A new approach for analysing national innovation systems in emerging and developing countries

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Abstract: *This paper presents a tool for the indicator-based analysis of national innovation systems (ANIS). ANIS identifies the economic strengths and weaknesses of a country-wide, regional or local system and includes a comprehensive examination and evaluation of the status of existing innovation systems. The use of a particular form of expert interviews at macro, meso and micro levels provides a detailed image of a national, regional or local economy. This analytical approach is intended mainly for emerging and developing countries, for which standard innovation benchmarking and monitoring approaches may not be appropriate. The ANIS approach provides a quick and comprehensive picture of the main scope of interventions for improving individual determinants of an innovation system. As a result, targeted policy measures can be formulated to address these determinants. Policy makers can thus benefit from clear advice when striving to overcome weaknesses in their innovation systems and in identifying those determinants that should receive special attention. An analysis of the local innovation system of Manaus in Brazil is presented here as an example.*

Keywords*: national innovation systems; innovation system analysis; ANIS; innovation indicators; policy recommendations; Brazil*

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When interviewing policy makers in emerging and developing countries about the possibilities for stimulating innovation in their economies, it often becomes apparent that they are looking for descriptions of their innovation systems and clear recommendations for improving their performance. Rather than asking for

scientific models of the functionality of the innovation system or for sophisticated, statistically-based performance indicators, they are more interested in the practical assessment of their economic environment with regard to innovation.

In short, policy makers look for precise recommendations on how to optimize the conditions for innovation capacities, particularly in an environment where the resources for public investment are limited. It is therefore very important that those determinants of an innovation system that can be improved with existing tools and financial resources are identified.

ANIS (Analysis of National Innovation Systems) is an analytical instrument that addresses this need. It provides a comprehensive examination and evaluation of the status of national, regional or local innovation systems and relates to the new approach of indicator-based studies relying on quantitative data generated by the evaluation of expert interviews. The concept, which was developed by the Institute for Innovation and Technology (IIT) in Berlin (IIT, 2012a), is comparable to the approaches of the Global Competitiveness Report, the European Scoreboard, the Nordic Innovation Monitor, or the Global Entrepreneurship Monitor.[1]

However, ANIS provides rapid results and recommendations that are based on expert interviews and peer group discussions and can thus be regarded as a 'high-level' scan of the maturity of the main determinants of an innovation system, using qualitative and quantitative research. With the help of expert opinion surveys answered by national stakeholders at macro, meso and micro levels of an innovation system, preferably in peer assessment groups, the exchange of ideas with regard to future developments of the economy of the country or region is promoted.

Thus as well as providing the statistical analysis ANIS also distributes knowledge to the participating parties, by including local experts in the respective country or region who learn the ANIS approach and support its implementation. As such, a 'train-the-trainer' approach is developed for each country or region that is analysed.

It is often the case that the knowledge of policy makers about their innovation system is sparse because policy makers and experts do not generally have opportunities to talk to each other. There is therefore a need to exchange knowledge about the different actors in the innovation system: with ANIS it is possible to connect the views and opinions of universities, innovation support institutions, programmes and industry. The participants of the expert group empathize with the views of others. As a result, the representatives of each level of the innovation system gain a detailed insight into their innovation system during the analysis. This self-assessment stimulates discussion among the stakeholders and generates an assessment of the maturity of the determinants and recommendations for activities to improve the country's innovation system with resultant, significant effects and the expenditure of little time and effort.

The ANIS tool can thus provide the basis for the development of policy measures having a long-term impact on the innovation system.

Background: the three-level hierarchy of an innovation system

The ANIS approach is based on the assumption that an innovation system is largely influenced by 30 determinants. ANIS provides an indicator-based assessment of these determinants, each of which reflects an aspect of the innovation system. The determinants may be grouped according to a three-level hierarchy.

- *Macro Level: Innovation Policy Level.* At the macro level, national innovation policies directly influence the framework conditions of an innovation system. Laws, decrees and regulations at this level may often be ground-breaking, in a positive or a negative way. Public investment in innovation directly relies on decisions made at policy level. However, such political decisions may only influence the framework conditions for innovation and might not convert innovation into practice.
- *Meso Level: Institutional Innovation Support Level and Innovation Programme Support Level*. Institutions operating at meso level are typically technology transfer centres, clusters, innovation service providers and funding agencies. They may be considered as the relevant tools for converting any political decisions regarding innovation into practice. In developing and emerging countries such institutions are mostly publicly owned. These institutions remain a key instrument for improving and encouraging the innovation capabilities of firms, especially in countries where public investment is limited. Innovation support includes public funding programmes and initiatives designed to convert innovation policy into practice. Such programmes might be managed either by policy makers or by innovation support institutions. Any measures at that level would require significant public investment.
- *Micro Level: Innovation Capacity Level*. The micro level provides overarching support for the main actors and enablers within an innovation system; for instance, enterprises (large, medium, small and micro), entrepreneurs, universities, public or private R&D institutions, innovators or financial organizations.

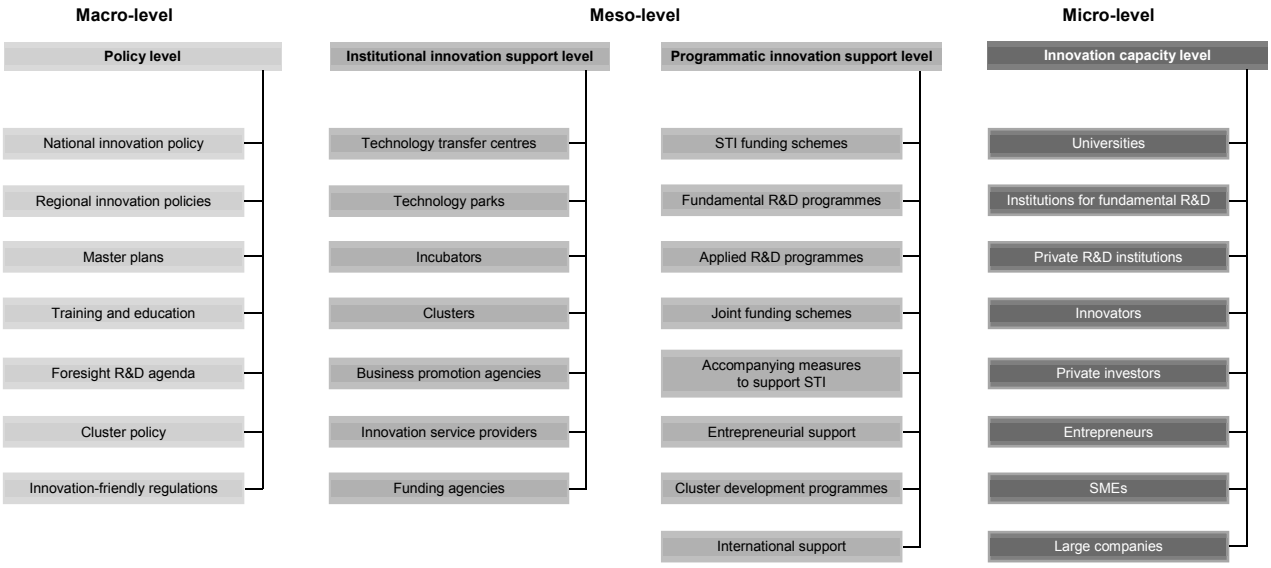

Figure 1. The 30 determinants of an innovation system.
Source: IIT (2012b).

The classification of the 30 determinants is shown in Figure 1. A comparison between the determinants of these different levels provides for the identification of key policy areas requiring a potential intervention to strengthen the innovation system.

The maturity level of an innovation system as well as the performance of its actors may be improved by means of policy measures addressing either individual determinants or groups of determinants. Because the determinants are often linked to each other it is possible for the extent of the improvement to increase, with a resulting stronger effect on the entire innovation system.

The ANIS approach for analysing an innovation system consists of the following steps:

(1) Analysis of existing literature regarding the innovation system;
(2) Interviews with experts regarding the innovation system;
(3) Completion of the expert opinion survey using expert peer groups;
(4) Evaluation and measurement of the outcomes;
(5) Identification of determinants having a strong impact with little cost;
(6) Formulation of recommendations for improving the prioritized determinants; and
(7) Comparison of own activities with those of countries at a similar level of maturity.

Each determinant may influence an innovation system differently. In the short term, some will require only low-level input, whereas others will need longer periods for improvement, combined with significant investment. Improving any determinant may generate magnified positive effects.

Role of indicators in measuring innovation system maturity

Measuring the maturity of innovation systems has been the focus of many systematic attempts to rank countries according to their innovative capacity. Among these are the various economic reports mentioned above, the results of which are normally based on 'indicators'. In this context, an indicator is '. . .a series of data which measures and reflects the science and technology endeavour of a country, demonstrates its strengths and weaknesses and follows its changing character notably with the aim of providing early warning of events and trends which might impair its capability to meet the country's needs' (OECD, 1976). Hence observing specific indicators also provides for the measurement of the maturity of an innovation system and can help to forecast upcoming trends.

Science and technology indicators that help to measure the maturity of innovation systems were established in the twentieth century, one of the main actors in this field being the OECD. Since the 1980s the OECD has developed science and technology indicators for the analysis of countries, regions or sectors and has published the results in numerous reports on a regular basis (for example, the *Frascati Manual*).[2] In the 1990s Eurostat started to publish a European report on science and technology indicators. With the *Oslo Manual* the

European Commission has also provided a basis for the development of science and technology statistics.[3]

The maturity of an innovation system can be measured by studying input indicators (such as the number of R&D personnel) and/or output indicators (such as the number of co-publications or patents). ANIS generates an analysis of the research systems by looking at input indicators *and* science indicators (current Science and Technology policies and innovation support activities). In this way ANIS analyses the knowledge flows between different institutions in industry and academia and at policy level. The indicators used in ANIS allow different, relevant countries to be compared with each other.

Science and technology reports as well as innovation analyses have developed variables by which the maturity of an innovation system can be measured. However, as Belitz *et al* (2011) have stated, referring to Patel and Pavitt (1995), '[t]here is consensus that an ideal ''catch all'' variable for innovation is not at hand'. Belitz *et al* emphasize that these rankings are nevertheless necessary to provide a sound foundation upon which policy makers can base their decisions. Belitz *et al* further emphasize that using in-depth analyses limits the database of countries because in-depth indicators are available only for a few nations. Using ANIS should make it possible to include more countries and especially emerging and developing nations.

Belitz *et al* state that the analysis of national innovation systems can be categorized into two approaches. On the one hand there is the descriptive method based on case studies, as introduced by Nelson (1993); on the other hand there is the theoretical approach based on secondary research and quantitative indicators, as presented by Lundvall (1992). ANIS is a mixture of these two approaches. Both approaches share the characterization of national innovation systems by the determinants of innovation processes.

The elements of ANIS

Analysis and comparative portfolio

With ANIS a set of three to five questions for each determinant is designed in order to characterize each of the 30 determinants accurately and assess their stage of development. The experts concerned are asked to offer their opinions regarding various aspects of innovation and the innovation environment in which they operate. The data gathered as a result of the expert interviews provide a detailed insight and a qualitative picture of the concept of innovation of each country or region and the representation of the situation in each country or region in comparison to others.

The ANIS approach is similar in some ways to the Delphi forecast technique, a qualitative research method described in detail by Wolf *et al* (2009) that is often used to specify the quantitative research that has taken place mostly prior to further in-depth analyses. The Delphi Method can help in particular when developing new ideas and concepts because it captures group opinions which then provide sufficient 'data' to formulate forecasts from which policy recommendations can be derived.

The comparative portfolio, which is an integrated element of the ANIS approach, against which the determinants of the innovation system are benchmarked, consists of the corresponding data from countries with comparable economies. The classification used in ANIS is based on the Global Competitiveness Report (GCR) of the World Economic Forum (Schwab *et al,* 2011). The GCR defines three different stages of economies: factor-driven (stage one), efficiency-driven (stage two), and innovation-driven (stage three). Countries situated between these stages are called 'transition' countries and are in transition either from stage one to stage two or from stage two to stage three.

Emerging and developing countries in particular, usually located at stage one and in transition to stage two in the GCR, can benefit from a comparison with countries of the same status because this avoids both the desperate pursuit of overambitious aims inspired by industrialized countries and the somewhat demotivating comparison with less developed countries.

Scope of intervention

In order to be able to evaluate the quality and the stage of maturity of an innovation system, it is important to describe the determinants. The maturity level of an innovation system as well as the performance of its actors may be improved by means of policy measures addressing either individual or groups of determinants. Because determinants may often be linked to one another, the potential impact might be augmented. Some determinants may easily be improved, whereas the task for others might be more complex.

A portfolio analysis is therefore used to compare the required mandatory effort and the potential impact of the determinants which are below average in the analysed innovation system. One scale represents the 'efforts needed' in terms of capability to provide public funds, investments in infrastructure and human resources, policy reluctance, structural changes, and so on. The other scale represents the 'expected impact' in terms of improved framework conditions or improved innovation capacity of the actors. As a result of these findings, specific policy measures addressing these determinants can be formulated.

The ANIS report

The policy makers or other interested parties receive an ANIS report which includes the following items.

(1) A brief description of the economic situation of the country.
(2) An analysis of each level of the innovation system of the given country, region or local economy.
(3) An evaluation of the determinants.
(4) The defining scope of intervention within the innovation system.
(5) Benchmarking with other countries, regions or local economies.
(6) A list of the interviewed partners.

The special nature of the ANIS report lies in the fact that the recommendations are derived from the current conditions of the specific country. Thus the recommendations are not generic; rather, they are suited to the economic situation of the respective country. The reports can be updated periodically in order to reveal trends which may be relevant for the adjustment of programmes and other innovation support measures.

Case study: ANIS in Manaus, Brazil

This section summarizes an example of a regional analysis conducted by the Institute for Innovation and Technology (IIT) and VDI/VDE Innovation+Technik GmbH in 2010 (IIT, 2010) and supported by local partners. More than 50 policy makers and innovation experts from Manaus contributed during the three-day ANIS workshop. The questionnaires were appraised on-site and the results of the analysis were available within four weeks.

The regional analysis focused on those determinants for innovation strategy that needed relatively small but appropriate efforts to achieve improvements with high potential impact – with a short interval between conceptualization and implementation. The final recommendations were intended for policy makers. They prioritized measures according to their effectiveness. The summary report and the concluding workshop, held in Manaus, provided a comprehensive description of how to implement the recommendations, including expert opinions from macro, meso and micro levels of the local Manaus innovation system. The main recommendation, which was derived from the expert opinion surveys and interviews, was to improve the 'well-being' of entrepreneurs, in particular through:

- Promotion and stimulation of entrepreneurial activities 'outside of the university' and/or 'outside of R&D institutions' (spin-off programmes);
- Integration of an 'entrepreneurial culture' in the curricula/programmes of all levels of formal education;
- Implementation of a broad variety of training programmes in entrepreneurship, management skills and innovation management and providing easy access to these programmes; and
- Promotion of campaigns and prizes to recognize the best business ideas and most successful entrepreneurs (business plan and start-up competitions).

The following results can be considered as being directly or indirectly connected to the ANIS activities in Manaus.

- Fapeam (Foundation to Support the Research of the State of Amazonas – Manaus) is starting a process of supporting a Business Plan Contest – the first in the Amazonas State – in which local technology-based start-ups will have their efforts rewarded. With the technical support of Fucapi (Analysis, Research and Technology Innovation Center Foundation of Manaus) the secondary goals of the contest are to boost the venture capital culture and stimulate the creation of an association of angel investors.
- Fucapi and Sebrae (the Brazilian service for assisting micro and small enterprises) have started a joint initiative, the ALI Project, in which junior professionals (Local Innovation Agents – ALI), supervised by a senior manager, help SMEs to establish and start the implementation of plans that focus on innovation. The objective is to make contact with at least 400 SMEs in Manaus, as a part of a nationwide initiative.

Conclusions

Advantages of ANIS

Many countries still face major challenges with regard to improving the productivity and effectiveness of processes for emerging innovations. Mapping the quality of the supporting environment for individual innovation is an important starting point for target-oriented activities. It needs a common, widely accepted and 'easy to use' interactive approach to involve major actors from academia, industry and governments – as a Triple Helix model – to enhance the linkages between these very different stakeholder groups. Enriched economic processes are required, using the value deriving from the commercialization of innovations.

The application of the ANIS methodology can lead to direct and immediate contributions that strengthen the innovation system, especially in developing countries.

The approach requires a very early personal, responsible and direct integration of the most important players from academia, industry and government. This results in immediate attention being given to the subject of innovation culture and the necessary changes in the system. Self-assessment stimulates discussion between the parties involved and the resultant direct involvement of important stakeholders, something very unlikely to be achieved by traditional desktop analysis or the evaluation of international studies. The results of the comprehensive ANIS process provide a good insight into the national, regional or locally related performance of the innovation system: it shows the best options for enhancing the performance and the long term impact.

ANIS is not only an indicator-based analysis tool but also a very practical implementation of a forward-looking Triple Helix model. The approach is focused on the main determinants that can influence an innovation system; not as an assessment of 'good' or 'bad' but rather as a valuation of the maturity of the determinants. It also initiates the development of essential strategies for the positioning of academics, industry partners and government to improve the subject of innovation as the main driver for economic strength. Comparisons with other ANIS-assessed countries of similar maturity provide for mutual learning and an easier identification of comparable problems and their solutions.

Regular updates of the analysis may reveal trends and options for further improvements of the innovation environment. As such, ANIS is applicable not only to transition and emerging nations but also to industrialized economies.

ANIS – a starting point for strategy development

The results of an ANIS process could provide an ideal starting point for changes in the innovation environment. Because these results contain not only the facts from the interviews and their interpretation but also the clear scope of intervention needed to improve the innovation system and achieve a more efficient performance and benchmarking against comparative portfolios, policy makers receive a detailed description of their innovation system on which they can base their decisions for further policy design and implementation. Furthermore, the 'train-the-trainer' approach ensures collaborative activity takes place between the ANIS analysts and the on-site experts in the respective country. The long-term impact still depends upon readiness to implement the recommendations, because all stakeholders must agree to develop and use new informal and formal mechanisms for enhancing the framework in order to derive benefits from the innovation.

Policy implications

Innovation can be a successful means of transforming ideas into financial wealth. The achievement of this goal needs a clear commitment from and involvement of the stakeholders at all levels of knowledge-based societies. Producing a practical and purposeful pathway leading to excellent performance and suitable support mechanisms requires detailed analyses of the existing environment in advance. Policy makers – in all areas of the global landscape – are often not very familiar with the specific toolsets that can be used to enhance the innovation culture. Opening up a channel for communication of innovation is one of the essential success factors for building the necessary capacities and capabilities. Debates about the demand within the Triple Helix of stakeholders should focus on the logical chain needed to develop the most suitable policy measures. The purposeful journey starts with monitoring and foresight, followed by development of policies and strategies and then publicizing the programmes and their implementation.

The strengthening of national innovation policies is critically important, particularly for developing countries. ANIS provides an analytical model which can be used as a basis for holistic profiles of governments to build or enhance strong national innovation programme-based policies that help to accelerate capacity building. As such we believe that ANIS is an exemplary Triple Helix approach.

Directions for further research

The ANIS toolset is a relatively new approach, designed and initially used in different regions of Indonesia and the Middle East (Egypt, Jordan, Syria), in Africa (Libya, Namibia, Zambia, Botswana) and South America (Manaus, Brazil). The ANIS approach is constantly evolving and its development into a Triple Helix model is a possible future activity for the ANIS team. Given this, close cooperation with regional experts is important.

As with every analytical tool ANIS exhibits some of the problems encountered in the social sciences that need to be addressed and solved. Table 1 summarizes the five most important problems and possible solutions and areas for further research.

In addition, it is possible that the ANIS approach could be used for specialized applications; for instance, to analyse national innovation systems with regard to specific fields of technology and their applications. ANIS could also be used to combine the results of national and local analyses by taking regional circumstances into account and benchmarking them with comparable sub-regions. Finally, ANIS could be used to study metropolitan areas as independent innovation systems with specific characteristics.

Table 1. Problem areas and further research aims of ANIS.

General objective	Problems	Solutions and research topics
Mapping the clear status of innovation for a nation or a region.	Measuring effectiveness and quality of innovation remains a challenging task.	Further research towards a generally accepted 'innovation support impact measurement'.
Exploration of interaction between academia, industry and government to enhance innovation culture.	Lack of openness, trust and knowledge during interviews or different understanding of the terms 'innovation' or 'system'.	Full involvement of main stakeholders with peer group interviews and train-the-trainer approaches.
Gap analysis of the innovation environment.	Tendency towards social desirability answering.	Introducing a model of feedback loops and strategic derivatives.
Benchmarking against comparative portfolios.	Comparing nations and regions could end up in simple 'better or worse' observations.	Introduction of ANIS in regional networks, such as the MENA approach by the World Bank (World Bank, 2012).
Clear scope of intervention to improve the innovation system with high potential impact.	Recommendations are often more a wish list, without a realistic perspective for implementation.	Development of an 'Innovation Value Chain' with an included time-resources strategy.

Notes

1 [From the World Economic Forum Website, see http://www.weforum.org/issues/global-competitiveness] 'The *Global Competitiveness and Benchmarking Network*, with its annual Global Competitiveness Reports, and other topical and regional reports, offers a structured, systematic and comprehensive approach to identifying and measuring the drivers of economic performance of more than 140 economies.' The *European Scoreboard* is produced by the European Commission, see http://ec.europa.eu/internal_market/score/index_en.htm. The *Nordic Innovation Monitor* is published by Nordic Innovation, see http://www.nordicinnovation.org. The *Global Entrepreneurship Monitor* is published by the GEM Consortium, see http://www.gemconsortium.org/.

[2] [From the OECD Website]: 'The *Frascati Manual* was originally written by and for the experts in OECD member countries who collect and issue national data on research and development (R&D). Over the years, it has become the standard of conduct for R&D surveys and data collection not only in the OECD and the European Union, but also in several non-member economies, for example, through the science and technology surveys of the UNESCO Institute for Statistics (UIS).' See: http://www.oecd.org/innovation/inno/frascatimanualproposedstandardpracticeforsurveysonresearchandexperimentaldevelopment6thedition.htm, last accessed 17 June 2013.

[3][From the OECD Website]: 'The ability to determine the scale of innovation activities, the characteristics of innovation firms and the internal and systemic factors that can influence innovation is a prerequisite for the pursuit and analysis of policies aimed at fostering innovation. The *Oslo Manual* is the foremost international source of guidelines for the collection and use of data on innovation activities in industry. The latest edition has been updated to take into account the progress made in understanding the innovation process and its economic impact and the experience gained from recent rounds of innovation surveys in OECD member and non-member countries. For the first time, the *Oslo Manual* investigates the field of non-technological innovation and the linkages between different innovation types. It also includes an annex on the implementation of innovation surveys in developing countries.' See: http://www.oecd.org/innovation/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.htm, last accessed 17 June 2013.

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