A VIEW ON THE NATIONAL CAPACITY OF SCIENTIFIC KNOWLEDGE ABSORPTION

STELIANA SANDU*
IRINA ANGHEL**

Abstract
The concept of the Absorptive Capacity has been approached in numerous theoretical and empirical studies during the last 20 years, covering multiple facets of the relationships between various external sources of knowledge and the capability of a firm, sectors or national economy to identify, assimilate and apply external knowledge in order to increase its economic performance.
Absorptive capacity (AC) has been extensively analyzed at the firm level, but significantly less consideration has been given to the AC at the national level. National capacity of absorption is definitely much more than the simple aggregation of the individual companies' capabilities or of the sectoral capacities, due to many systemic complex factors that may add to, or detract from the national AC: the multiplication and propagation effects, access facilities the stock of national and international knowledge, various synergetic mechanisms, knowledge spillovers etc.
Based on the literature available, the authors attempted to design a system of indicators to quantify the relative scientific knowledge absorption capacity of different European countries compared with the EU average and the EU leader. Further on, these indicators will be aggregated, providing a fundament for comparative weighted estimations of the national absorptive capacities for scientific knowledge across EU.

Keywords: *national absorptive capacity, R&D activity, National System of Innovation, system of indicators*

Introduction

The concept of "absorptive capacity" becomes more and more significant, in theory and practice, in the context of increasing innovation performance within a knowledge-based economy. Based on a detailed analysis of 285 studies on absorptive capacity, a very interesting paper published in 2006 (Lane et al, 2006) states that "absorptive capacity is one of the most important constructs to emerge in organizational research in recent decades". According to another more recent empirical assessment, the number of research papers on the "absorption capacity, published, between 2005-2009 in the top ten journals in business management, has more than doubled compared with 1990-2005" (Jimenez et al, 2010). Along the 2010 year, the literature has also been enriched with many other works on this issue.

If Cohen and Levinthal, the pioneers of "absorptive capacity" construct, defined it as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990), further developments of the concept extended the notional sphere, adding new dimensions, determinant factors, and applying it to other levels of aggregation as well (from firm level, to industry or national level).

Most of the work on the issue of AC is focused at the firm level, where learning processes and technological changes effectively take place and, "little research has been done to examine the determinants of a country's absorptive capacity and its relationship with national R&D activities, and the general characteristics of the international technological environment"(Criscuolo and Narula, 2002).

** Ph.D Candidate, research assistant in " Economics of R&D and Innovation" Department, Institute of National Economy, Romanian Academy.

It is important to understand that, while learning and absorption take place at the firm level, the success or failure of individual firms occurred in orchestration with an entire system (Narula, 2004) of interconnections and interdependences between the firms from the same sectors or from different sectors, or between firms and other non -firm institution that could facilitate or hinder knowledge absorption. On the other hand, firms are connected to the international stock of knowledge that could be assimilated only if a country has an adequate national absorptive capacity.

Based on the literature available, we designed a system of indicators for quantifying the relative national absorption capacity of different European countries compared with the EU average and the EU leader. Further on, these indicators will be aggregated, providing a fundament for comparative weighted estimations of the national absorptive capacities across EU.

1. Literature review: from micro to macro level approaches of absorption capacity

In our attempt to construct a system of indicators for assessing the relative level of the national AC of EU countries, we tried to find the valuable ideas in the literature of AC at firm level that can be extrapolated and applied at national level.

Thus, the theoretical background for our work is derived from the main thesis of some of the most visible papers on the issue of AC, regarding the conceptual evolution and its main determinants. Based on ideas from some significant works about AC at the firm level and following the model of one of few works that approached the absorption capacity topic at macro level (Narula, 2004) we tried to extrapolate the main theoretical determinants from micro to macro level

It is worthy to note, from the most cited works of Cohen and Levinthal (Cohen and Levinthal, 1990, 1994), the multidimensionality of the concept that springs out from its processual nature: the knowledge, in order to be effectively absorbed, should be firstly *acknowledged*, than *assimilated* and, at last, *converted* to commercial gain. Moreover, there is indirectly suggested a conditional correlation between the company's prior accumulated knowledge and the absorptive capacity. In other words, AC is cumulative and past dependent, and its current accruement allows for future higher increasing rates.

Cohen and Levinthal (1990) also differentiate between the absorptive capacity at individual and organizational level, stating that the last one cannot be a mere sum of the members' absorptive capacities. According to the authors, gaining absorptive capacity infers knowledge transfer processes, from the external environment to organization, as well as within the inner environment of the company. Therefore, high significance is given to the company's specific mechanisms for the stimulation of communication and interaction between its employees.

By extrapolation, we can say **that the national absorption capacity** is certainly not a simple sum of AC of national firms or industries. At macroeconomic level, there are multiple specific factors with determinant impact on the magnitude and dynamics of the AC: multiplicative effects, R&D spillovers, national potential of high educated people, development of national RD system, institutional intermediate for knowledge transfer that support interactions between the companies, as well as between the different components of the national RDI system, the effectiveness and coverage of various public supportive mechanism etc. There are "synergic effects, inter-firm and inter-industries influences, due to systemic and institutional elements that facilitate absorption" (Crisculo, Narula, 2002).

In most of the authors papers is mentioned the cumulative feature of the learning process and that the learning performance is greatest when the object of learning is related to what is already known. Diversity of knowledge plays an important role at the firm level. A diverse background provides a more robust basis for learning. **At the national level**, the assimilation of external knowledge is more difficult because the quantity, quality and diversity of knowledge are higher than at the firm level. On the other hand, the accumulation of knowledge is depending also on the stage of technological development and the distance to technological frontier. The ability of a country to assimilate knowledge spillover will be changed with his level of development and is. For a given level of AC, the farther from the frontier a country is, the easier it would be to assimilate foreign knowledge.

A firm's ability to exploit external knowledge is often generated as a by-product of its own R&D. Through its R&D activities, a firm develops organizational knowledge about certain areas of science and technology. The extent to which it invests in absorptive capacity for a given area is a function of the relevance of that area of science or technology to the firm's strategy. **At the national level**, because external knowledge is more and more high tech, more diverse, and more scientific, the assimilation of knowledge from abroad needs an increasing financial and human R&D effort, both for creation of knowledge and for acquisition and efficient integration of external knowledge into the national production.

Criscuolo and Narula (2002) pointed out the significance of human capital, as a core determinant of absorptive capacity both, at the firms and also at the national level. But, more than at micro level, at macro level a large stock of qualified workers is not a sufficient condition for assimilate external knowledge. The institutions, the incentive mechanisms, R&D market regulations, intensity of relationship and degree of cooperation between firms and external producers of knowledge (universities, public research lab, capacity of networking) could facilitate or hinder the development of the potential absorption capacity.

An important aspect that we are having in view is the distinction between potential and realized absorption capacity made by Zahra and George (2002). The potential absorptive capacity represents the ability to identify and obtain important knowledge that is critical to its main activity field. The organizational routines and processes that allow for analyzing, processing, interpreting and understanding the acquired information smooth knowledge assimilation. The *effective* absorptive capacity refers to the transformation and effective use of the new knowledge through its integration and capitalization towards organizational objectives.

Both aspects are very important in grasping the level of a company's absorptive capacity, even if they are related to different organizational characteristics and different transmission channels. The potential AC depends on the availability of relevant knowledge sources and the type of partners the company has access to, while the realized AC is dependent on the ability to appropriate new relevant technology.

Trying to review and re-conceptualize the AC, the authors emphasized the dynamic nature of the absorptive capacity, which follows the processes and the routine of the company but also triggers change and organizational development. Therefore, the absorptive capacity is defined as a "set of organizational routines and processes whereby a company acquire, assimilate, transforms and uses knowledge in order to create a dynamic organizational capacity". The absorptive capacity represents, hence, the capacity to assimilate and manage the technological and scientific knowledge in order to improve the innovative performance and competitive advantage**.** The three processual components of the AC mentioned by Cohen and Levinthal, the authors bring in a new element, that is *knowledge transformation*. This may be considered **at the national level** as integrant to the *capitalization* stage of the process, and implies the capacity to develop and enhance the match between the prior knowledge and the newly adopted and assimilated one.

Lane, Koka and Pathak (2006, p. 856) added new aspects for a more detailed definition, such as: "absorption capacity is a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through **exploratory learning**, (2) assimilating valuable new knowledge through **transformative learning**, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through **exploitative learning**". Each phase of this process is determined by internal and external factors. **At the national level**, the learning process is more complex, including formal education and skills formation but also many informal sources of learning.

The complexity of the absorptive capacity infers serious difficulties in defining a direct measurement system. Moreover, the few approaches to quantifying the AC and the determining factors are heterogeneous in methodology and results.

The estimation model designed and used by Tobias Schmidt (2005, 2010) provides an empirical analysis of the intensity and of the mechanisms of the impact of the most significant national AC determinants.

The author refers to three types of absorptive capacity, according to the different types of knowledge to be absorbed:

- Absorptive capacity for intra-industrial knowledge
- Absorptive capacity for inter-sectoral knowledge
- Absorptive capacity for scientific knowledge.

Therefore, AC for intra-industry knowledge is necessary for obtaining relevant knowledge from companies inside the industry; AC for inter-industries supports the absorption of knowledge generated within other activity fields; while AC for scientific knowledge attracts knowledge that becomes available to the business sector through cooperation with universities and public / private research institutions.

The results of the study indicate high correlation between the absorptive capacity of an organization and the personnel involved in intramural R&D, which seems to have an even greater impact on AC than the expenditures for research and innovation. We keep out this idea because at macro level the learning processes are more important but, also more complex and dynamic. An interesting assertion that could be extrapolated at **national level** is referring to the fact that organizational ability to assimilate and use external knowledge depends not only on the R&D expenditure level, but, also, on the stock of knowledge priory acquired and incorporated in the human capital and individual capacities. The organizational structure and managerial practices and also the type and intensity of the interactions and cooperation with external partners (other companies, universities, research institutes, etc) are often more important. A most important assertion that inspired us for this topic is the distinction between the three-mentioned types of absorption capacities. Our paper is focused on the third type, namely absorptive capacity for scientific knowledge.

All the determining factors for the level of absorptive capacity are interdependent, intercorrelated and, even, complementary: the intramural R&D activity depends on the educational level of the employees, and organizational knowledge is very tightly connected to the management strategies and methods.

2. The absorption of scientific stock of knowledge from universities and research institutes

The universities have an increasingly important mission to create and transfer knowledge through various mechanisms, through patents, licenses, and spinout or by collaborative research with industrial sector organizations. Public research institutes and universities generate scientific knowledge that is very seldom directed towards specific users. Therefore its effective value will be dependent on the capacity of the potential receptors to assess, assimilate and exploit it (Abreu et al, 2010).

Whatever the external knowledge source, the absorption and assimilation of new knowledge is contingent on the organization's effort, expertise and pro-active attitudes of the researchers from within. Thus, the absorptive capacity becomes even more important for an effective knowledge transfer from the public research sector to industry.

On the other hand, the linkages between research and industry are an important determinant of AC. Some empirical studies proved that more companies develop sustained relationships with research institutes; the more increase their absorptive capacity (Schmidt, 2005). The more intensive the connections between companies and scientists, university researchers and research institutes personnel, the more capable will the company be to take advantage of the research results in its innovative activity. At the same time, as in a virtuous circle, high absorptive capacity improves the company's ability to exploit and turn to value new scientific *fundamental* knowledge.

The capacity to absorb research results provided by universities and research institutes is particularly dependent on the factors that are specific, intrinsic to the potential receptor. That is why, **at the national level**, the rate of tertiary education personnel, the share of employees which play the interface between the scientific knowledge source and the organization, the level of sustained involvement in own R&D activities and the stock of similar knowledge already acquired are some of the most important elements that would make the available knowledge appropriable.

It is worth mentioning that, in order to build a common platform between internal and external research, necessary for an effective knowledge transfer, the company should encourage its employees to acquire a common scientific language with knowledge providers, that would improve the ability to acknowledge, absorb and exploit the scientific research result. Higher intensity of research performed within the company is a good lever for a more effective and timely turn to profit, through innovation, of the scientific research results obtained in universities and research institutes.

In order to capitalize on scientific knowledge, the level of absorptive capacity should be higher than in case of other types of knowledge. A higher absorptive capacity is closely related to the organization's ability to use fundamental scientific knowledge provided by its external environment.

A very important element of the cooperation between the public research sector and industry, at national level is represented by the mediators, support institutions whose mission is to smooth and facilitate the connection between the knowledge creators and receptors, to encourage the business sector receptivity and absorptive efforts. This is an explanation for the numerous references in the literature on this field, on the significance of clusters, technological platforms, scientific knowledge transfer networks, partnerships between universities, public research units and potential users in the business sector (Abreu et al, 2010).

3. An attempt to design a system of indicators for evaluating the relative absorption capacity of EU countries.

Our starting point in designing the system of indicators for relative absorption capacity evaluations is the valuable ideas we have fund in literature about determinants and influencing factors of AC.

Making a deep analysis of the literature previous 2002 year, Tobias Schmidt
(2010) identified the following determinants of absorption capacity mentioned in the most of the studies:

a. **Research and development activity**, expressed by the indicators as R&D intensity, continuous R&D activity and existence of an laboratory inside a firm.

b. **Prior related knowledge.** Schmidt remarks that "the cumulative nature of absorptive capacity has not taken into account by a lot of empirical studies, despite it is extensively discussed in the literature on knowledge and spillover. In his opinion, the level of education and training of the firm emplowees express the cumulative nature of AC.

c. Organizational structure and human resources management practices

In accordance with Cohen and Levinthal, the author refers to ability of an organization as a whole, to stimulate and organize the transfer of knowledge across departments, function and individual, its tools and incentives to stimulate knowledge exchange and learning. The results of Tobias Schmidt empirical estimations prove that employees with higher education, continuous R&D activity and informal contacts have a positive influence on absorptive capacity but R&D intensity but not contributes to the building of AC but helps to develop skills and knowledge stock that contribute significantly to exploitive capacity. Broad dissemination by papers, seminars and workshops influences positively scientific knowledge absorption: "the more knowledge is translated the higher is probability to integrate into the existing knowledge base utilized in innovation process" (T.Schmidt, 2005, p.20).

A recent paper (Murovec, Prodan, 2009) proposes a direct measure of absorptive capacity and a wide range of variables in a cross-nationally tested structural model. The results of estimations show that there exist two kinds of absorptive capacity: demand-pull and science-push. Their most important determinants proved to be internal R&D, training of personnel, innovation co-operation and attitude toward change. Both kinds of absorptive capacity are positively related to product and process innovation output.

One of few but the most relevant work focused on national absorptive capacity is that already cited, of Rajneesh Narula (2004).In his construct the national absorption capacity is more than a simple aggregation capacity of its firms or its industries, other additional multiplicative effects, which, although insignificant at the firm level, became very significant at the national level.

The national absorption capacity concept refers to "the ability to search and select the most appropriate technology to be assimilated from existing ones available, as well as the activities associated with creating new knowledge. Absorption capacity also reflects the ability of a country to integrate the existing and exploitable resources-technological opportunities-into the production chain, and the foresight to anticipate potential and relevant technological trajectories. The international technological environment therefore affects this ability (Narula, 2004).

The main sources of knowledge has to be absorbed at national level are: foreign knowledge coming from foreign suppliers and customers, foreign non- firms organizations, as universities, public research institutes, stock of knowledge in the domestic firm sector and in the MNE subsidiaries, stock of knowledge in the domestic non-firm sector. Industrial policy regime, including competition policy, governmental funding organizations, government funding for education, intellectual property regime are environmental factors that influence the transforming of potential AC into a realized, effective AC.

National absorptive capacity is taken to be a function of the distance from the technological frontier, which is defined as the difference in knowledge stock at the country level and at the frontier.

As the author conclude, his construct should be seen as a tentative that provide a basis for more accurately estimating national absorption capacity, remaining considerable lacunae which deserve further theoretical and empirical analysis.

As an answer to this provocation, we attempt to add a modest contribution to the statistical estimation of the variation among the EU member states, regarding the absorptive capacity for scientific knowledge in the business environment.

We, hereafter, propose a methodology for a statistical estimation of the variation among the EU member states, regarding the absorptive capacity for scientific knowledge in the business environment. This follows the construction and calculation of a composite indicator that would integrate and express the impact of the different categories of determinants of the absorptive capacity at the national level.

Thus, the inconvenience of using a single indicator for the absorptive capacity of R&D results would be avoided, as multicriterial synthetic indicators can express different quantitative and qualitative aspects of the analyzed issue (Mitrut et al, 2010).

The resulting index will represent only an assessment of the relative position of the level of AC of each statistical unit among the EU member states, without providing an absolute quantitative value of their absorptive capacities. Yet, it may render valuable information, as it allows for multicriterial ranking of the statistical units, as well as for quantifying the gaps among them.

The smoothness, effectiveness and intensity of the scientific knowledge absorptive process depends, largely, on the quality, time and relevance of the knowledge generated by knowledge producers (which are, mainly, the RDI institutes, university centers and, seldom, even the business sector); on the ability of potential knowledge users to understand available knowledge, to assess its economic potential, to absorb it, to transform it and turn it to commercial value; on the intensity and functionality of the cooperation/communication network established within the National Innovation System between various actors; and, on the performance of the public support for RDI, for knowledge creation and knowledge transfer.

Choosing appropriate indicators for each factor-group (see figure 1) has proved a difficult task, as serious difficulties and limitations are imposed by data availability. As far as data source is concerned, we have drawn mainly on the Eurostat database and the Innovation Union's performance scoreboard for Research and Innovation (Innovation Union Scoreboard 2010)

The capacity of generating scientific knowledge may be expressed through input indicators – variables referring to national human and financial resources employed in R&D, such as the total R&D personnel (in full-time equivalents) as a % of total employment, total expenditures on R&D (GERD), and, through output indicators, e.g. scientific publications among the top 10% most cited publications worldwide, international scientific co-publications per million population, number of patent applications.

The effective capacity of the business sector to absorb and assimilate scientific knowledge is determined by the available and employed human and financial resources. We have chosen: business R&D expenditures as % of GDP, R&D personnel employed in the business sector (% of total employed), highly educated human resources available and effectively employed in science and technology, persons with tertiary education attainment, PhD students and graduates.

The openness of the business sector towards cooperation with knowledge providers, be they in the same or in different industries, in the universities or R&D institutes, is the main factor that stimulates and ensures good, productive linkages between scientific knowledge producers and users. The chosen indicators estimate the innovative enterprises cooperating with other actors, among which we are interested especially on cooperation with public research institutes and universities, business expenditures allotted to R&D performed in public research labs and institutes, private-public cooperation in publishing.

The public support for AC at national level, that means the legislative and financial support proves very important in ensuring a favorable environment for high-quality and relevant new scientific knowledge, for high capacity of absorption and for good cooperation relationship between knowledge creators and users. We chose to express it through various variables, such as the public expenditure assigned to R&D (GBOARD), the share of R&D performed in the private sector with public funds in total private R&D activities, % of enterprises that received any public funding, total public expenditure for tertiary education, as % of GDP.

Therefore, the level of the National AC may be expressed through a function of four groups of factors: (a) scientific knowledge creation capacity, (b) employed and available resources for scientific knowledge absorption at the company level, (c) the linkages between scientific knowledge providers and users and (d) the public support for knowledge growth.

The final composite index will aggregate the four synthetic indicators calculated for each block of indicators. At their turn, each sub-group synthetic indicator, if analyzed, may bring forth specific information on the strengths and weaknesses that may amplify or hinder the development of an economy's absorptive capacity.

Using and aggregating 22 different indicators raise the heterogeneity issue, which may be handled through normalization (min-max method). The variation range is standardized, limited to interval (0,1) no matter the nature or initial variation of the given indicators. Bringing them to a common scale may compare data on different scales.

After normalization, the readjusted values for each indicator are:

$I_i^j = \dfrac{X_i^j - X_{\min}^j}{X_{\max}^j - X_{\min}^j}$, if there is a positive correlation between the factor expressed through indicator X_i and the level of AC, and

$I_i^j = \frac{X_{\max}^j - X_i^j}{X_{\max}^j - X_{\min}^j}$, for indicators which are in inverse ratio to the absorptive capacity level,

where X_i^j is the absolute value of „j" indicator for the EU state „i", $X_{\min}^j$ and $X_{\max}^j$ represents the minimum and the maximum values of „j" indicator.

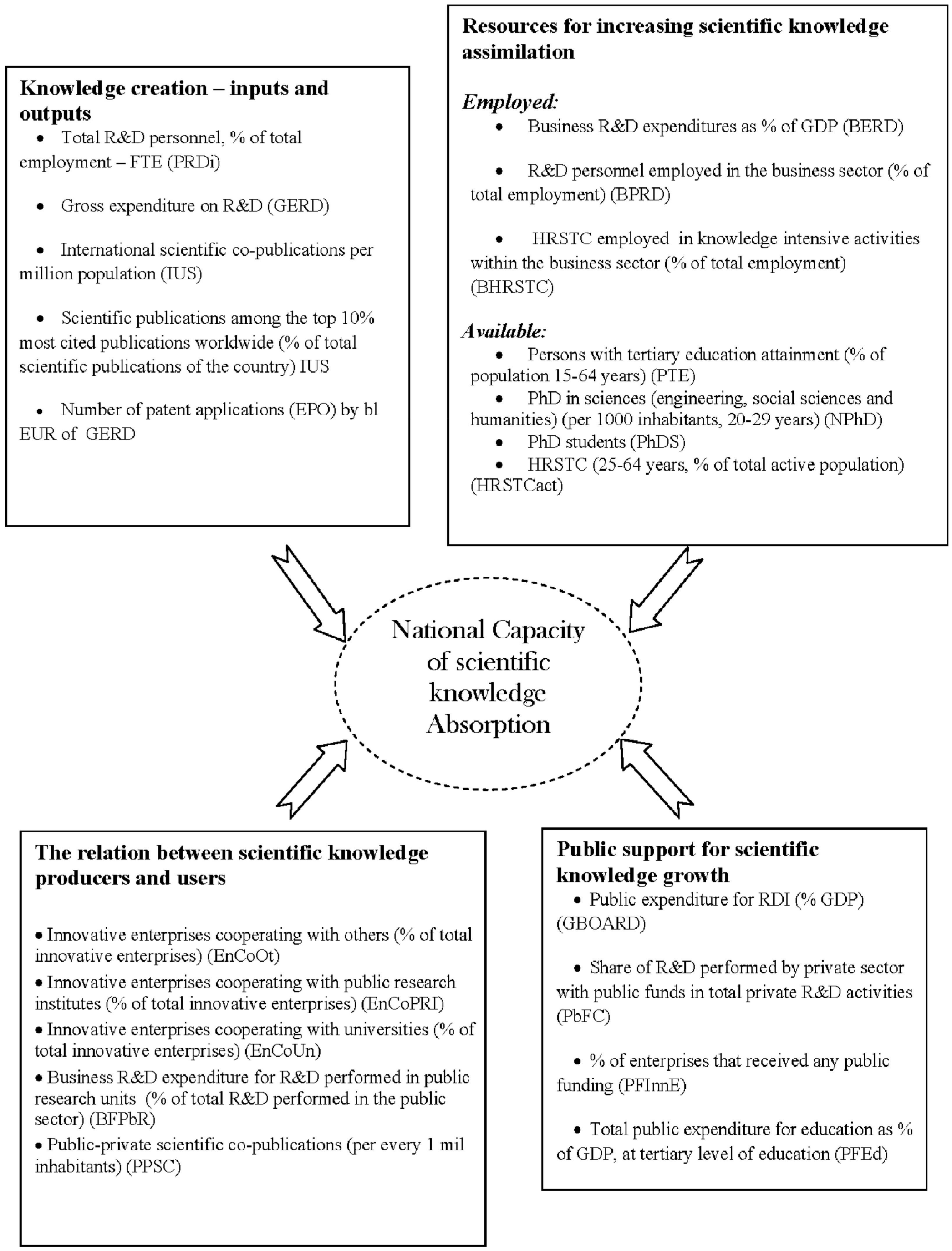
Further on, for each statistical unit „i" (EU member state) and for each indicator group („g"), a synthetic group index $\boldsymbol{I_g^i}$ will be determined as a weighted arithmetic average of the component indicators: $\overline{I_g^i} = \frac{\sum_{j=1}^{m} I_j^g \cdot p_j^{\,g}}{100}, \quad i = \overline{1,n},$ where $p_j^{\,g}$ represents the weight of indicator „j" belonging to the factor group „g" The specific weights granted to each indicator in a sub-group shall sum up to 1.

In calculating the final composite indicator for each statistical unit „i", each group of indicators will also be given a specific weight, as their impact on the level of NAC is relative . The statistical weights sum shall equal 1, as well. ($\sum_{g=1}^{5} \boldsymbol{p_g} = 100\%$)

Therefore, the Absorptive Capacity relative composite index for the EU state „i", will eventually be calculated as $\overline{\boldsymbol{I}}_{\boldsymbol{i}} = \frac{\sum_{g=1}^{m} \boldsymbol{I_g^i} \cdot \boldsymbol{p_g}}{100}, \quad \boldsymbol{i} = \overline{1,\boldsymbol{n}}$.

The value of the composite index can be of, maximum, 1 – if the same unit scores the highest regarding all indicators and of minimum 0, if the same unit ranks the lowest for all indicators.

Figure 1. Indicators for evaluating a relative level of national AC within the EU



4. Conclusions

Indicators suggested in the figure nr.1 allow for international comparisons between the different relative national absorption capacities of scientific knowledge of the EU member states. This would provide supplementary effective tools for better assessment of national performances in innovation and competitiveness, of the gaps between countries and of the factors that may stimulate or hinder the capacity of an economy to absorb new available knowledge, to assimilate it and effectively use it towards higher competitiveness and productivity.

Our proposal of a methodology for a statistical estimation of the variation among the EU member states, regarding the absorptive capacity for scientific knowledge in the business environment is a modest contribution to the macro level literature on the absorptive capacity that has been scarcely and somehow inconsistently approached, with limited empirical, econometric applicability.

This follows the construction and calculation of a composite indicator that would integrate and express the impact of the different categories of determinants of the absorptive capacity at the national level.

Thus, the inconvenience of using a single indicator for the absorptive capacity of R&D results would be avoided, as multicriterial synthetic indicators can express different quantitative and qualitative aspects of the analyzed issue.

The papers contribute to the clear up of specific aspects of absorption capacity of scientific knowledge, constructing a system of AC components composed of four groups of indicators expressing: the capacity of generating scientific knowledge; **t**he effective capacity of the business sector to absorb and assimilate scientific knowledge; the openness of the business sector towards cooperation with knowledge providers and the public support for AC at national level.

Bibliographic references

- Abreu, Maria, Grinevich, Vadim, Hughes, Alan, and Kitson, Michael, "Knowledge exchange between Academic and Business, Public and Third Sectors". Academic Survey Report, University of Cambridge, 2010, p.
- Cohen, Wesley. M., and Levinthal Daniel A., "Absorptive capacity: A New Perspective on Learning and Innovation", in Administrative Science Quarterly, vol.35, nr.1, Special Issue:Technology, Organizations and Innovation, March 1990, p.128-152.
- Criscuolo, Paolo and Narula, Rajnees, "A Novel Approach to National Technological Accumulation and Absorptive Capacity: Aggregation Cohen and Levinthal", paper presented to DRUID Summer Conference, 7 May 2002
- Jimenez, Bertha, Angelov, Bojan, and Rao, Bharat, "Service Absorptive Capacity: Its evolution and Implications for Innovation", in PICMET 2010 proceedings, July,18-22, Phuket,Thailanda, 2010, p.2937-2949
- Lane, Peter, Koka, Blaji R., Pathak Seemantini, "The Reification of Absorptive Capacity: A critical Review and Rejuvenation of the Construct", in Academy Management Review, no.4, 2006, p.833-863.
- Mitrut, Constantin, Zaman, Gheorghe, Goschin, Zizi, and Constantin, DanielaL., "A Composite Index of R&D Absorption Capacity. Spatial Configuration in Romania", Economic Computation and Economic Cybernetics Studies and Research (www.ecocyb.ase ro), no.1/2010, vol.44, pp. 5-20
- Murovec, Nina, and Prodan, Igor, "Absorbtive capacity, its determinants and influence on innovation output: Cross section cultural validation of the structural model", in Technovation, vol.29, issue 12, December 2009, p.859-872
- Narula Rajnees, "Understanding Absorbtive Capacities in an Innovation Systems context: Consequences for Economic and Employment Growth", ILO background paper for the World Employment Report, 2004
- Zahra, Shaker A, and George, Gerard, "Absorptive Capacity: A Review, Reconceptualization and Extension", in Academy of Management Review, vol.27, no.2, 2002, p185-203.