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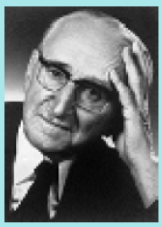



Martin Effelsberg

Measuring absorptive capacity of national innovation systems

Diskurs 2011 – 4

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Abstract

A rising competitive pressure for innovations comes along with an increasing number of companies and public research facilities that include external sources of information into the innovation process. This trend towards an open innovation process can be verified empirically. External R&D expenditures are those invested in R&D activities outside the firm's boundaries, e. g. license fees, research assignments or collaborations with public research institutes and companies. Investments in external R&D allow fast adaptations within the innovation process in case of changing market trends or radical innovations. Furthermore, opening up the innovation process simplifies an integration of required know-how from another industry. Altogether, the flexibility of innovation can be increased without an expansion of a company's own capacities.

Beside the trend of integrating knowledge from outside the firm's boundaries, an increasing internationalization of R&D can be observed in several branches. Hence, this article examines the following questions: Which factors determine the absorptive capacity of national economies? How can these factors be operationalized and how can an adequate framework be developed to increase national absorptive capacity?

Keywords:

Innovation systems, absorptive capacity, theory

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Measuring absorptive capacity of national innovation systems

Introduction

A rising competitive pressure for innovations comes along with an increasing number of companies and public research facilities that include external sources of information into the innovation process.[1] This trend towards an open innovation process can be verified empirically. For example, the external R&D expenditures of German companies nearly quadrupled between the years 1991 and 2009 and account for almost 20% of the total R&D expenditure.[2] External R&D expenditures are those invested in R&D activities outside the firm's boundaries, e. g. license fees, research assignments or collaborations with public research institutes and companies. Investments in external R&D allow fast adaptations within the innovation process in case of changing market trends or radical innovations. Furthermore, opening up the innovation process simplifies an integration of required know-how from another industry.[3] Altogether, the flexibility of innovation can be increased without an expansion of a company's own capacities.

Beside the trend of integrating knowledge from outside the firm's boundaries, an increasing internationalization of R&D can be observed in several branches. For example, the inclusion of knowledge across national borders accounts for 50% of external R&D expenditures in the German pharmaceutical and chemical industry. It therefore can be noted that an increasing amount of knowledge is transferred between national and international innovation actors and that the absorption of external knowledge has become a significant factor of success.[4] Hence, this article examines the following questions: Which factors determine the absorptive capacity of national economies? How can these factors be operationalized and how can an adequate framework be developed to increase national absorptive capacity?

As the absorption of external knowledge mainly depends on the characteristics of a national innovation system including the innovation actors, the following chapter two deals with the concept of national innovation systems as well as the innovative capacity of national economies in terms of open innovation processes. In chapter three, the absorptive capacity of national innovation systems is analyzed in detail and possible forms of its operationalization are introduced. This is the basis to derive implications in chapter four. The article closes with a conclusion in chapter five.

Innovative capacity in national systems of innovation

A high innovative capacity can increase the growth and employment of a national economy sustainably and thus determines the realization of political, economic and

[1] Cf. LICHTENTHALER/LICHTENTHALER (2009), p. 1315.
[2] Cf. STIFTERVERBAND FÜR DIE DEUTSCHE WISSENSCHAFT (2010), p. 24.
[3] Cf. STIFTERVERBAND FÜR DIE DEUTSCHE WISSENSCHAFT (2010), p. 11.
[4] Cf. STIFTERVERBAND FÜR DIE DEUTSCHE WISSENSCHAFT (2010), p. 25.

social objectives on a national scale.[5] In order to evaluate the innovative capacity of a national economy and to deduce specific implications for an innovation policy, the innovation process has to be focused. This process is traditionally seen as linear, consisting of fundamental research, applied research, experimental development and commercialization. This traditional view is increasingly substituted by the innovation systems' approach.[6] An essential progress of this systemic view is the understanding of innovations as the result of dynamic interactions between innovation actors.[7] Thus, interactions are increasingly focused which become more important in open innovation processes. Regional[8], sectoral[9] (branch specific) and national[10] innovation systems can be distinguished, whereas only national systems will be analyzed in the following chapters. Components of a national innovation system are an institutional framework, the innovation actors and processes between the actors.[11] Figure 1 shows the aforementioned relationship.

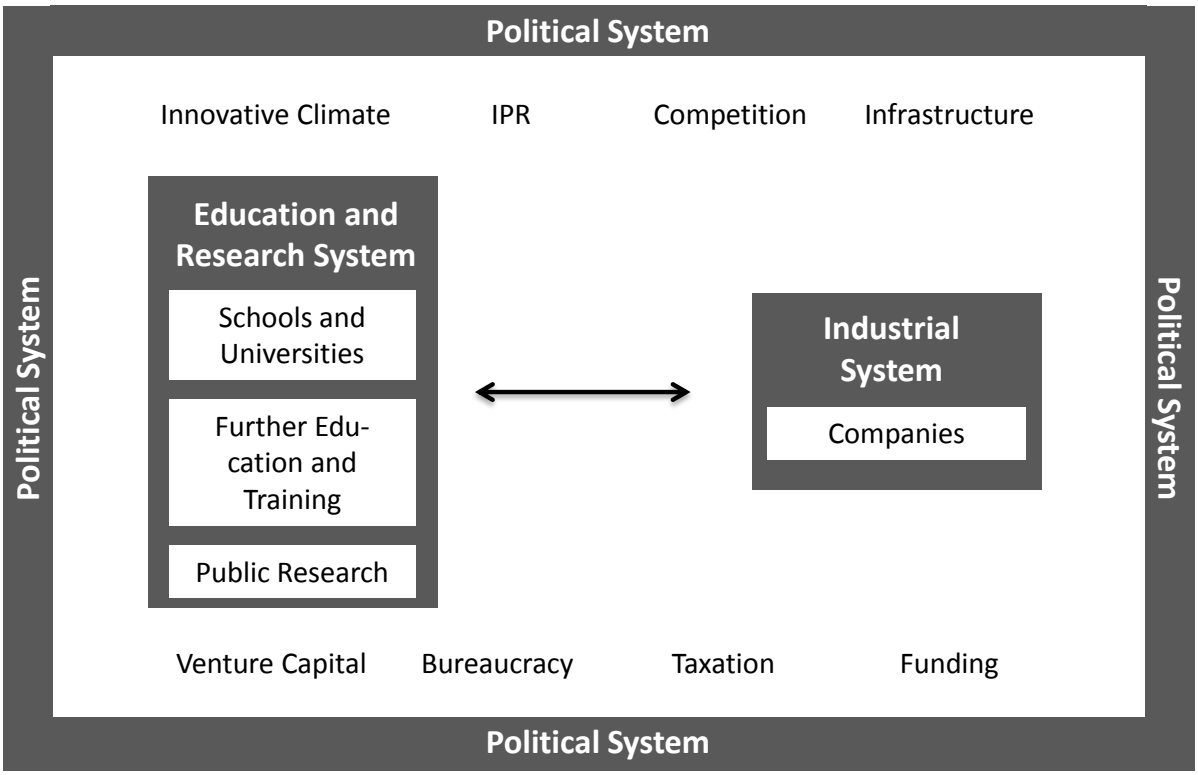

***Figure** Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-1** Innovation systems contain connected innovation actors, embedded into an institutional framework.*

FREEMAN defines the institutional framework of a national innovation system as a "network of institutions in the public and private sector whose activities and

[5] Cf. WERSCHING (2008), p. 2, quoted from EFFELSBERG (2011b), p. 34.
[6] Relevant contributions to the innovation system approach come from FREEMAN (1987) and LUNDVALL (1992). On criticism of linear innovation processes see COOK/MEMEDOVIC (2003), p. 4.
[7] Cf. BLÄTTEL-MINK/EBNER (2009), p. 11.
[8] Cf. COOKE (1998), p. 11.
[9] Cf. BRESCHI/MALERBA (1997), pp. 130 and CARLSSON (1995).
[10] Cf. LUNDVALL (1992), p. 2.
[11] Cf. ETZKOWITZ/LEYDESDORFF (2000), pp. 114.

interactions initiate, import and diffuse new technologies."[12] This framework or structure of an innovation system includes the existing intensity of competition, bureaucracy, available access to venture capital, tax treatment of investments in innovation, the country's infrastructure and the innovative climate which stands for the willingness of the population to accept innovations.[13] These conditions are mainly affected by the country's political system. Innovation actors, which mainly perform innovation activities, can be further differentiated into the industrial system (companies) and into the education and research system.[14] Actors in the education and research system are universities, training institutions and facilities of further education as well as state-owned research organizations, e. g. Max-Planck Institutes or Fraunhofer Institutes in Germany. Thus, a national economy's structure, the actors and the processes are three central components of national innovation systems.[15] This categorization of a national system of innovation is applied in chapter three when the operationalization of national absorptive capacity is discussed.

The innovative capacity of a national innovation system is crucial for its competitiveness. Therefore, a detailed analysis of the innovative capacity's elements is essential. LICHTENTHALER/LICHTENTHALER classify six elements of a company's innovative capacity which can be transferred to the innovative capacity of national innovation systems.[16] To give consideration to the phenomenon of open innovation, internal (closed innovation) and external (open innovation) elements of innovative capacity are distinguished with regard to exploration, retention and exploitation of knowledge. The external view refers to innovative activities outside the considered innovation system. The six individual capabilities are partially complementary and can therefore compensate each other.[17] Figure 2 shows these six elements of innovative capacity.

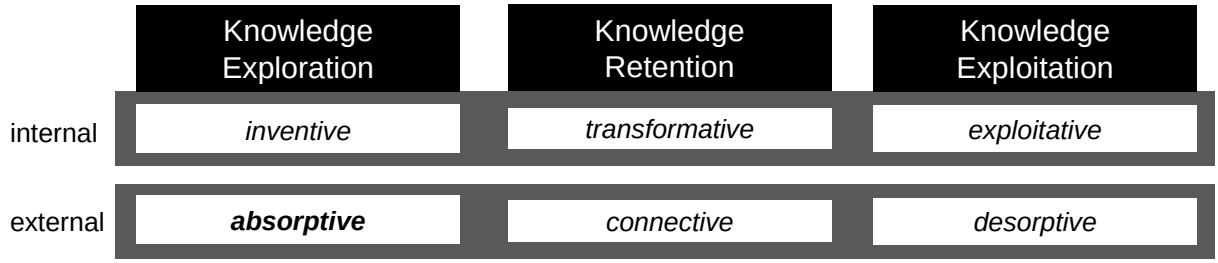

***Figure** Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-2** Elements of innovative capacity of national innovation systems.*[18]

The *inventive capacity* as part of the internal innovative capacity includes the capability to generate knowledge within a system of innovation. This partial capability is well-developed if effective basic research is conducted, which primarily aims to generate new knowledge as a combination of existing knowledge. Sound previous knowledge, the awareness of the market's demands, creativity and investments in in-

[12] FREEMAN (1987), p. 1. NELSON/ROSENBERG (1993), p. 4 define a national system of innovation as a "set of institutions whose interactions determine the innovative performance, (…) of national firms."
[13] Cf. KUHLMANN/ARNOLD (2001), p. 2.
[14] Cf. CRISCUOLO/NARULA (2008), p. 61.
[15] Cf. NIOSI/BELLON (2002), p. 7.
[16] Cf. LICHTENTHALER/LICHTENTHALER (2009), pp. 1315.
[17] Cf. LICHTENTHALER/LICHTENTHALER (2009), p. 1317.
[18] Source: Author's design; based on LICHTENTHALER / LICHTENTHALER (2009), p. 1318.

house R&D can improve this capability.[19] The intensity of *transformative capacity* determines whether the generated knowledge can be preserved for a long time and reactivated on demand.[20] If it is possible to maintain the knowledge base within the borders of the innovation system, this capability to retain knowledge internally is well pronounced. A high employee turnover, e. g. as a result of a low location's attractiveness, can bring about brain drain and is an example of a low development of this partial capability. The *exploitative capacity*[21] includes the application of generated and retained knowledge for new products or services within an innovation system.[22] It can be measured by the duration of transformation into a marketable product (time-to-market).

As part of the external innovative capacity, the *desorptive capacity* contains the exploitation of own knowledge in innovations outside the considered innovation system. Ideas that are not expedient for one's own research and are therefore discarded can be exploited externally by either out-licensing or spin-offs.[23] In contrast to the retention of knowledge within the innovation system, *connective capacity* paves the way for an access to external knowledge without absorbing it. This can be managed by means of virtual networks. If needed, the know-how of the network partners can be accessed within such a network.[24] The capacity to absorb externally generated knowledge, e. g. in R&D cooperations or licensing agreements, is the *absorptive capacity*[25] which will be analyzed in terms of its operationalization within the following sections.

Why is it important to take a closer look at absorptive capacity? High absorptive capacity can positively affect the competitiveness of innovation actors by increasing the speed and frequency of innovations.[26] The capacity to absorb knowledge requires an active confrontation with innovative developments in the corporate environment. Thus, a sensorium for innovative trends[27] can be developed to improve the competitiveness. It also leads to an avoidance of so-called lock-in effects, that is the danger of overemphasizing technologies or fields of research which might lose importance.[28] The higher the absorptive capacity, the easier will be the understanding of external knowledge and the lower will be the costs of know-how transfer, e. g. in R&D collaborations.[29] Consequently, this capacity is crucial to let innovations arise by using external knowledge sources, e. g. in cooperations.[30] Reducing barriers of absorption equals a reduction of transaction costs which is particularly important for emerging countries in catching-up processes, since these mainly depend on the integration of know-how and technologies from abroad due to their underdeveloped R&D infrastructure.[31] Increasing national absorptive capacity

[19] Cf. SHANE (2000), pp. 448.
[20] Cf. GARUD/NAYYAR (1994), p. 378.
[21] LICHTENTHALER/LICHTENTHALER (2009) term this partial capability as „innovative capacity". The term exploitative capacity has been introduced in this article to clarify the differentiation from the generally used term of innovative capacity.
[22] Cf. KHILJI/MROCZKOWSKI/BERNSTEIN (2006), p. 536.
[23] Cf. LICHTENTHALER (2007), p. 83.
[24] Cf. KALE/SINGH (2007), p. 981.; LICHTENTHALER (2008), p. 202.
[25] Cf. COHEN/LEVINTHAL (1990), p. 128.
[26] Cf. HELFAT (1997), pp. 343.
[27] Cf. SCHREYÖGG (2010), p. 11.
[28] Cf. LEVINTHAL/MARCH (1993), p. 104.
[29] Cf. CARAGLIU/NIJKAMP (2008), p. 11.
[30] Cf. EFFELSBERG (2011a), p. I.
[31] Cf. CRISCUOLO/NARULA (2008), p. 57; NARULA (2004), pp. 40.

can also improve competitiveness in industrialized countries, because broadening established fields of research allows faster reactions to changing trends and thus flexibility of innovation rises.[32] Before implications to increase national absorptive capacity can be derived, an operationalization of this concept is necessary.

Operationalization of national absorptive capacity

To capture the capacity for the integration of external knowledge into the innovation process, COHEN/LEVINTHAL developed the concept of "absorptive capacity"[33]. This concept has been theoretically discussed and empirically tested from a corporate perspective. Yet, an adaption of this concept to the level of national innovation systems is still lacking.[34] According to COHEN/LEVINTHAL, three dimensions of absorption can be distinguished.[35] During the phase of identification, external knowledge is screened and its potential benefit for the own innovation process is being valued. The phase of identification is followed by the integration of beneficial knowledge. The objective is to learn and understand external information in order to implement it into the innovation process. The commercial exploitation of the absorbed external knowledge follows upon integration. The higher the absorptive capacity is in these three dimensions, the lower is the effort to integrate external knowledge into the internal technological knowledge base.

In order to measure corporate absorptive capacity in general, cumulative internal R&D-intensity is frequently used.[36] The reason for this approach is a "dual role" [37] of internal R&D: Investments in own R&D improve both the own technological knowledge base and the absorptive capacity, as the improved internal knowledge base reduces the cognitive distance to externally available knowledge. An integration is thus simplified. The lower investments into own R&D, the greater the technological and cognitive distance will be to the innovative environment and the more complex will be the absorption of external knowledge. Since this very general measure for absorptive capacity is not appropriate to derive propositions for the three partial dimensions of absorptive capacity (identification, integration, exploitation), a more differentiated operationalization for national innovation systems will be proposed hereafter.[38] This proposal for an operationalization does not target an absolute measure of absorptive capacity but a relative measure for its individual dimensions in order to compare different national systems of innovation more precisely.

To develop a measurement of each dimension of absorptive capacity, the approach of national innovation systems – presented earlier in this article – is combined with the concept of absorptive capacity. Determinants for the identification, integration and exploitation of external knowledge are derived for each part of an innovation system, in particular the structure, actors and processes. A comprehensive overview of

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[32] Cf. LANE/KOKA/PATHAK (2006), p. 839.
[33] Cf. COHEN/LEVINTHAL (1990), p. 128.
[34] „A systematic account of antecedents of absorptive capacity beyond the dyad, for example at national level, is up till now missing." VAN DEN BOSCH/VAN WIJK/VOLBERDA (2002), p. 29; see also CRISCUOLO/NARULA (2008), p. 57; DAHLMAN/NELSON (1995), pp. 82. and NARULA (2004), p. 5.
[35] For a summary of the discussion about different theoretic models to measure absorptive capacity see EFFELSBERG (2011a).
[36] Cf. MOWERY/OXLEY/SILVERMAN (1996), pp. 77.
[37] Cf. COHEN/LEVINTHAL (1989), p. 569.
[38] Cf. LANE/KOKA/PATHAK (2006), p. 838.

determinants and indicators for the operationalization will be presented in the following discussion. This overview offers possibilities of a measurement. Figure 3 shows determinants of national absorptive capacity which will be clarified and complemented with indicators below.

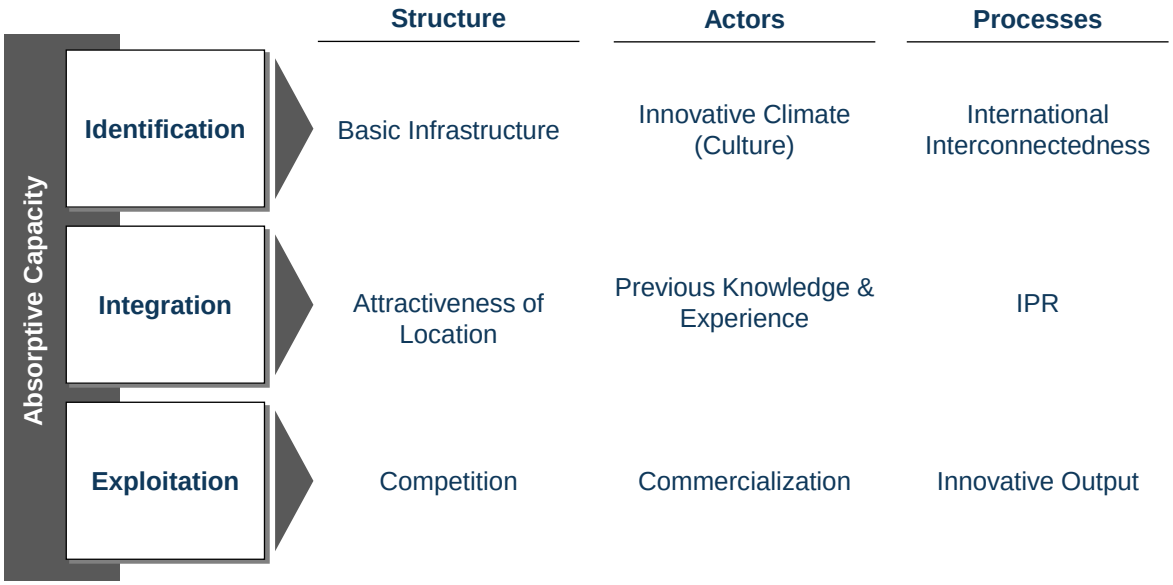

***Abbildung** Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-3** Determinants of national absorptive capacity.*

Identification

The basic infrastructure of a national economy is a crucial *structural* determinant for the identification of external knowledge. This includes Information and Communication Technology (ICT) and mobility.[39] A well-developed ICT and a reliable transportation system simplify the communication with companies or research facilities abroad. Appropriate indicators to measure the basic infrastructure are the share of ICT expenditures as percentage of GDP and measures of the transportation system's quality.[40] The innovative climate, that is the employees' willingness to accept external sources of information, determines the ability of identification in terms of *innovation actors*.[41] "Not invented here"[42]-syndrome designates a phenomenon that describes an inefficient neglect of external sources of information within an innovation process for reasons of the employees' unwillingness. One motive for this attitude might be that the integration of external knowledge can cause a change in the employees' status or position within a company which might result in inefficient outward separation.[43] Existing corporate incentives for the integration of external ideas[44] or the degree of liberality in a national trade policy[45], which avoids a

[39] Cf. GIULIANI (2005), p. 281; NARULA (2004), p. 16.
[40] Cf. ROGERS (2004), p. 581. For further indicators of basic infrastructure see NARULA (2004), p. 32. Indicators for a nation's quality in transportation can be found at DIW (2009), p. 255.
[41] Cf. COLLINS/SMITH (2006), pp. 554; KOSCHATZKY (2001), p. 187 and ZHAO/ANAND (2009), p. 969. An overview of indicators for the innovative climate can be found at DIW (2009), p. 246. For the culture of openness and willingness to change see KROMALCAS/JUCEVICIUS (2009), p. 7.
[42] KATZ/ALLEN (1982), p. 7.
[43] Cf. SCHREYÖGG/VAILLANT (2010), p. 18.
[44] Cf. SCHREYÖGG (2010), p. 19.

discrimination of imports, can be considered as indicators to measure the innovative climate in terms of openness for external ideas within a national economy. The key determinant of the ability to identify external knowledge in terms of *processes* is international interconnectedness.[46] The more intense international networks are established, the higher will be the probability to identify beneficial knowledge. A great variety of international relations increases the variety of potential partners and knowledge suppliers. International interconnectedness can be measured by the share of foreign direct investments, the share of international license fees or the import quota of capital goods as they include technology transfer.[47] The existence of international networks between education and research facilities can be measured by the share of international co-publications per scientist, by the frequency and importance of international scientific exchange on conferences or international research projects.[48]

Integration

The ability to integrate external knowledge, that is to learn and understand others' ideas, depends from a *structural* point of view on the location's attractiveness of an innovation system. A high attractiveness can allure innovative companies to settle in the innovation system. Highly qualified staff will decide to work within attractive locations and as a result, knowledge in terms of personnel is integrated.[49] The attractiveness of a location is, for example, determined by the wage level, the quality of public health[50] and national security. The balance of qualified employees entering or leaving the innovation system and the share of newly established companies indicate the attractiveness of an innovation system. A high level of bureaucracy and a poor access to financial resources can reduce the location's attractiveness for the establishment of new companies. In some sectors, e. g. the aircraft or software industry, the existence of "engine companies" affects the location's attractiveness for new firms. These companies induce the settlement of smaller supplier firms and thus attract the interest of venture capital firms.[51] As a consequence, a self-reinforcing process of new settlements arises within a region and promotes its attractiveness. Path-dependent individual previous knowledge and experience in innovation and cooperation determine the ability to integrate external knowledge in terms of the *innovation actors.*[52] The more often a scientist has been confronted with knowledge-integration in the past, the better it can be handled in the future.[53] Learning success is very high if knowledge which has to be integrated refers to the already existing knowledge base.[54] The cumulative R&D-intensity which is often used as a measure

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[45] Cf. MOWERY/OXLEY (1995), p. 68.
[46] Cf. ZAHRA/GEORGE (2002), pp. 185; GIULIANI (2005), p. 281.
[47] Cf. NARULA (2004), p. 1; MOWERY/OXLEY (1995), p. 70; ROGERS (2004), p. 579; CRISCUOLO/NARULA (2008), p. 61 and for an overview of different kinds of technology flows which require absorption processes see NARULA (2004), p. 8. A summary of indicators of interconnectedness can also be found at DIW (2009), pp. 242.
[48] Cf. GIULIANI/BELL (2004), p. 14; ROGERS (2004), p. 581; KROMALCAS/JUCEVICIUS (2009), p. 12.
[49] Cf. NIOSI/BELLON (2002), p. 9; KROMALCAS/JUCEVICIUS (2009), p. 7.
[50] Cf. ROGERS (2004), p. 580.
[51] Cf. NIOSI/BELLON (2002), p. 14 and p. 17.
[52] Cf. ZHAO/ANAND (2009), p. 967; GIULIANI (2005), p. 281 and VAN DEN BOSCH/VAN WIJK/VOLBERDA (2002), p. 6.
[53] Cf. CRISCUOLO/NARULA (2008), p. 57.
[54] Cf. CARAGLIU/NIJKAMP (2008), p. 5.

for the complete absorptive capacity (see above) is suitable to measure the ability to integrate external knowledge on the actors' level.[55] The communication between partners within R&D collaborations can be improved by a high level of previous knowledge about related topics, because a common language[56] avoids misunderstandings in negotiations and in joint research activities.[57] Previous knowledge in companies and in public research facilities depends on the capability of the national education system.[58] Indicators for an assessment of an education system's quality can be educational input (expenses per person) and educational output. Educational output includes the quality of education in schools/universities. It can be measured by the results of internationally accepted rankings for the assessment of educational institutions, the share of graduates in higher education within the population[59] and the availability of qualified personnel within a country.[60] Experience of innovation actors can be operationalized by the average number of years in service within a specific sector.[61] In terms of *processes*, the ability to integrate external knowledge depends on the protection of intellectual property.[62] High and effective patent protection complicates knowledge transfer and thus constitutes a barrier of integration.

Exploitation

The intensity of competition in a certain industry can be seen as a *structural* basic condition for the ability to exploit external knowledge.[63] A high intensity of competition requires innovating firms to deal with their ability to exploit new ideas. A high share of young start-up companies is an indication for low barriers to entry a market and thus for a higher intensity of competition.[64] The share of university spin-offs can also help measuring the intensity of competition as spin-off companies usually are highly innovative because they pursue the commercialization of ideas coming from public research institutions. A company's or research facility's individual marketing competence decides about its ability to exploit on the level of innovation *actors*. This can be operationalized by the average time-to-market for cooperatively developed innovations which shows the time lag between the end of development and the sales launch. A short time-to-market can indicate a high ability to exploit ideas. Other possibilities to embrace the innovation actors' ability to exploit are to measure the share of expenses for advanced marketing training or the importance of collaborations with customers. A high relevance of cooperative agreements with customers suggests a higher ability to commercialize because a customer's wishes can more easily be taken into account. At *process*-level, jointly developed innovative output shows the ability to exploit external ideas. Innovative output in terms of interactions between innovation actors can be measured by the share of international

[55] Cf. ROPER/LOVE (2006), p. 439; MUELLER (2006), p. 1500; TSAI (2009), p. 765. and CRISCUOLO/NARULA (2008), p. 60.
[56] Cf. GUPTA/GOVINDARAJAN (2000), p. 476.
[57] Cf. VAN DEN BOSCH/VAN WIJK/VOLBERDA (2002), p. 8.
[58] Cf. CRISCUOLO/NARULA (2008), p. 59.
[59] Cf. GIULIANI/BELL (2004), p. 14.
[60] Cf. DIW (2009), pp. 237.
[61] Cf. GIULIANI/BELL (2004), p. 11; NIOSI/BELLON (2002), p. 9.
[62] Cf. NIOSI/BELLON (2002), p. 18; NARULA (2004), p. 16; MOWERY/OXLEY (1995), p. 89.
[63] Cf. MOWERY/OXLEY (1995), p. 86.
[64] Cf. KROMALCAS/JUCEVICIUS (2009), p. 11.

co-patents (applied for with international partners). Public research's innovative output can be measured by international co-publications.

Implications

The transition from a resource-based to a knowledge-based economy requires a high priority of activities to cope with new challenges.[65] Addressing national absorptive capacity should be included. Breaking an innovation system down to its structure, actors and processes between the actors allows a differentiated deduction of approaches to increase national absorptive capacity. These implications can be systemized into the creation of structural conditions, strengthening the actors' individual absorptive capacity and support for international interconnectedness.[66]

Structural conditions

Ensuring a powerful basic infrastructure is an important prerequisite to improve knowledge transfer because it allows more intense international linkages and cross-border communication.[67] The high relevance of measures to ensure fundamental infrastructure is obvious for developing countries which especially depend on knowledge transfer. Promoting competition, e. g. by improving entrepreneurship, is another approach to improve structural conditions of absorption because competitive companies are forced to struggle with "knowledge gaps" and thus might have to integrate external knowledge.[68] A positive attitude towards start-up companies and low bureaucratic barriers for the foundation of innovative companies can improve the attractiveness of an innovation system and thus also the intensity of competition.

Strengthening individual absorptive capacity

An improvement of the innovation actors' existing individual knowledge bases can further raise national absorptive capacity. To improve the knowledge base of the industrial and education/research system, investments in basic research and trainings are needed.[69] In this way, innovation actors' previous knowledge, experience and ability to exploit can be broadened. The success of absorption is biggest if external knowledge has references to the existing knowledge base. These references are more likely to exist if education is enhanced. The lower the cognitive distance to new knowledge, the higher is the probability to avoid the "Not invented here"-syndrome.

International interconnectedness

Besides the improvement of an existing knowledge base, an expansion of it can be reached by international linkages.[70] Economic policy's task is to create framework

[65] Cf. OECD (1999), p. 3.
[66] Cf. ROTHAERMEL/HESS (2007), pp. 898.
[67] Cf. KOSCHATZKY (2001), p. 305.
[68] Cf. MUELLER (2006), pp. 1506; NARULA (2004), p. 16.
[69] Cf. MUELLER (2006), p. 1506; NARULA (2004), p. 16 and NIOSI/BELLON (2002), p. 15. Improving knowledge of foreign languages also increases individual absorptive capacity; see ROGERS (2004), p. 579.
[70] Cf. MOWERY/OXLEY (1995), p. 88.

conditions which eliminate barriers of international cooperation.[71] Collaborations can fail if bureaucratic rules complicate the enforcement of patents, if basic information about legal conditions is lacking or if a partner for a joint innovation project is searched but no adequate partner is found. Providing contact- or information platforms is a possible support to avoid those failures.[72]

Limitations

In order to assess the approach of operationalizing national absorptive capacity, it is important to consider its limitations. Conceptual limitations deal with a critical analysis of the theoretical framework. Limitations of operationalization deal with problems in terms of measurement and acquisition of data.

Conceptional limitations

An important conceptual limitation can be found if the analysis unit of a national innovation system is scrutinized. The borderline between different innovation systems in this case corresponds to national borders. This choice is questionable because national borders blur in the course of an increasing integration of individual states into confederations, such as the European Union. Different national policies of innovation hence are aligned and companies are getting more and more internationally interdependent which distorts the analysis of national systems of innovation. Multinational enterprises can globally access their resources. This makes it difficult to separate national from international contributions for innovations.[73] In case of an international knowledge transfer between individual units of a multinational enterprise the isolation of a cross-border absorption is difficult. In order to derive economic implications, the unit of analysis should equal the institutional framework which decides about the innovation system's structure and which has the sovereignty to influence rules. Hence, an analysis on the level of national innovation systems is legitimate but has certain limitations.

Another limitation of the presented concept is that both the exploitative and the desorptive capacity include the commercialization of (internal and external) knowledge. These can hardly be distinguished from the dimension "exploitation" as part of absorptive capacity. However, measuring the ability to exploit is reasonable to capture absorptive capacity, because thereby also output measures (e. g. patent data) are taken into account.

Limitations of operationalization

Patent data allow an objective measure of innovation activities, but they also have some disadvantages. A patent merely shows the innovation that has been applied for at the patent office. It does not show the innovation's commercial value.[74] Measuring innovation activities in patents thus only partly displays the real innovation activities. If an application for a patent is not chosen for strategic or financial reasons, an

[71] Cf. NARULA (2004), p. 16.
[72] Cf. KOSCHATZKY (2001), p. 305.
[73] Cf. MAYNTZ (2009), p. 8; NARULA (2004), p. 18.
[74] Cf. NEGASSI (2004), p. 368.

innovation is not recorded.[75] It is especially important to note that a comparison of patent data from different countries partly shows differences in national patent laws: Costs for patent application, the extent of the guaranteed IP protection or a company's conduct in terms of patenting might differ internationally.

Another limitation is that the derived determinants are not exhaustive or non-overlapping but should rather be understood as possibilities of operationalization which ought to be validated in future research.

Conclusion

An increase in globally networked innovation activities and limited resources[76] make the innovative capacity of national innovation systems more and more dependent on the ability to identify relevant external knowledge, integrate it into the own innovation process and exploit it commercially. The concept of absorptive capacity which is being discussed intensively in literature can also be applied to national innovation systems. For this purpose, this article systemizes an innovation system into its structure, the involved innovation actors and processes. The absorptive capacity of national innovation systems thus covers all structures, actors and processes that influence the ability to identify, integrate and commercially exploit external knowledge. A minimum of national absorptive capacity is necessary to benefit from international technology transfers. In order to compare the absorptive capacity of different national innovation systems and to investigate potential improvements, possibilities for a differentiated operationalization of each dimension of absorptive capacity have been pointed out. Implications to improve national absorptive capacity can be categorized into an improvement of structural conditions, a strengthening of individual absorptive capacities and an intensification of international interconnectedness.[77]

This approach provides a basis for a more precise valuation and operationalization of national absorptive capacity. These implications can help to improve national innovativeness especially in developing countries which depend on an intense technology transfer from industrialized countries. Within the context of the identified limitations, several fields of further research have been presented.[78] For example, the consideration of national innovation systems could be extended to supra-national innovation systems, such as the European Union.

[75] Cf. FABRIZIO (2009), p. 265.
[76] Cf. NARULA (2004), p. 5.
[77] Cf. GIULIANI (2005), p. 284.
[78] Cf. CRISCUOLO/NARULA (2008), p. 70.

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