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An IQ Test for Regions

iit Innovation Capability Indicator

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Introduction

There is no need to convince anyone that in developed economies, the capacity to innovate is one of the most important prerequisites for competitiveness and prosperity. This makes it all the more surprising that there are not yet any widely-used methods for measuring and assessing innovation capability. With the use of categories such as 'enablers' or 'absorptive capacity', established innovation indicators do cover some ground that relates to aspects of innovation capability. However, the construct of 'innovation capability' is not adequately reflected by these categories because they are either too narrow or too broad. There is often insufficient clarity in the distinction between 'innovation' and 'innovation capability'.

The intelligence of an individual person is a prerequisite for cognitive performance at school, in training settings and in the workplace. Similarly, an economy's 'collective intelligence' is what enables it to innovate – its innovation capability. The Institute for Innovation and Technology (iit) in Berlin has developed the iit Innovation Capability Indicator, which is an instrument for comprehensively depicting the innovation capability of economies (Hartmann et al. 2014), regions, sectors and companies.

Why develop a new indicator?

Innovation is about creating new things, i.e. new products and processes. Without ideas, knowledge and skills, no innovations can be introduced. Only those with the ability to create new things will be able to be constantly innovative. As such, the ability to innovate is one of the most crucial abilities required for competing in the 21st century marketplace.

The focus on innovation capability results in a perspective that differs from conventional innovation indicators, which are based on the well-established input-throughput-output model. In the input-throughput-output model, the innovative process is depicted as a kind of production function. The input (e.g. research and development expenditure) goes through the 'production process' – via the throughput stage (e.g. patents) – and becomes an output (e.g. new products). It is common knowledge, however, that different countries have different 'innovation production functions'. The effect of 1,000 new engineers in France will not be the same as the effect of 1,000 new engineers in Greece. For this reason, conventional innovation indicators not only account for input factors but also for throughput factors and output factors.

Nevertheless, the innovation capability – the ability to use inputs to generate throughputs and outputs – is not specified or depicted by these indicators. Innovation capability, however, is the very factor that determines the efficiency of a country's 'innovation production function'. The European Commission's 'European Innovation Scoreboard' (EIS)[1] and the innovation indicator developed by Germany's academy for technological knowledge (acatech) in partnership with the Federation of German Industries (BDI)[2] are two examples of well-known innovation indicators. The EIS includes the sub-indicator 'enablers', which touches on aspects of innovation capability. From an innovation capability perspective, however, this sub-indicator is too broad in some ways. For example, it includes data about public spending on research and development, which is more pertinent to general resources and framework conditions. In other ways, the 'enablers' sub-indicator is too narrow. Higher education is the only aspect of human capital that is considered. This means that vocational training, which is proven to make an important contribution, is not included. On the other hand, the BDI/acatech indicator combines the conventional input-throughput-output model with an emphasis on the subsystems within the innovation system: the state, education, research, the private sector and wider society. The indicators in these subsystems range from very basic conditions such as the risk affinity/aversion of the population, right through to the indirect consequences of the innovation process, such as GDP growth. It is extremely difficult to distil innovation capability from these indicators. Furthermore, the way that requirements, innovative performance itself and its consequences are blended in these kinds of composite indicators causes serious methodological problems given the basic logic of the input-output model and of the innovation efficiency approach.

The iit Innovation Capability Indicator, however, makes it possible to perform a clear and rigorous analysis of innovation capability. Furthermore, the innovation capability it measures can be contrasted with clearly defined metrics of innovative performance including product and process innovations – the EIS sub-indicator 'outputs', for instance.

1 European Innovation Scoreboard (EIS): http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_de
2 Innovation Indicator 2017 by Germany's academy for technological knowledge (acatech) in partnership with the Federation of German Industries (BDI): www.innovationsindikator.de

iit Innovation Capability Indicator: An IQ Test For Regions

'Innovation capability' is defined as the capacity of a group, organisation, network or society to continuously generate innovations (Trantow et al. 2011). Following this definition, innovation capability is determined by the stock of knowledge available and the ability to combine useful knowledge. Thus a region's capacity to innovate and to translate these innovations into competitive products, processes and services is not only determined by the quality and diversity of the knowledge it possesses but also by its ability to combine the different stocks of knowledge that are available.

As such, according to the definition used by the iit (cf. Hartmann et al. 2014), innovation capability is not only determined by the quality of the education and training of the workforce and the diversity of useful knowledge that makes it possible to manufacture complex products. It is also determined by the ability of organisations to combine various internal and external stocks of knowledge (see Figure 1).

Indicator concept

Since (economic) innovations are primarily introduced by companies and entrepreneurs, the theoretical approach of the iit Innovation Capability Indicator starts with the company level. In order to be able to compare regions, the company level data is then aggregated to the regional level (the NUTS 2 level territorial units[4]).

In theoretical terms, the iit Innovation Capability Indicator draws on the approaches of Cohen and Levinthal (1990), Stewart (1998) and on a development of Stewart's concept by Alwert (2006), which describes human, structural and relational capital as being determinants of a company's innovation capability. The iit has built on this concept and added the idea of complexity capital, which draws on the theoretical considerations of the 'Atlas of Economic Complexity' (Hausmann et al. 2013). As a result, the iit Innovation Capability Indicator covers four areas of capital, which together determine the capacity for innovation:

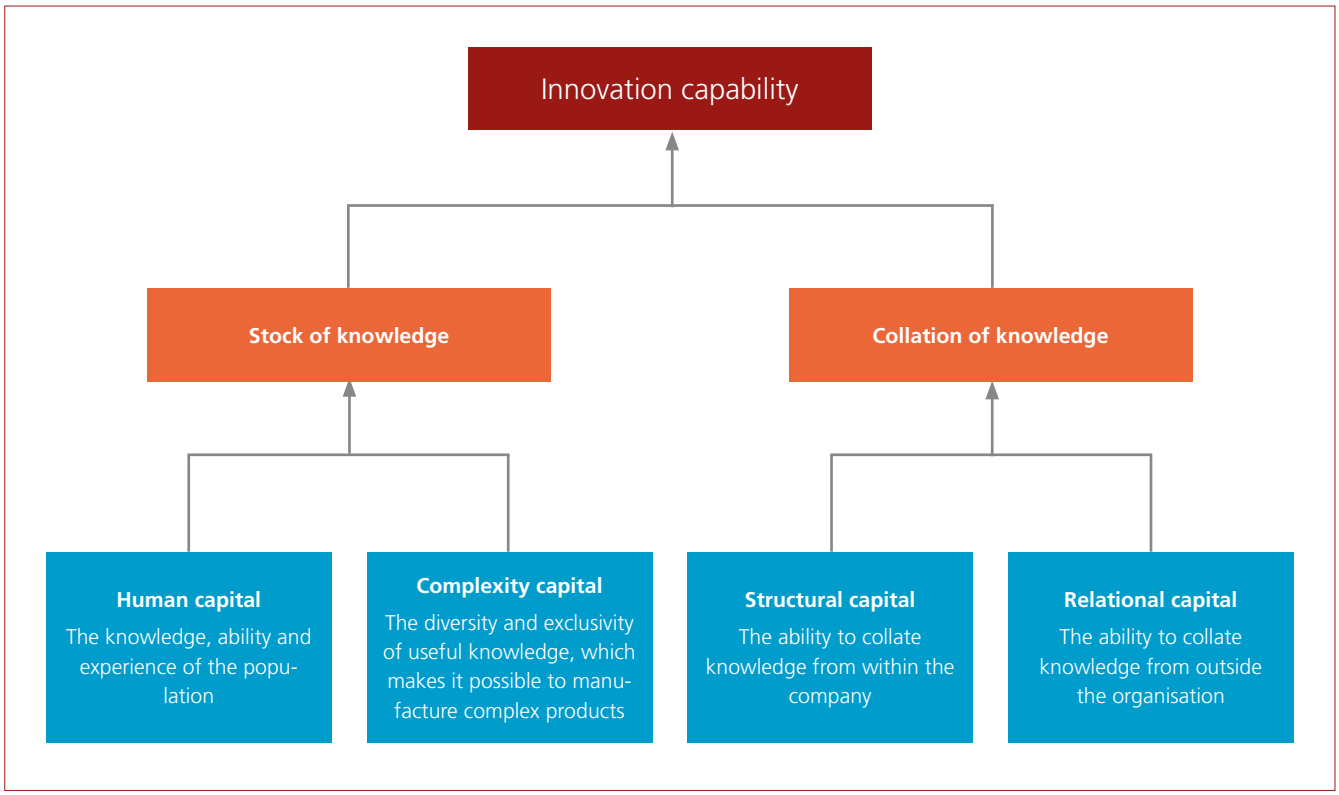

Figure 1: Innovation capability as the ability to use knowledge

3 The abbreviation 'NUTS' stands for 'Nomenclature des Unités territoriales statistiques' and refers to the territorial units that are used for statistical purposes within the member states of the European Union. The NUTS 0 level refers to nation states. In Germany, NUTS 1 refers to federal states and NUTS 2 refers to government regions and former government regions, or to federal states. 'R&D' stands for 'Research and Development'

- Human capital: The education, training and lifelong learning of the workforce
- Complexity capital: The diversity of useful knowledge, which makes it possible to manufacture complex products
- Structural capital: The ability to combine knowledge from within the company
- Relational capital: The ability to combine knowledge from outside the organisation

Human capital is determined by the knowledge, abilities, skills, competencies and experience of the employees. Human capital is a key determinant for innovation capacity because without well-educated employees, there can be no innovation.

Nevertheless, innovation requires more than just a highly-qualified workforce. For the design and manufacture of innovative, complex products, it is necessary for wide-ranging expertise and diverse stocks of knowledge to interact and be combined. Innovation research has shown that both the intensity of knowledge (level of qualification etc.) and the diversity of useful knowledge are important for innovation capability (Tavassoli and Carbonara 2014; Beaudry and Schiffauerova 2009; Audretsch and Feldman 2004; Audretsch and Vivarelli 1996). Hence the heterogeneity of knowledge is a key determinant for the innovation capability of industrial districts (Carbonara and Tavassoli 2013). The diversity of the useful knowledge that is available is denoted by the term *complexity capital*.

Nonetheless, the diversified knowledge of a highly qualified, specialised workforce can only be utilised if these competencies are brought together. In the iit Innovation Capability Indicator, the ability to combine knowledge from within and outside of an organisation is depicted using the concepts of *structural capital* and *relational capital*.

Structural capital denotes internal structures and processes that combine the knowledge dispersed throughout an organisation and by doing so contribute to the company's innovation capability. Such structures include R&D[4] units and organisational structures that promote learning throughout the whole company (Hartmann and Garibaldo 2011).

Relational capital denotes the network of relationships that the company has with external players. This includes any of the company's relationships with external groups – such as partners in the private sector, the scientific and education sectors, politics and government – that are of relevance to knowledge creation and knowledge transfer in the innovation process.

Data set and indicator calculations

The data analysed by the new iit regional indicator is a combination of reliable secondary data, which is publicly available, and primary data, which is collected using computer-assisted telephone interviewing (CATI). This makes it possible to create a profile of the innovation capability of regions, sectors or clusters.

Secondary data

For human capital, the regional iit Innovation Capability Indicator uses data about adult tertiary training and education. Data concerning the participation of adults (aged 25 to 64) in training and education comes from the 2016 EU Labour Force Survey. The survey question asks about participation in training and education in the four weeks leading up to the survey and takes into account both formal and non-formal education. The source of the data concerning tertiary education is the 2016 EU Labour Force Survey. It describes the proportion of the population aged 30–34 who have educational qualifications at ISCED levels 5–8 (Bachelor's degree or equivalent from a university or higher education institution; Master's degree or equivalent from a university or higher education institution; doctoral or post-doctoral qualification).

Complexity capital depicts a particularly sophisticated aspect of knowledge. The data concerning complexity capital describes the extent to which companies or regions have access to diverse and 'rare' (exclusive) knowledge that enables them to product things that others cannot produce. The complexity values used by the iit come from the Atlas of Economic Complexity' (Hausmann et al. 2013). Thus, here the iit indicator is based on a methodology from Harvard University's 'Center for International Development' (CID). The CID uses a complex procedure to calculate index values for the economic complexity of products and economies (countries). If a product has a higher complexity value, it means that only a few countries are able to produce and export this product. An example of a product with a high complexity value is a CT scanner. By contrast, many agricultural products have low complexity values. There is no export data or product-specific manufacturing data for regions but we can make use of statistics that map products to different sectors within the manufacturing industry. With this information, it is

4 'R&D' stands for 'Research and Development'

possible to identify the complexity level of the products that the various sectors within the manufacturing industry are capable of producing. The results are then weighted according to the relative importance of the sectors in the region (percentage of the working population or of the working population employed in manufacturing). This generates the complexity values of the regional manufacturing industry. This provides some regional data regarding innovation capability, which in turn makes it possible to estimate the regional differences in the ability of the manufacturing industry to manufacture complex products.

In terms of structural capital, the iit Innovation Capability Indicator uses data about workplace structures that promote learning. There are various descriptors for the extent to which a workplace promotes learning, such as the complexity of the tasks (i.e. how varied and demanding they are) and the intensity of learning involved. Other decisive factors include social support, collaboration and sufficient levels of autonomy. An important data set for this is the BIBB/BAuA Survey of Employed Persons, which is conducted regularly in Germany. The BIBB/BAuA survey contains data that can be used as an indicator for the extent to which working conditions promote learning within companies. For example, the survey includes the question of how often it is necessary for gaps in an employee's knowledge to be identified and rectified.

To measure relational capital, data on regional R&D collaboration between small and medium-sized enterprises (SMEs) and other companies, research institutes and higher education institutions is used. The data source is the 2015 innovation survey (referring to 2014) carried out by the Centre for European Economic Research (ZEW). It describes the percentage of SMEs that are engaged in collaborative innovation activities with other companies or organisations.

The data for the areas of human capital, complexity capital, structural capital and relational capital was aggregated into the respective sub-indicator categories. These four sub-indicators then feed into the overall indicator. The relative weighting of the individual sub-indicators was determined by statistical analysis (regression analysis). Innovation capability is the ability to innovate. This means that a region with higher innovation capability will also have a higher level of innovative performance than regions with low levels of innovation capability. As such, an indicator for innovation capability should be able to predict a region's actual innovative performance. For this reason, the relative weighting that was chosen for the individual sub-indicators corresponds to the combination that can best predict innovative performance.

Collection of supplementary primary data

As described above, an initial set of data is available for providing important insights regarding regional innovation capability. This data makes it possible to make a quick, rough estimation of regional conditions and is particularly useful for the process of outlining hypotheses for further analysis. In order to provide the full picture of regional innovation capability, however, additional data is required and must be collected accordingly (primary data collection).

The iit has developed a standardised instrument for eliciting primary data for this kind of further analysis. The method uses computer-assisted telephone interviewing to collect data that depicts the innovation capability of a sample of companies. In principle, clients can choose any sample they wish. The telephone interviews are carried out using a script, which encompasses additional aspects of innovation capability in the areas of human capital, complexity capital, structural capital and relational capital. The resulting data depicts aspects that are not captured by the secondary data. For example, such surveys make it possible to thoroughly assess the complexity capital of regions where the manufacturing industry is relatively weak but the creative industries are very strong. Moreover, the collection of primary data facilitates more in-depth analysis of specially selected aspects of regional innovation capability.

Summary and Outlook

The iit Innovation Capability Indicator is built on the insight that innovation capability is driven by knowledge, i.e. by the use of in-depth specialist knowledge (human capital), by the diversity of the knowledge available (complexity capital) and by the ability of companies to combine these different stocks of knowledge, both internally (structural capital) and across organisations (relational capital).

In this way, the iit Innovation Capability Indicator analyses aspects that are not captured by other indicators:

- It makes explicit, clear-cut reference to innovation capability as opposed to innovative performance.
- In the area of human capital, lifelong learning is factored in – which is not the case with any of the other indicator systems. This factor is very important, particularly in light of the demographic changes taking place, the resulting elongation of working lifetimes and the accelerated pace of technological change.
- By including complexity capital, the important role that knowledge diversity plays in innovation capability is also recognised.
- In terms of structural capital, clear emphasis is given to the importance of workplace structures that promote learning and of innovative working environments – no other indicator system includes these factors either. This eradicates one of the blind spots of innovation indicators.

In order to foster and strengthen 'industrial ecosystems', there is a need for targeted innovation policies that constantly monitor the whole range of components associated with innovation capability. These components include the training of very highly qualified people (post-doctoral level), life-long and informal learning, structures for R&D partnerships between the private sector and academia and structures within companies that promote learning and innovation. Here, a positive interplay between these components is likely to make more of an impact than the isolated optimisation of individual aspects.

If a differentiated analysis of a region's innovation capability is performed, regional innovation policy can be tailored more accurately. After all, political measures that target crucial areas can only be suggested once the relative strengths and weaknesses of a region have been analysed across the four dimensions (human capital, complexity capital, structural capital and relational capital). These targeted measures then improve the region's innovation capability, which in turn strengthens its long-term innovative performance. For example, a region that is relatively weak in the areas of relational and human capital would require different measures to a region with pronounced weaknesses in the area of structural capital. For instance, analysis of the structural capital sub-indicators in the latter example might reveal that in a specific region, improvements are needed in the workplace structures that promote learning. In the former example – a region with weaknesses in the areas of relational and human capital – a differentiated analysis might show that new forms of collaboration in the region could provide alternative ways of utilising potential that has previously been unused (or not used efficiently enough).

The iit Innovation Capability Indicator provides decision makers from politics and the private sector with a reliable instrument with which they can measure the ability of regions to turn ideas into new products and services. This specialised indicator makes it possible to translate the results of rigorous empirical analysis into specific measures for economic, education and research policy that yield targeted improvements to the region's innovation capability.

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Institute for Innovation and Technology (iit)

The Institute for Innovation and Technology (iit) is a cross-sectoral facility within VDI/VDE Innovation + Technology GmbH. It offers consultancy in the areas of innovation-related policy and research. The iit also analyses, designs, assists with and evaluates policy programmes for research and innovation in areas where the private sector, science and politics intersect. This work builds on the expertise of more than 250 scientific assistants from all kinds of different disciplines.

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