows that with regard to the levels of educational attainment and employment in knowledge-intensive services reached there are three country groups that can be identified. While the Scandinavian countries, Switzerland and also the Benelux countries have attained a relatively high level, and France and Germany rank in the upper mid-range, the readings for the Central and Eastern European countries (CEECs) of the EU are lower, as expected.

A similar conclusion was reached by the analysis of the correlation between *private R&D expenditure* and *high-technology patents*. In Finland, Sweden and Switzerland private research spending and the number of patent filings are relatively high, whereas Germany is again in the upper mid-range and the CEECs rank in the lower third.

Private R&D expenditure and high-tech patent applications

X-axis: private R&D expenditure as % of GDP;
Y-axis: high-tech patents filed per million inhabitants, 2005



Sources: Eurostat, DB Research **15**

Differences in granularity receive little attention

Besides the interdependencies, especially in the input area, another criticism focuses on the differences in granularity of the respective indicator bundles, i.e. the differing significance of the indicators selected for measurement. At least no comments are made about the ranking and the order in the reports. While a number of indicators refer to a clearly defined situation at the micro level (e.g. the share of collaborating companies), a different indicator describes the macro level (e.g. high-tech orientation).[41]

Unknown factor: optimum resource utilisation

Moreover, no answer is supplied to the question of what should be the optimum levels for the individual indicators to reach. All the indicators deployed for measuring are included in the composite index under the assumption of “the more, the better”.[42] This assumption does not, however, hold *ad infinitum* for many indicators, such as spending on R&D or education (as a percentage of GDP). For example, it is immediately clear that R&D expenditure equivalent to 100% of GDP makes no sense.

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41 Schibany, A. et al. (2007). Der European Innovation Scoreboard: Vom Nutzen und Nachteil indikatorgeleiteter Länderrankings.

42 Schibany, A. et al. (2007).

Money is not the be-all and end-all

What this all boils down to is that a country distinguishes itself by its ability to boost its innovation performance over the long-term using available resources, like technology, human and social capital, to generate the highest possible output. Input factors are scarce resources. To combine this efficiency[43] it is not only the marginal productivities of the individual factors, but also substitution elasticities[44] between them that have to be taken into consideration. Determining an optimum would enable a targeted innovation or economic policy intervention. But is there actually an optimum level, for example, of R&D spending?

According to a survey by the Max Planck Institute of Economics and the National Research Council in Italy, R&D expenditure is an important driver of a country's productivity growth, with an R&D spending share of between 2.3% and 2.5% of GDP providing long-term maximisation of the productivity growth rate. The question that remains unanswered, however, is whether this finding applies equally to each of the 34 countries surveyed.

The fact that the "the more the better" assumption made with the input indicators does not apply *ad infinitum* but can also lead to suboptimal results is shown among other things by the correlation analysis we conducted into the rates of change in indicators over time (see Appendix). An increase in input indicators between 1999 and 2005 is not necessarily accompanied by higher output, which is confirmed by the low and in some cases even negative correlation coefficients.

Furthermore, there may be no such thing as a stable optimum, because the innovation system is not a rigid construct. Dynamic and evolving processes are taking place that result in the cumulative growth of usable problem-solving knowledge within society.

Strong focus on high technology

Criticism is also directed at the focus on high-tech and advanced technology.[45] For example, the exports of high-tech and advanced technology goods are frequently drawn on to describe export performance. There is no doubt that R&D activities are responsible for radical innovations. At the same time it should not be overlooked that incremental changes (refinement or marginal improvements to existing products) also occur outside the high-tech and advanced technology segment and that they contribute to a country's export success as well.

In addition, innovations are not the preserve of R&D departments; they also occur at the organisational level and in the marketing process. This means it is not only graduates in science and technology who are important for the innovation process, but equally graduates in social sciences and humanities as well as skilled workers with secondary school qualifications. For every good idea, regardless of the author's educational achievements, adds value to the innovation process.

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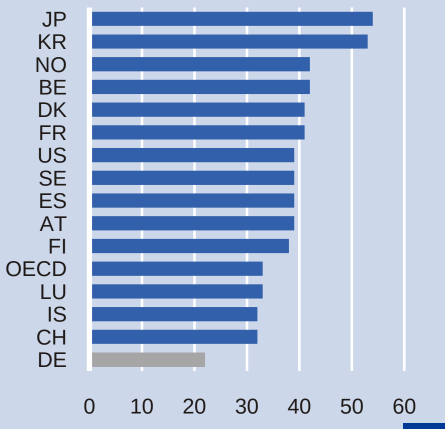
43 The innovation efficiency improves if either a constant input generates a greater output or if the same volume of output is achieved using less input.

44 The substitution elasticity states to what degree one production factor can be substituted by another for a given level of production efficiency and constantly held output.

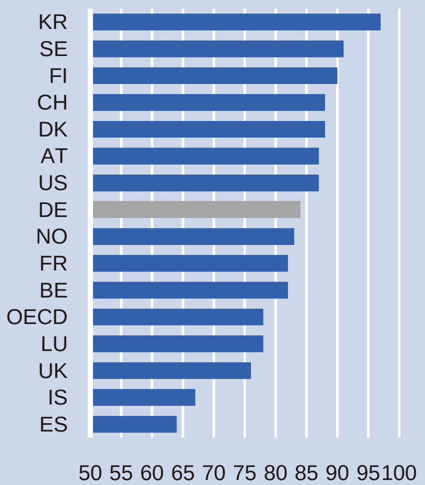
45 In accordance with international criteria, high-tech and advanced technology are defined by the amount of R&D spending as a proportion of sales. For advanced technology the figure is about 7%, while for high-tech it is between 2.5% and 7% of sales.

Educational attainment in tertiary segment
% of population aged 25 to 34, 2006



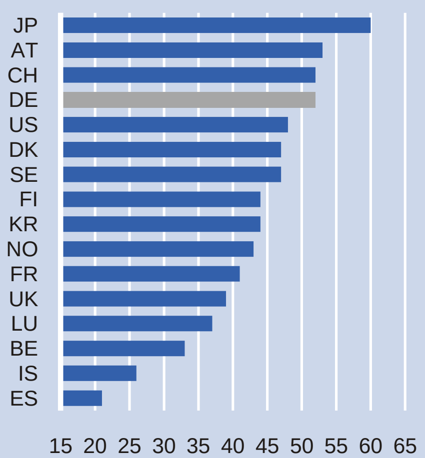
Source: OECD 16

Educational attainment in secondary segment
% of population aged 25 to 34, 2006



Source: OECD 17

Educational attainment in secondary segment
% of population aged 25 to 64, 2006



Source: OECD 18

4. Germany: A strengths and weaknesses profile

The indicators used to estimate innovation performance not only enable the compilation of country rankings, but also – as already discussed – the derivation of strengths and weaknesses profiles for individual economies.

Even though Germany is one of the leading economies in terms of innovation according to related studies, there are gaps developing between Germany and other countries in certain sectors which in some cases, in fact, are quite worrying.

In principle, strengths and weaknesses can be profiled on the basis of all the indicators used to estimate a country's innovation performance. However, we confine ourselves in the following to a small selection of indicators which we consider important in the innovation process. We focus exclusively on input indicators, because only they can be influenced by the decision makers.

Germany is relatively weak in tertiary education …

While innovations are not necessarily linked to the degree of education of those involved, the respective core competencies and the acquired skills do play a key role in product developments in the high-tech segment. Logically, a large proportion of university graduates in the respective age cohorts, particularly among those studying science and/or engineering, also suggests high innovation performance.[46]

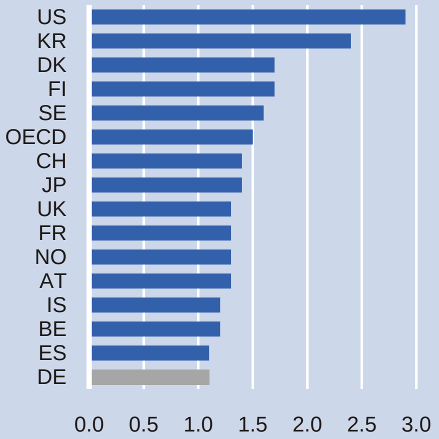
According to the OECD, Germany has a relatively low proportion of tertiary graduates by international standards. In the cohort of those aged 25-34 years old, Germany posted a share of 22% in 2006 and thus ranked far behind Japan (54%), Korea (53%) and Norway (42%), and even fell short of the OECD average (33%).[47] This means that other countries are evidently better at tapping their potential for university education. However, to a certain degree it is legitimate to doubt their international comparability.

Note that institutions of higher learning and universities bear twofold responsibility in the innovation process. For one thing, they serve as a place of learning for creative R&D staff and, for another, they are process catalysts, research facilities and partners in cooperative alliances.

It is vital especially in view of the potential productivity-damping effects of an ageing and shrinking population to increase the share of tertiary-level graduates. The number of 18 to 21-year-olds, that is the number of potential university enrolments, is set to decrease by around 40% by 2050, from 3 million now to a mere 1.75 million. If this cohort shrinks, however, the number of persons producing top-notch results and particularly innovative work may also decrease. At the same time, the median age splitting the total population into equal halves is set to rise from about 42 years at present to about 52 years by 2050. There is much to suggest that innovation performance in countries with a young, growing population is better than in fast-ageing nations with a shortage of young people. Advances in scientific and technological research are mainly driven by young people who are still working towards or have recently

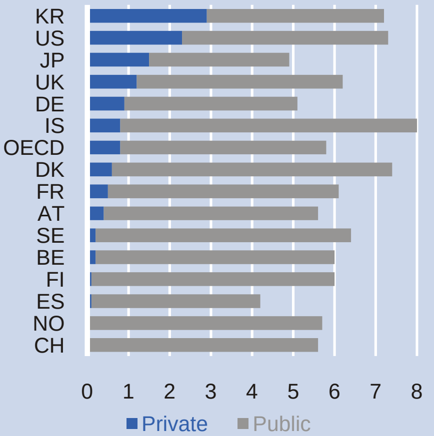
46 Werwatz, A. et al. (2008).
47 OECD Indicators (2007). Education at a Glance.

Expenditure on tertiary education
Private and public spending as % of GDP, 2005



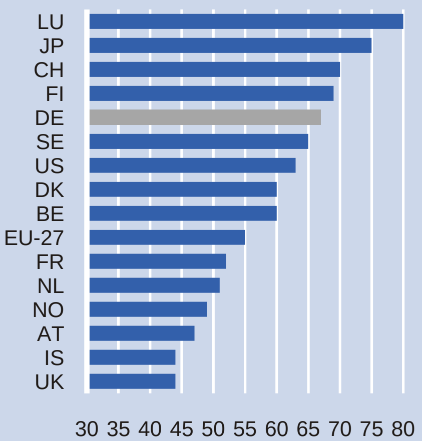
Source: OECD **19**

Sources of funding for education
Private and public spending as % of GDP, 2005



Sources: OECD, DB Research **20**

Private-sector R&D spending
In % of total spending on R&D, 2004



Source: Eurostat **21**

attained their academic qualifications. While scientists are awarded the Nobel Prize in most cases in later years, their related accomplishments are usually achieved when they are young.

… while exhibiting relative strength in the dual training system

The secondary education segment and here in particular the dual training system show a much more encouraging picture, however. For instance, Germany's dual training system, sponsored by the business community and vocational schools, is an internationally recognised education system. Some 84% of the German population in the 25-34 year cohort have completed some sort of vocational or professional training. This benefits the *Mittelstand* in particular – the small and medium-sized enterprises that are the backbone of the German economy. Thus, Germany managed an average ranking internationally in 2006, trailing countries such as Korea, Sweden, Finland, Switzerland, Denmark, Austria and the US, but still outstripped the OECD average of 78%. In the 25-64 cohort Germany ranked in the top group with a share of 52%, beaten only by Japan by a larger margin. The reason could be that nearly the entire population of the ex-GDR had completed some form of vocational or professional training.

Education expenditure across countries …

When addressing the question of how the share of tertiary graduates can be increased, attention immediately focuses on education expenditure. Korea, for instance, with the second-highest level of spending on tertiary education[48] (2.4% of GDP), also achieved the second-highest ranking on the number of tertiary graduates (53%) in the 25-34 age cohort. In the secondary segment of this age cohort, in fact, Korea reports the highest level of educational attainment at 97%.

On the other hand Japan, for example, spent much less on education (1.4% of GDP) compared to Korea, but actually produced a marginally higher share of tertiary graduates (54%). Obviously, money alone is not a panacea for all ills in the education sector. The US, for instance, spends the most on education in the tertiary sector at 2.9% of GDP, but the share of graduates comes to merely 29%. However, it has to be noted that the data on tertiary graduates and education expenditure are still not meaningful in describing the quality of the university system.

… and sources of related funding give a mixed picture

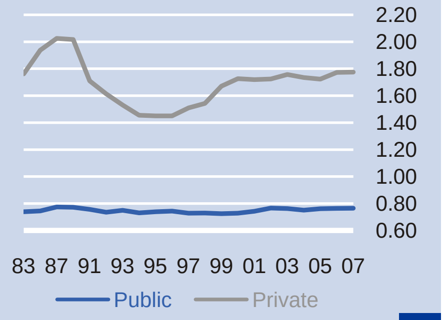
A look at the expenditure side provides another interesting piece of information.[49] While Korea, the US and Japan report a relatively high private-sector share in total spending on education, the Scandinavian countries fund their education systems nearly exclusively via public monies, but are also among the nations with the highest share of tertiary graduates. Thus, there does not appear to be any ideal way of going about the financing either.

Germany spends the least on tertiary education

In Germany, though, both private-sector and public-sector expenditures on education are relatively low in relation to GDP. Like Spain, Germany spent merely 1.1% of GDP on education in 2005,

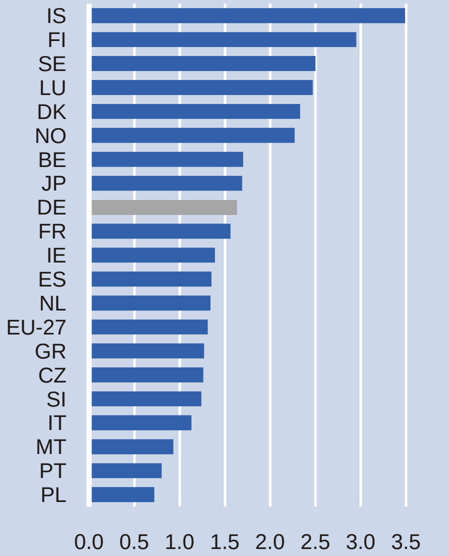
48 Public and private spending on education.
49 Private expenditures include, in most cases, household spending as well as scholarships from religious, charitable or other not-for-profit organisations.

German public and private spending on R&D
% of GDP per year, 1983 - 2007



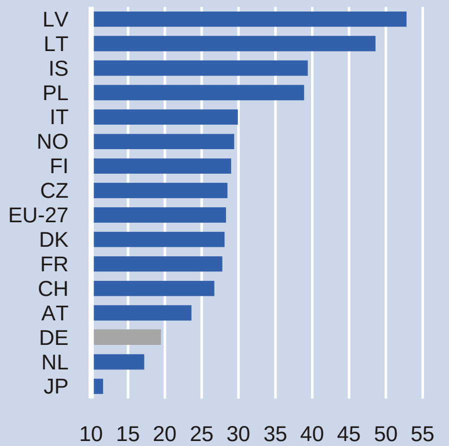
Source: Federal Statistical Office 22

R&D staff
% of labour force, 2005



Source: Eurostat 23

Participation rate of women in R&D personnel
% of total R&D staff, 2004



Sources: Eurostat, OECD 24

thus falling far short of the OECD average of 1.5%. However, Spain produced nearly twice as large a share of tertiary graduates (39%) as Germany.[50]

R&D expenditure

The R&D segment is usually considered the hotbed of innovation in any economy. In this respect, R&D spending, the amount of staff employed in the R&D sector and the share of female researchers can be used as indicators for the strengths and weaknesses profile of any given country.

With the Lisbon Strategy, the members of the European Union agreed in 2000 to increase the share of research and development in the economy to at least 3% of GDP in order to narrow the gap to Japan and the United States. The high-tech strategy adopted by the German government in 2006 was designed to achieve this target in 2010. However, this is unlikely to materialise considering the slump in private-sector R&D investment seen in the course of the deep recession.[51] R&D spending totalled 2.5% of GDP in Germany in 2005. In 2006 and 2007, expenditures persisted at this level. In an international comparison, the Nordic countries Sweden and Finland in particular as well as Japan are in the lead, spending well over 3% of their GDP on R&D (figure 6).

Private-sector spending on R&D is particularly important. In this context, Germany held 5th place in a comparison of the EU member states and several other selected countries, scoring 67% and thus clearly outstripping the EU-27 average of 55%. Over the past 20 years, the private sector's share in R&D spending has averaged around 70% in Germany. This means that Germany, together with Luxembourg (80%) and Finland (69%), meets one of the EU targets, i.e. two-thirds of the funding for R&D spending comes from the private sector.

Employment in research and development: Germany not much better than average

As for the number of people employed in the R&D sector in 2005, Germany scored only slightly better (1.63% of total workforce) than the EU on average (1.31%). In this case, too, the Scandinavians are among the leaders. Their reported values range between 2.27% (Norway) and 2.95% (Finland), so along with Luxembourg (2.47%) they rank ahead of Belgium (1.70%) and Japan (1.69%). Iceland clearly outdistances the group for first place with a share of 3.49%.

Women are underrepresented in R&D personnel

Furthermore, the share of women in the number of R&D staff may shed light on how modern, open and gender-equitable the innovation process is in an economy. Germany lags considerably behind the average in terms of the female share in R&D personnel. With a female share of 19.5% of total R&D staff, Germany in 2004 fell short of both the EU-27 average and the levels achieved by France (27.8%), Denmark (28.1%), Italy (29.9%) and Spain (36.1%). By contrast, women are strongly represented in these fields in the Baltic countries of Latvia and Lithuania as well as in Iceland and

[50] For more on education expenditures at the state level in Germany see Dapp, T. and I. Rollwagen (2009). Schulverwaltungsausgaben auf dem Prüfstand: Investitionen in Lerninnovationen statt Geld für Bürokratie.

[51] In March 2002 it was agreed at the European Council in Barcelona to increase the target for European R&D spending to 3% of the EU's GDP; two-thirds of this amount is to be generated via private investment.

Poland. Latvia leads the way with a female share of over 50%. A certain amount of scepticism is still warranted though regarding the international comparability of the readings.

Women and innovation: latent potential

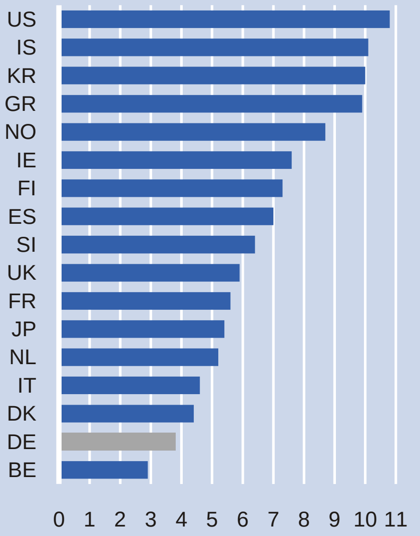
Generally speaking, the participation rate of women both in the academic sector as well as in R&D staff has much to say about a country's innovation performance. Are women integrated and accepted to the same degree as men or are they in some places still struggling against discrimination and gender-specific discrepancies? There would seem to be latent potential in Germany in particular in view of the low participation of women in R&D.[52]

Company start-up activity in Germany on the weak side

Not all innovation processes take place at existing companies. Radical discoveries in particular lead to the founding of new companies. According to the Global Entrepreneurship Monitor 2008 Germany landed in second-last place on this criterion among the 18 economies classified as innovation-driven. A mere 3.8% of the labour force aged between 18 and 64 had set up a company or were about to set one up during the previous 3 ½ years.[53] More than twice as many people set up a company in Greece, where the share is 9.9%. The shares registered in Korea, Iceland and the USA come to over 10%. In Germany, the number of firm start-ups has in fact declined since 2005, so the share of company founders in the labour force has fallen by over 1.5 percentage points.

Start-up activity of 18-64 age cohort

Persons who have set up a firm in the past 3 ½ years, in % of the population, 2008



Source: Global Entrepreneurship Monitor **25**

Company start-ups in the high-tech segment in particular are of major significance in a knowledge-based economy. And the reason is not least because the services sectors are becoming increasingly important and there have been considerable shifts in weighting within industry and the services sector towards technology-oriented and/or knowledge-based industries. The founding of research-intensive companies is predicated as well on (highly) qualified staff. Some 52% of Germany's company founders had a university degree in 2007 and 13% had completed their doctorate or postdoctoral work ("Habilitation").[54]

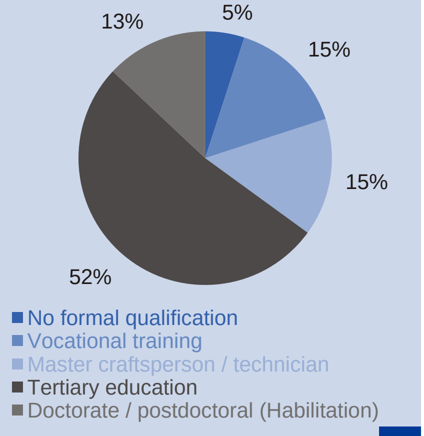
Poor supply of venture capital

When it comes to funding company start-ups or expansion, what is needed is not only a bright idea and a promising business model in both the start-up phase and the expansion phase but also investment and/or risk capital. Banks, private investors, business angels[55] or venture capital companies established specifically for this purpose usually put up the necessary risk capital.

In Germany, the process of securing venture capital in the start-up and expansion phases takes a relatively long time. This knowledge as well as high savings ratios and households' low participation in

Germany: Educational attainment of company founders

Research-intensive firms as % of all firms, 2007



Source: ZEW-Hightech-Gründungspanel **26**

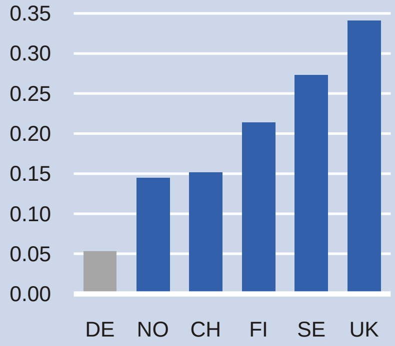
52 For possible explanatory approaches see Schaffnit-Chatterjee, C. (2009). Who is washing the dishes tonight? The gender gap in household work: causes and effects.

53 Global Entrepreneurship Monitor 2008.

54 Gottschalk, S. et al. (2007).

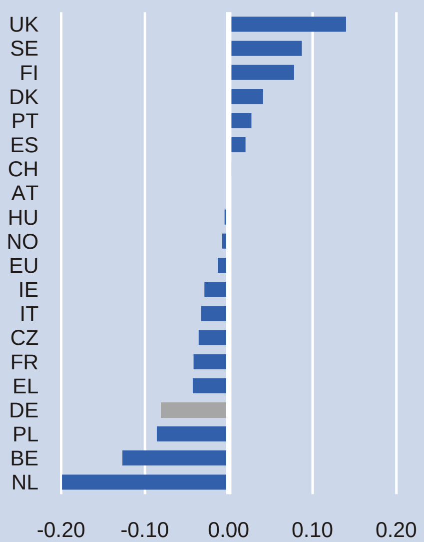
55 Business angels are private investors who take a stake in a company and create value for the company beyond the purely financial contribution, e.g. in the form of consultation and advisory services or via direct assumption of company responsibilities. The number of active business angels in Germany is estimated to total 2,700 to 3,400 persons. In the US there are about 258,200 such investors, i.e. for every million inhabitants in Germany there are about 33 to 41 business angels, whereas in the US the number runs to as many as 850.

Venture capital
Risk capital investment as % of GDP (2007)



Sources: Eurostat, EVCA 27

Venture capital
Change in share of GDP (pp, 1999-2007)



Sources: Eurostat, EVCA 28

equity and derivatives markets also allow conclusions to be drawn on the general level of risk tolerance among investors in Germany. By international standards, Germans are deemed to be rather risk averse.

Germany ranks far below the EU average of 0.13% in terms of the ratio of start-up capital to GDP with a reading of merely 0.05%. From 1999 to 2007 investment in venture capital declined in fact. By contrast, the United Kingdom, the countries of Scandinavia and Switzerland are more willing to put up risk capital.

5. Conclusion: Your country needs innovative minds!

Innovations are part of the very fabric of human life. Knowledge and creativity as well as the courage to be pro-active unleash the innovative potential of an economy.

Man is the most important resource in the innovation process

It is humans whose capabilities generate the decisive stimuli for an economy and thus become the focus of the innovation process.

The requisite linkage and coordination of the individual factors and the resulting interdisciplinarity determine the efficiency of the innovation process. The societal climate for innovation plays an important part in this respect.[56] The climate for innovation in turn depends on individuals' attitudes towards science, technology, research and development. Since, in the words of Christian Morgenstern, every creation is a risk, it is freedom above all that humans require to be able to realise their potential. Innovation flourishes best in a societal environment where factors such as freedom, confidence, courage, risk appetite, tolerance and openness are practised and promoted.[57] In an open economy with open-minded and tolerant citizens innovations are accepted and adopted more readily. It is precisely openness and tolerance towards new things that also entice innovation-promoting (highly) educated people to immigrate from abroad.[58]

More action needs to be taken

Germany has hitherto succeeded in remaining internationally competitive by supplying innovative products and services. Resting on its laurels would nevertheless be a grave error. Success does not come about on its own. A look at Germany's strengths and weaknesses profile reveals the economic and innovation policy challenges facing the country. Action needs to be taken in a number of areas including:

— Inward migration of skilled workers

— Boosting the autonomy of higher education institutions

— Knowledge and technology diffusion, at best in accordance with the high-tech strategy

— Female participation in research and knowledge-intensive occupations

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56 Belitz, H. and T. Kirn (2008).
57 A detailed discussion concerning social capital can be found in Bergheim, S. (2008). The broad base of societal progress.
58 Florida, R. (2002).

— Innovation-promoting tax system and the expansion of funding options (venture capital especially for company start-ups)

— Reform of intellectual property rights

Innovations know no bounds

Ten years ago the multimedia, navigation-equipped mobile phone mentioned at the start of this report offered far fewer user benefits. Compared with today's versions it was relatively bulky, less powerful, had fewer functions and was even fitted with a protruding antenna. Who would have dreamt then of the functions that a mobile phone now boasts?

But how do things look now in 2009? Can we conceive of a time in the future when mobile phones will be able to project holograms right in front of us of the people we are talking to at that moment? Perhaps in future we will no longer operate our mobile phones with our hands, but instead by making gestures or perhaps using our thoughts? Cloud gazing? Yes, possibly. But ideas that are crazy now may already become commonplace (very) soon. After all, knowledge economies require creative and flexible doers especially in turbulent times. That is why: Your country needs innovative minds!

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Appendix

Correlation matrix for 2005

	Correlation for 29 countries	Input								Output				
		Tertiary graduates	Education expenditure	Public R&D expenditure	Priv. R&D expenditure	Venture capital	Broadband conn. enterp.	Employees in knowledge-intensive serv.	Corruption Perc. Index	Exports of knowledge-intensive services	High-technology exports	Share of global high-tech	High-technology patents	Royalty fees
Input	Tertiary graduates	**1.0**												
Input	Education expenditure	0.3	**1.0**											
Input	Public R&D expenditure	0.6	0.5	**1.0**										
Input	Priv. R&D expenditure	0.8	0.6	0.7	**1.0**									
Input	Venture capital	0.4	0.6	0.5	0.4	**1.0**								
Input	Broadband conn. enterprises	0.7	0.5	0.6	0.7	0.5	**1.0**							
Input	Employees in knowledge-intensive services	0.9	0.5	0.6	0.7	0.6	0.7	**1.0**						
Input	Corruption Perceptions Index	0.8	0.2	0.6	0.7	0.6	0.7	0.8	**1.0**					
Input	Exports of knowledge-intensive services	0.5	0.1	0.0	0.4	0.2	0.2	0.5	0.3	**1.0**				
Output	High-technology exports	0.2	0.4	-0.2	0.3	0.3	0.3	0.3	0.4	0.3	**1.0**			
Output	Share of global high-tech market	0.3	0.6	0.2	0.2	0.1	0.1	0.3	0.1	0.1	0.3	**1.0**		
Output	High-technology patents	0.7	0.4	0.6	0.8	0.3	0.6	0.7	0.6	0.2	0.3	0.2	**1.0**	
Output	Royalty fees	0.6	0.5	0.2	0.6	0.7	0.5	0.7	0.6	0.6	0.4	0.4	0.5	**1.0**

Grey = Correlation coefficient >=0.5

Source: DB Research

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Correlation matrix for 1999

	Correlation for 29 countries	Input								Output				
		Tertiary graduates	Education expenditure	Public R&D expenditure	Priv. R&D expenditure	Venture capital	Broadband conn. enterp.	Employees in knowledge-intensive serv.	Corruption Perc. Index	Exports of knowledge-intensive services	High-technology exports	Share of global high-tech market	High-technology patents	Royalty fees
Input	Tertiary graduates	**1.0**												
Input	Education expenditure	0.6	**1.0**											
Input	Public R&D expenditure	0.5	0.3	**1.0**										
Input	Priv. R&D expenditure	0.6	0.6	0.6	**1.0**									
Input	Venture capital	0.6	0.4	0.5	0.5	**1.0**								
Input	Broadband conn. enterprises	0.4	0.5	0.1	0.3	0.1	**1.0**							
Input	Employees in knowledge-intensive services	0.7	0.6	0.5	0.8	0.7	0.2	**1.0**						
Input	Corruption Perceptions Index	0.7	0.3	0.5	0.7	0.3	0.3	0.8	**1.0**					
Input	Exports of knowledge-intensive services	0.3	0.6	0.0	0.4	0.2	-0.1	0.5	0.3	**1.0**				
Output	High-technology exports	0.1	0.6	-0.1	0.2	0.3	0.1	0.3	0.3	0.2	**1.0**			
Output	Share of global high-tech market	0.2	0.7	0.3	0.3	0.4	-0.2	0.3	0.1	0.1	0.4	**1.0**		
Output	High-technology patents	0.6	0.4	0.8	0.8	0.5	0.3	0.7	0.7	0.1	0.4	0.2	**1.0**	
Output	Royalty fees	0.4	0.6	0.3	0.6	0.3	0.0	0.5	0.5	0.3	0.2	0.5	0.5	**1.0**

Grey = Correlation coefficient >=0.5

Source: DB Research

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Correlation matrix for change between 1999 and 2005

	Correlation for 29 countries, absolute change in %	Input								Output				
		Tertiary graduates	Education expenditure	Public R&D expenditure	Priv. R&D expenditure	Venture capital	Broadband conn. enterp.	Employees in know-ledge-intensive serv.	Corruption Perc. Index	Exports of knowledge-intensive services	High-technology exports	Share of global high-tech market	High-technology patents	Royalty fees
Input	Tertiary graduates	**1.0**												
	Education expenditure	-0.2	**1.0**											
	Public R&D expenditure	-0.1	-0.3	**1.0**										
	Priv. R&D expenditure	-0.1	0.2	0.2	**1.0**									
	Venture capital	0.2	0.2	0.1	0.3	**1.0**								
	Broadband conn. enterprises	0.4	-0.2	-0.1	-0.3	-0.1	**1.0**							
	Employees in knowledge-intensive services	0.4	0.2	0.2	0.0	-0.3	0.4	**1.0**						
	Corruption Perceptions Index	0.4	-0.3	0.1	0.0	-0.4	0.1	0.0	**1.0**					
	Exports of knowledge-intensive services	0.3	-0.1	0.0	0.0	0.2	0.0	0.1	0.2	**1.0**				
Output	High-technology exports	-0.1	0.5	0.1	-0.1	0.0	-0.1	0.3	-0.2	-0.1	**1.0**			
	Share of global high-tech market	-0.2	0.0	0.1	0.4	-0.2	-0.4	-0.1	-0.1	0.0	0.4	**1.0**		
	High-technology patents	-0.1	-0.1	-0.1	-0.4	0.0	-0.2	-0.3	0.0	0.5	0.1	0.1	**1.0**	
	Royalty fees	0.0	-0.5	0.2	-0.4	0.0	0.3	0.1	0.1	0.0	0.1	0.0	0.1	**1.0**

Grey = Correlation coefficient >=0.5

Source: DB Research

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ISSN 1612-314X

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Printed by: HST Offsetdruck Schadt & Tetzlaff GbR, Dieburg

ISSN Print: 1612-314X / ISSN Internet and e-mail: 1612-3158