Institut für Volkswirtschaftslehre

Volkswirtschaftliche Diskussionsreihe

Recent Trends in the Research on National Innovation Systems

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Beitrag Nr. 254, November 2003

Recent trends in the research on national innovation systems

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Abstract. In this paper, we give an overview on recent developments in the research on national innovation systems (NIS). Essentially, we identify three development lines of the concept. These are policy-oriented studies that frequently combine the NIS approach with the terminology of corporate benchmarking, contributions to formalize the concept of NIS through descriptive or analytical models, and NIS studies of countries beyond the group of highly industrialized economies. It follows from the analysis of these research trends that the concept has developed in distinctive directions. In international comparisons of innovation systems, heterogeneity in the structure of the systems is only marginally taken into account, an aspect that may reduce the explanatory power of such system-level comparisons. Contrary to this, historically grown organizational and institutional structures are extensively described and considered in NIS studies of industrializing countries, a characteristic which ties up with early studies of national innovation systems.

Key words: innovation, national innovation systems, comparative studies

JEL classifications: O110, O310, O500, P510

1. Introduction

The national innovation systems approach has been introduced in the late 1980s (see Freeman (1987), Dosi et al. (1988)) and further elaborated in the years thereafter (see Lundvall (1992), Nelson (1993), Edquist (1997)). A national innovation system can be perceived as a historically grown subsystem of the national economy in which various organizations and institutions interact and influence each other in the carrying out of innovative activity. In the NIS approach, innovative activity is usually analyzed in a broader sense: Instead of focusing solely on the number of introduced product and process innovations in a country, it encompasses also research and development efforts by business firms and public actors as well as the determinants of innovation like, for instance, learning processes, incentive mechanisms or the availability of skilled labor.

So the systemic approach to innovation is based on the notion of non-linear and multidisciplinary innovation processes, and interaction on the organizational level as well as the interplay between organizations and institutions are given central interest.

At the outset, the NIS approach has been applied to reveal the structure of and the main actors involved in innovation processes in a couple of highly industrialized countries as well as in a smaller number of emerging countries. Typically, these early NIS studies (see Nelson (1993)) did not follow a formalized structure and concentrated at one country at a time.[1] Due to the insights on the distinctive patterns of innovation processes and their determining forces that have been gained in these studies, and due to the realistic assumptions underlying the NIS approach, it disseminated rapidly through the economics of innovation literature.

This has lead to the introduction of related but otherwise confined approaches to innovation systems. Consequently, the systemic approach to innovation now consists of various branches. Depending on the chosen level of analysis, the concepts of regional innovation systems (e.g. Braczyk et al. (1998), Ohmae (1995)), sectoral innovation systems (Breschi and Malerba (1997), Malerba (2002), Cooke et al. (1997)) and technological systems (Carlsson (1995, 1997), Carlsson and Stankiewicz (1995)) constitute three alternatives to the concept of national systems. In addition, related concepts like the concept of industrial clusters (e.g. Porter (1998)) have been introduced.

Beyond its spread among the academic community, the concept of national innovation systems has been increasingly used by international organizations as an analytical framework for the study of technological change. It has also attracted growing interest by policymakers around the globe as a means to derive technology policy measures, aiming to improve the organization of innovation processes on the national level.

Another important aspect is that together with the spread of the NIS approach, research interests in its applications have noticeably become broader and more diverse: In early NIS studies, nation-specific innovation patterns have typically been put into a historical, political and cultural context while the detection of heterogeneous elements across systems has been given main interest. Deviating from this research focus,

[1] Exceptions are the study by Edquist and Lundvall (1993) where the Danish NIS is compared with its Swedish counterpart, the international comparison by Patel and Pavitt (1994), and the study by Gregersen et al. (1994).

performance comparisons across systems have gradually moved in the center of attention while less importance has been given to the consideration of systemic dissimilarities. We can thus currently observe an intended convergence of two rather conflicting streams: On the one hand, the systemic perception of innovation processes which puts emphasis on country-specific structures and elements. On the other hand, comparisons across systems that need to partly abstract from systemic heterogeneity and that aim to yield clear-cut advice for national policymakers.

In the light of these new developments, we want to provide an overview on latest trends in the research on national systems of innovation in this paper. Furthermore, and on the basis of the observed research trends in the NIS literature, we will make some suggestions on possible future development paths of this body of research.

2. Overview on recent developments of the NIS concept

2.1 Performance-oriented studies

Particularly since the late 1990s, several attempts have been made to evaluate and to compare innovation systems in terms of their performance, which in turn is defined and measured in different ways. In some cases, comparative studies on the system-level have been utilized as a preliminary step to generate rankings of national innovation systems (see e.g. Porter and Stern (2002)). They can be classified in policy-oriented studies and in research-driven advancements of the NIS approach.

The growing number of *policy-oriented studies* of innovation systems signals that the creation of innovation-enhancing framework conditions has become a central target of policymakers around the globe[2], and particularly in highly industrialized countries.[3] Due to the pragmatic assumptions underlying the NIS concept, and due to the insightful outcomes gained so far in studies of national innovation patterns, the systemic approach to innovation enjoys growing popularity among technology policymakers as a means to derive technology policy implications. At the same time, learning processes from own experience and from the experience made by other countries in the organization of

[2] Even though economic growth in industrializing nations is mainly grounded on labor cost advantages and on the adoption of technologies developed abroad, the creation of innovation-spurring institutional and organizational structures in such nations is an issue that enjoys growing awareness (see e.g. Radosevic (1999) or Paasi (1998)).

[3] This is also confirmed by Kleinknecht (2000), p. 196) who points out: "Public policy is increasingly concerned about promoting innovation in order to stimulate economic growth, employment and ecological sustainability."

national innovation systems are meanwhile recognized as an important input to innovation policy design. This awareness calls for broad international comparisons of innovative strength and institutional frameworks, especially of incentive mechanisms to innovative action.

Indeed, political interest and political agreements triggered off the carrying out of national benchmarking studies while employing the innovation systems terminology. Most importantly, the European Union urged its Commission to work together with the EU-15 countries in order to "develop indicators and a methodology for the benchmarking of national research policies"[4]. The fulfillment of these targets requires a conjunction of benchmarking techniques on the one hand and a systemic approach to innovation on the other. So we currently observe an intended convergence of two conflicting methodological streams, namely a systemic perception of innovation processes with strongly country-specific features on the one hand and objectives to obtain clear-cut policy recommendations through the carrying out of benchmarking exercises on the other hand.[5] Typically, the intended "benchmarking studies" follow, at least implicitly, a two-step procedure: First, by resorting to various indicators of innovative efforts or outcomes, the studies aim at identifying "best practice" policies and/or "best practice behavior" among the countries under study. In a second step, and grounded on the results of the search for best practice, policy recommendations are derived. The following studies are good examples of this procedure: A broad empirical cross-country analysis that in many parts draws on OECD data is the analysis carried out by Eichhorst et al. (2001) where Germany is "benchmarked" with seventeen OECD member countries. Although this benchmarking study actually concentrates on the German labor market, "all" the factors affecting its performance are sought to be investigated as well. Therefore, not only indicators that reveal the relative size and strength of the German educational system are displayed; further indicators capture the innovative performance of Germany's business sector, the founding climate in the business sector together with various proxy variables of the degree of product market regulation in Germany. Another example is the international comparison of the relations

[4] European Commission (2000, p. 3). This plan of work, being a result of the Lisbon Summit of the European Union held in March 2000, was agreed upon by the Council of Research Ministers of the EU on June 15, 2000.

[5] The word "conflicting" means that corporate benchmarking exercises typically analyze the efficiency of similarly structured firms or business processes while the NIS approach seeks to accentuate structural dissimilarities across systems. Discussions of the usefulness of benchmarking exercises across national innovation systems can be found in Lundvall and Tomlinson (2002) or in Balzat (2003).

between the private business sector and scientific research bodies by Polt et al. (2001). A third example is related to the work by the OECD on the employment situation in several of its member countries. One fragment of the so-called "OECD Jobs Study" (1998) was the finding out of best practice policies related to technology and innovation.

Apart from this political background, *research aims in the economics of innovation literature* can be observed as the second main driver towards comparative studies of NIS. In order to explain this argument, it may be helpful to review some of the limitations of earlier done NIS studies and of the research course pursued: First, these early studies have typically given verbal descriptions of national innovation patterns while the number of utilized indicators of innovative activity has been rather small.[6] Second, early NIS studies have usually concentrated on one country in order to thoroughly describe the functioning of the innovation system under consideration. Third, the set-up of NIS studies has varied considerably because of a lacking formalized methodology to carry out such studies.

These limitations may have stimulated research efforts to carry out system-level comparisons as well as to formalize the NIS concept.[7] These efforts have lead to the introduction of descriptive frameworks and to the development of analytical models.

A good example of a *descriptive model* of national innovation systems which is meant to capture the structure and performance of an NIS is the conceptual framework introduced by Liu and White (2001). This framework is built on five different activities of innovation processes. These activities are research, production, "end-use (customers of the product or process outputs)", "linkage" and "education" (Liu/White (2001, p. 1094). In this respect, this descriptive model differs from the widely agreed actor-specific viewpoint to analyze innovation systems which Liu and White criticize

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[6] This limitation may also reflect that data on innovative activities - including measures of innovative efforts and of innovative outcomes - have long been (and partially still are) unsuitable to carry out cross-country comparisons because there were differences in measurement practices across nations for what were supposed to be 'similar' indicators, a problem that is discussed in detail in Kleinknecht (2000) and in Smith (2001). Viewed from this angle, the OECD project on NIS can be seen as an important contribution to close this gap. As it has been emphasized by the OECD, it is a main target to "improve the comparability of innovation indicators" of its member countries (OECD, 1999, p.1) through its NIS project which it has started in the year 1994.

[7] As Edquist et al. (2001, p. 4) claim: "[T]he innovation system approach can be used to compare how efficiently different institutional frameworks and combinations of agents point innovative activities in directions that are favorable for economic growth". A similar point is made by Kuhlmann who claims that national innovation systems "were discovered...as explanations for the differing degrees of competitiveness of economies, especially of their technological competitiveness and their ability to innovate" (Kuhlmann (2001, p. 958).

sharply.[8] They apply their descriptive concept of an NIS in order to analyze the innovation system in China through an inter-temporal comparison between different development stages (or regimes) of that system. In detail, differences in the set-up, the organization, and the performance between China's former (socially planned) NIS and China's current (democratically organized) NIS are highlighted.

Another model to study the composition and strength of a country's innovation system has been introduced by Chang and Shih (2003). Based on previous work by the OECD (1999), the model is made up of six elements - R&D expenditure, R&D performance, technology policy, human capital development, technology transfer and the climate for entrepreneurial behavior. With these basic criteria, it is intended to allow for an analysis of the structural specifics of a national system of innovation. To capture the performance of a system, four fundamental groups of indicators have been employed: formal and informal co-operation in R&D, measures of the dissemination of innovations, and finally the mobility of the national workforce. A comparison between China's NIS with its Taiwanese counterpart is carried out in the empirical part of Chang and Shih (2003).

In contrast to these descriptive NIS models, a *formalized way* of doing cross-country comparisons of innovative performance has been introduced by Furman et al. (2002) with the concept of "national innovative capacity" (NIC). This concept is based on a combination of three different - though closely related - theoretical concepts: endogenous growth theory (see e.g. Romer (1990)), the theory of international competitiveness as developed by Porter (1990), and the national systems of innovation approach as described above. National innovative capacity is defined as "the ability of a country to produce and commercialize a flow of innovative technology over the long term [...depending] on the strength of a nation's common innovation infrastructure [...], the environment for innovation in a nation's industrial clusters, and the strength of linkages between these two"[9]. Each of these three components - infrastructure, cluster conditions and linkages - is measured by a number of variables. Then, these three components enter the main regression model in the form of complementary independent

[8] Liu and White argue that it is advantageous to focus on "system-level characteristics [...] such as the organization and distribution of activities in the innovation process, control and coordination mechanisms, and information flows, that affect [...the performance of an innovation system]" (Liu and White (2001, p. 1111).

[9] Furman et al. (2002, p. 899). For a detailed description of these three determinants of "national innovative capacity", see Furman et al. (2002, pp. 910-911).

variable blocks. Patent data, i.e. "the number of patents granted to investors from a particular country other than the United States by the USPTO in a given year,"[10] are used as the dependent variable. For the main model, a knowledge-driven endogenous growth model serves as a basis in order to establish a linkage between the independent input factors and the dependent output measure of innovations. But again, deviating from standard endogenous growth theory where a variation of a country's real economic activity is taken as a dependent variable (like the growth rate of GDP, for instance), patent growth, i.e. the growth of patent applications in the USA per country, is employed as a 'growth' variable in this framework.[11] The sample includes seventeen highly industrialized countries in total.

The NIC model can be considered as an ingenious contribution to the NIS approach, because it builds a bridge between elements of economic growth theory and a modern, systemic approach to innovation which is thus extended by a (non-descriptive) technique to carry out international comparisons of innovative strength. In spite of this, it is a major drawback of the model that it only takes account of one output measure of innovation, given that in an NIS various actors contribute in many different ways to the system's performance.

Porter and Stern (2002) have recently applied the national innovative capacity model to a larger number of countries (75 countries in total) than Furman et al. (2002) have.[12] Apart from the different sample size and differences in the employed data set, Porter and Stern (2002) make use of the empirical results in order to generate a ranking of the nations analyzed.[13]

An alternative way to do formalized system-level comparisons has been presented by Nasierowski and Arcelus (1999, 2000) where coherent country groups in terms of technological capabilities are identified on the basis of a *system of structural equations*

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[10] Furman et al. (2002, p. 909).

[11] The accumulated number of patents that have been granted by the USPTO to a certain country is interpreted as that country's knowledge stock.

[12] While it is explicitly explained in Furman et al. (2002) that the national systems of innovation approach is a major component of the national innovative capacity model, Porter and Stern (2002) fail to do so. Implicitly, though, they give a helpful definition of national innovation systems (see Porter and Stern (2002, p. 102).

[13] A nation's ranking is calculated as follows: For each of the four employed sub-indexes called "proportion of scientists and engineers", "innovation policy", "cluster innovation environment", and "linkages", a numerical value is derived from the regression analysis. The unweighted sum of these four sub-index values then yields the overall national innovative capacity index (see Porter and Stern (2002, p. 111).

that consist of inputs, outputs and moderators.[14] Cluster analysis techniques lead to a classification consisting of two country groups, one covering technological leaders[15] while the other group embraces emerging countries that base their technological progress mainly on the import of innovations developed abroad. Through factor analysis methods, the analyzed countries are then ranked according to their technological strength. In addition to these empirical tests, Nasierowski and Arcelus (2003) have developed a data envelopment analysis-based model consisting of two inputs, two moderators and three output variables with the aim to study the efficiency of national innovation systems. The efficiency evaluations are split into two parts, one is concerned with the measurement of efficiency in the generation of innovations - which is called "R&D efficiency"-, and the second part examines "R&D productivity"[16] which is defined as a country's efficiency in the translation of technological success into national productivity growth. The basic idea underlying the efficiency measurement by Nasierowski and Arcelus (2003) is to perceive a national innovation system as an isolated sector of the entire economy.[17] However, such a definition of the term can be misleading because it contradicts to the widely held stance that innovation systems need to be understood as open systems.[18]

2.2 NIS studies of low- and mid-income countries

So far, we have sketched two trends in the literature on national innovation systems, namely policy-oriented studies of NIS and the development of descriptive or analytical models as a means to accomplish comparative studies of NIS in a formalized manner. A third research trend regards the analysis of innovation systems of countries outside the

[14] Inputs are defined as "the extent to which the economy acquires technology from abroad, the intensity of domestic technological effort it undertakes and the level of technical human capital". Thus, inputs are closely linked with the current and future observable performance of an NIS. The definition of outputs - being the result of technological efforts - appears equally common. In contrast, the term 'moderator' is rather exceptional in the context of NIS. Moderators are described as all those socio-economic factors that have a decisive impact upon inputs and outputs as well as upon the relation between inputs and outputs (see Nasierowski/Arcelus (1999), p. 236 and pp. 237-240). Examples of moderators are cultural factors like risk avoidance, individualism and the literacy rate, but also harder economic factors like GDP, PPP and population size.

[15] Members of this class are the G7 country group plus further highly developed west European nations. These nations share such features as a high educational level of the workforce combined with a large share of scientists and engineers, high levels of economic wealth, large inflows of foreign direct investment, a dominance of privately financed over publicly financed technological search activities, high levels of productivity and so forth (see Nasierowski/Arcelus (1999, p. 243) and Nasierowski/Arcelus (2003, p. 5).

[16] Nasierowski/Arcelus (2003, p. 2).

[17] See Nasierowski/Arcelus (2003, p. 3).

[18] See e.g. Edquist (2001, p. 4).

group of highly industrialized nations, including developing countries, transformation economies in Eastern Europe as well as newly industrialized countries in Asia.

The idea to draw on the NIS approach to analyze technical change in such countries is not new, as the collection of five different country studies in Part III of Nelson (1993) shows. However, further studies of low- and middle-income countries have since then been rare. Recently, various efforts have been made to close this gap. These studies are insightful extensions of the NIS approach because they accentuate important differences between national systems. Especially, they point to specifics of the different development stages that the various systems have reached.[19] Compared with mainly numerical performance comparisons, these studies are hence more in line with the basic ideas underlying the NIS approach, particularly with the idea to reveal country-specific innovation patterns. For instance, by using Brazil and South Korea as two representative cases, Viotti (2002) deals with innovation patterns in technological laggards. The transforming organization of innovative activities in former socialist countries in Central and Eastern Europe is e.g. addressed by Freeman (forthcoming) and by Radosevic (1999) while the innovative success of developing economies in Latin America and in Asia is examined by Alcorta/Peres (1998) and by Intarakumnerd et al. (2002), respectively.

In those and related studies, not only the development stage and the functioning of the corresponding innovation systems is drawn attention to, the relevance of the NIS approach in the case of these nations is also discussed. This latter issue is - in the light of the fragmented structure of most of the systems analyzed - viewed controversially. Alcorta and Peres (1998) do not reject the relevance of the NIS concept in their study of innovation systems in Latin American countries. Radosevic (1999, p. 313) claims that "catching up and growth of the CEECs is closely related to the emergence of systems of innovation" but that it is "not yet possible to talk about national or regional systems of innovation in CEECs". With this position, however, he leaves it open whether or not the very framework of national systems of innovation is suitable to describe technical change in these economies. Viotti (2002, p. 654) refutes the usefulness of the NIS concept in the case of technological laggards when he points out: "The NIS approach is not appropriate for dealing with the processes of technical change typical of

[19] Even among the group of so-called Asian tiger countries, distinctive nuances between Korea, Taiwan and Singapore have been found out by Wong (1999), a result that refutes the commonly held notion that the success of these technologically successful countries could be traced back to a set of common factors.

industrializing economies, which are extremely different from those of industrialized countries". Based on this critique, he develops the notion of national learning system (NLS) as an alternative. The distinction he draws between these two concepts appears too sharp, though. The reason for this is that the NIS concept does by no means exclude the consideration of learning processes. Instead, learning has always been considered as being a fundamental activity in any NIS (see Lundvall (1992)).

All in all, our view is that the empirical finding of fragmented innovation systems in low- and middle-income countries does not irrevocably imply that the NIS framework is useless in these contexts. One could argue that the application of this framework points to a variety of determinants and specifics that accounted for the innovative success of capitalist economies. Identifying the lack or weak development of such factors and hence finding out areas of improvements can in fact be a valuable step to enhance the organization of innovation processes on a national level.

3. Outlook on possible future developments of the NIS concept

Having considered latest trends in the research on NIS, we now propose where we see possible development paths of the NIS approach in the future.

Generally speaking, it seems obvious that the systemic approaches to innovation will continue to constitute a decisive framework for empirical studies in the economics of innovation literature, especially in the context of highly industrialized and newly industrialized countries.[20] Concerning the use of the national innovation systems approach as a framework to carry out country-level comparisons of technological performance, it is plausible that some of the recently introduced models will not be put aside but will be applied and further elaborated in future research. This appears likely considering the apparent interest in international evaluations of innovative strength.

However, there is still much room for extension of the NIS concept. At least three areas for broadening the approach shall be brought up here.

First, a clearer and more explicit combination of the NIS approach with economic growth is still lacking. While the linkage between technical change and economic growth has long been studied through distinct models of economic growth, modern

[20] Aside from the developments in research work on innovation systems, it is noticeable that the very term "innovation system" has unfortunately become a highly fashionable expression among business editors and other writers dealing with innovation and technical change.

concepts of innovation like that of (national) innovation systems have thus far not been tied with economic growth in an analytical way.[21] We believe that this constitutes a gap in the literature, even though it has been stated elsewhere that the NIS approach per se could be viewed as a means to study economic growth[22].

Second, the interplay between a country's innovation system and other economic subsystems (e.g. the labor market or the financial system) is far from being studied exhaustively. This limitation is even more striking since innovation systems have been defined as being open systems and since it is widely held that the strength of an innovation system depends upon the linkage with other sub-segments of an economy.

A third course to extend the NIS approach has to do with our still limited knowledge on the dynamic properties of national innovation systems, especially with regard to their stability and their structural evolution.[23] By studying these aspects, the NIS concept would be more aligned with its theoretical foundation of system theory and evolutionary economics.[24] It is a basic element of this line of economic theorizing to consider qualitative change, implying that dynamic processes have to lie in the center of attention.[25] In addition, the variety of the units of analysis and their observable performance levels are usually given special interest. So if the theoretical foundation of the notion of innovation systems is to be taken seriously, a more subtle understanding of the evolution of the systems is required. Above all, it appears appealing to retrace different development stages of national systems together with the structural and institutional modifications theses stages entailed in the course of time. By carrying out this type of analysis, it could be demonstrated that different countries have taken different roads to cope with the competitive and technological challenges they have been and still are exposed to. Perhaps, and viewed from a methodological perspective, it may be helpful to build simulation models. Resorting to this type of models is

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[21] Porter and Stern have shown that the index values of their concept of national innovative capacity strongly correlate with the levels of GDP per head in the sample of countries they have used (see Porter and Stern (2002, p. 114).

[22] See Lundvall (1998, p. 415).

[23] This gap has also been identified by Carlsson et al. (2002, p. 236) who argue that "there is nothing preventing a more dynamic analysis" of national innovation systems.

[24] It has been clarified repeatedly that evolutionary economic theory constitutes the theoretical fundament of the NIS approach (see e.g. Saviotti (1997), McKelvey (1997), or Edquist et al. (2001)). However, the relation between system theory and the NIS approach is barely investigated; an exception is Andersen et al. (2000).

[25] See e.g. Pyka (1999) for a concise outline of the basic principles of evolutionary economic theorizing.

particularly suitable, if not only the values of the units of analysis vary but the very units of analysis themselves are subject to change.[26]

Even though we have just exposed possible directions to extend the NIS approach, it shall be emphasized that we do not take the continuing significance of the *national* innovation systems approach for granted. Rather, it is also conceivable that in the near future the research focus may shift from the now frequently chosen national perspective of innovation systems towards a sectoral or a regional perspective including cluster theories.[27] Such shifts in the preferred analytical level are likely if international intra-sectoral ties in the generation of innovations will continue to intensify while domestic ties lose importance, and if the significance of national institutional framework conditions should descend at the expense of regional or sectoral framework conditions. Trends like these could very well reduce the relevance and usefulness of the concept of nationally demarcated innovation systems. Besides this, it is preferable to use less aggregated concepts of innovation systems than the NIS concept if sector-specific or region-specific criteria in the organization of innovation processes are sought to be studied in great detail. That is because the concept of national systems of innovation puts emphasis on *national* differences in the relationship between the institutional set-up and technical development and on *national* differences in economic structures.

The usefulness of a *national* boundary of innovation systems can also be reduced through growing[28] international economic integration if national specifics and national determinants of innovative action are removed at the expense of international economic framework conditions. In the context of the European Union, for instance, less self-determination of the participating nation-states in numerous fields, including innovation policy design, could be a logical outcome of increasing institutional harmonization across countries. In this case, and if the concept of innovation systems is to be applied, a supranational analytical level may be advantageous to a national one. However, as

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[26] See Etzkowitz and Leydesdorff (2000, p. 114).

[27] Such possible changes in analytical levels do not mean that the various sub-approaches of the innovation systems approach exclude one another. The same line of reasoning is taken by Beije who underlines that "[r]egional or sectoral innovation systems are subsystems of the national system in which the institutions (or some of them) are specialized in the innovation problems of a specific sector or region" (Beije (1998), p. 257).

[28] "Growing" economic integration can indeed be understood ambiguously: It includes either the geographical extension of international (trade) agreements or the deepening of existing international economic integration by harmonizing more and more formal institutions in the member countries.

recent research on this topic has shown, it is at the present time far too early to think in terms of a supranational European innovation system.[29]

4. Summary and conclusions

In this paper, we tried to identify and outline current research streams in the concept of national innovation systems. In the following chart 1, these research streams are summarized in catchwords. On the basis of this overview, we have then expressed our view on possible future development lines of this concept while pointing to some of the shortcomings that still exist in the NIS literature.

Trends in the research on NIS

Performance comparisons	Studies of low- and middle-income countries
▪ efforts to give the concept of NIS an operational dimension	▪ analysis of the development stage of the national system of innovation
▪ performance measurement / "efficiency" measurement of NIS	▪ verification of the relevance of the NIS concept
▪ methods: - use of innovation indicators - analytical models - calculation of index numbers (ranking of the systems analyzed)	▪ methods: - detailed verbal descriptions - use of innovation indicators
▪ negligence of historically grown - innovation patterns - institutional frameworks	▪ emphasis on historically grown - innovation patterns - institutional frameworks

Chart 1: Latest contributions to the NIS approach: A summary of typical elements.

In many of the latest extensions of the NIS concept, international comparisons have been put in the center of attention. By means of system-level comparisons, it is sought to get a better understanding of the functioning of the systems analyzed, and to derive policy implications. Mostly, the functioning of a system is described by such terms like

[29] See Maurseth and Verspagen (1999) who find that technologically relevant knowledge does not diffuse easily across all national borders even inside the EU. That it is at this point in time still inadequate to study innovation structures in terms of a supranational, European-wide innovation system is also maintained by Gutowski (2000, p. 235).

'innovative performance' or 'innovative efficiency'[30]. So basically, the functioning of a national system of innovation is regarded as its ability to generate innovative outcomes or the intensity of linkages between its main elements in innovation processes. Distinctive conceptual frameworks have been introduced in order to capture the functioning of innovation systems empirically. These frameworks rely either on a compilation of descriptive indicators or on higher formalized analytical models.

Another noticeable stream in the NIS literature can be described as the analysis of innovation systems of countries beyond the club of highly industrialized economies. Regarding the geographical dimension, the studies concentrate on countries in Eastern Europe, Latin America, and Asia. Classifying the analyzed countries according to their level of economic development, the spectrum ranges from developing nations to middle-income countries. Even though the very existence and development of a system of innovation in those nations is often a focal point in these studies, cross-national performance comparisons are carried out as well in some cases. In this way, this stream of extending the NIS approach to less industrialized economies is closely related to the above mentioned research stream of performance comparisons on the level of national innovation systems. But, in spite of this relation, it shall be emphasized that the consideration of historically developed organizational and institutional structures plays an important role in (comparative) studies of industrializing countries.

It is difficult to foresee in which direction the concept of national innovation systems will proceed in the near future. But, in our view, in order to answer this question it is helpful to consider the following three aspects: First, the systemic approach to innovation in general - regardless of the analytically selected boundary of the system - is by now established as a useful framework to study technical change and its determinants. Second, the concept of *national* innovation systems enjoys continuing popularity even though innovation processes increasingly entail an international dimension. Third, the NIS approach still leaves much room for extensions, both in terms of its theoretical foundation and of its empirical application.

[30] Yet, the expression 'innovative efficiency' can be misleading in the context of national systems of innovation. That is because efficiency is commonly defined as a ratio of output(s) to input(s), abstracting from interactive or systemic attributes of the processes measured. But these attributes are of course at the core of the NIS approach.

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