Global Review of Competitive R&D Funding

- A project commissioned by the World Bank, Washington

Synthesis Report

Karlsruhe, December 2012
Authors

Dr. Henning Kroll / Dr. Thomas Stahlecker

Fraunhofer Institute for Systems
and Innovation Research ISI
Breslauer Strasse 48
76139 Karlsruhe
Germany
Phone +49 721 6809-173/181
Fax +49 721 6809-176
E-Mail: henning.kroll@isi.fraunhofer.de
    thomas.stahlecker@isi.fraunhofer.de
## Contents

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1    General Introduction ................................................................. 3</td>
</tr>
<tr>
<td>2    Specific Challenges for R&amp;D Funding in Emerging Economies.............. 7</td>
</tr>
<tr>
<td>3    A Structured Approach to Identify Lessons Learned............................ 8</td>
</tr>
<tr>
<td>4    Findings Regarding Public R&amp;D Funding Institutions............................ 12</td>
</tr>
<tr>
<td>- 4.1 General Background ........................................................................ 12</td>
</tr>
<tr>
<td>- 4.1.1 Innovation System ......................................................................... 12</td>
</tr>
<tr>
<td>- 4.1.2 Policy System / Key Challenges ...................................................... 14</td>
</tr>
<tr>
<td>- 4.2 Design of Public R&amp;D Funding Institutions .......................................... 15</td>
</tr>
<tr>
<td>- 4.2.1 Vision and Mission / Detailed Funding Objectives ............................ 15</td>
</tr>
<tr>
<td>- 4.2.2 Organizational Models ..................................................................... 19</td>
</tr>
<tr>
<td>- 4.2.3 Funding Model ................................................................................ 21</td>
</tr>
<tr>
<td>- 4.2.4 Funding Instruments ........................................................................ 24</td>
</tr>
<tr>
<td>- 4.2.5 Selection Criteria ........................................................................... 28</td>
</tr>
<tr>
<td>5    Summary ............................................................................................... 31</td>
</tr>
<tr>
<td>References .................................................................................................. 33</td>
</tr>
</tbody>
</table>
Tables and Figures

Table 1: Funding objectives of the different R&D supporting organizations ............ 16
Table 2: Comparison of different funding models ................................................. 23
Table 3: Funding instruments implemented by the different organizations ....... 24

Figure 1: Different technological Challenges at different Levels of Development ................................................................................................................. 6
Figure 2: Typical R&D funding Challenges in Emerging Economies ............... 7
Figure 3: Analytical Framework to Understand Decisions in the Process of Establishing or Reforming an R&D Funding Institution ......................... 11
Figure 4: Structural characteristics of the R&D funding institutions compared .... 31
1 General Introduction

In a good governance framework, the motivation to publicly fund research and development (R&D) is to yield added value to society and, in doing so, remain accountable to the taxpayer. While the link between funding allocated and actual added value felt by society will inevitably turn out to be time-lagged and indirect it should nonetheless remain the ultimate rationale for public intervention in the field of science and technology.

Against this background, public funding may follow three clearly distinct but nonetheless closely interrelated rationales for funding:

- Support for Scientific Merit
  To support scientific endeavor on the basis of excellence rather than immediate benefits for society, based on the notion that basic research needs time to reveal its full potential and that the utility of scientific projects is by nature unknown, as are their results.
  Typically, such endeavors are the realm of public research.

- Support for Commercialization
  To support projects related to the application or the adaptation of existing knowledge with a concrete perspective of economic or societal benefit, based on the notion that basic research results alone do not have the necessary potential to assist socio-economic transformation.
  Typically, such endeavors are the realm of either enterprises or co-operative projects.

- Link to Local Needs
  To support projects which directly address a public demand for solutions, beyond a concrete perspective of benefit. The benefit itself is already specified, based on the notion that public money should be allocated in a targeted manner to address existing problems.
  Typically, such endeavors are the realm of either enterprises or co-operative projects.

The Perspective of Emerging Economies

In general, the pursuit of scientific merit for its own sake has to be viewed critically in economies with limited budgetary means, strong societal challenges and only nascent research capabilities. To become a legitimate undertaking even in those economies, domestic investment in basic research has to demonstrate a potential to inform national policy makers in a relevant manner. Hence, it has to be focused on addressing societal challenges that the respective nation is facing as well as to display a certain potential to yield meaningful results.
As in all nations, however, policy makers in emerging economies have a legitimate interest in procuring internationally acknowledged if not leading-edge scientific advice – to obtain best value for their taxpayers' money and create real added value with a view to decision that will impact their citizens' lives. Given the only nascent capacities of the domestic research systems in many emerging nations, domestic scientists will in many cases face difficulties to live up to these criteria on their own. International scientists, to the contrary, may be globally leading in their respective subjects but lack a sufficiently in-depth knowledge of the respective nation's particularity to provide relevant advice. Hence, most emerging economies have an inherent interest to support thematically focused co-operations between domestic and international researchers. In the short run this helps to effectively generate the required results. In the long run, it will help domestic scientists to better meet international scientific standards and to possibly even develop leading capacities in selected fields.

Beyond this merely science-oriented perspective and arguably more importantly, R&D investment in emerging economies can be considered as a central prerequisite for economic development beyond the basic stages of development:

Undoubtedly, the recent two decades have seen a widespread acknowledgement of the relevance of research and development far beyond those economies which are traditionally regarded as scientific leaders. The technology based catch-up of not only the "tiger economies", most notably South Korea and Taiwan PoC, during the 1980s and 1990s but also more recently China illustrated that investments in science and technology are crucial ingredients to emerge from the "middle income trap" – in which countries are no longer poor enough to compete based on price, but not yet technologically mature enough to compete based on innovation (ADB 2011).

Additionally, many emerging economies have aspired, and in the case of South Korea succeeded in, jumping rows in the "flying geese" formation of leading and lagging economies (Akamatsu 1962) by "leapfrogging" backwards in the classic product life cycle (Vernon 1966) and to realize their own, independent breakthrough innovation (Schumpeter 1943). Even though practical evidence of such phenomena is rare (with the possible exception of South Korea), many emerging economies have used this argument to justify investment in independent basic research, for example in the field of electro-mobility in China.

Beyond these general, more abstract considerations, most domestic R&D capacities in emerging economies are sufficient to adapt internationally existing knowledge to generate innovations tailored to the domestic market (Lall 1992; Wong 2001) while there are limited competencies for generic innovation (Gu 1999). Even those "tiger econo-
mies" which have nowadays managed to "leapfrog" (arguably South Korea and Chinese Taipei) have in earlier stages started by investing heavily in learning how to assimilate and improve existing technologies – in order to develop a basis for generating new ones at a later stage (Kim 1999).

Moreover, a notable share of new technologies which are introduced in emerging economies is acquired from extra-regional sources (Ernst 2002), in which foreign direct investments (FDI) still play a prominent role as anchor-points and antennas for the sourcing of international knowledge (Revilla Diez/Berger 2005).

Currently, many developing innovation systems are characterized by a fragmentation of actors and institutions. There is also a substantial lack of trust and, consequently, fruitful linkages between the two (Intarakumnerd et al. 2002). Furthermore, many basic investments in the innovation infrastructure need to be made to generate a full set of actors that can perform the different roles needed for an operative national innovation system (Yusuf/Stiglitz 2001).

All that said, it is easy to realize that public funding institutions in emerging economies have to tackle a multitude of different problems. It is equally clear that many preconditions remain to be fulfilled before the elaborate systems of program-based project support known from Western economies can become operative in an effective way. Consequently, the seemingly easy approach of using best-practice templates to improve national funding system raises questions of relevance from two perspectives:

Firstly, successful examples of public funding institutions such as the US NSF, the French ANR, or the German DFG were established to support an established academic system that is in a leading position or at least competitive worldwide, i.e. one that displays a natural demand for high-level funding of cutting-edge projects.

Secondly, many of these best-practice institutions were set up to support researchers when the respective countries were already industrially at the leading edge of technological development worldwide, i.e. they are designed to support high-class pre-competitive research in a framework where cutting-edge results meet a demand of the private economy, even from SMEs.

Evidently, none of these two conditions is very prevalently fulfilled in emerging economies.

In consequence of the above said, the following study has to take into account that the economic and societal benefit referred to in the introductory paragraph may be quite different, depending on the respective nation's current level of development and realistic ambition (Figure 1).
While most internationally renowned public funding institutions focus on economies reaping their strongest economic and societal benefit from new-to-the-world innovations, many emerging economies can still reap much higher benefits from the customization of existing developments to the domestic market or even from updating outdated technologies so that more firms can start to compete on a quality, even if not yet an innovation-oriented basis.

Importantly, this figure must not be misunderstood as arguing that cutting-edge discoveries could by definition not be made in emerging economies. Quite in contrast, support for high-level endeavors may indeed have a role to play with a view to the above-mentioned leapfrogging argument. Nonetheless, there is an undeniable difference in the weight challenges between those economies which crucially depends on defending their leading-edge positions and those which have to continue investing into their further catch-up with this group.

Figure 1: Different technological Challenges at different Levels of Development

![Diagram showing different technological challenges at different levels of development.]

Source: Own figure, based findings of Lall (1992); Gu (1999); Kim (1999); Wong (2001); Ernst (2002); ADB (2011)

Furthermore, the following analysis has to take into account the systemic perspective. To arrive at a qualified assessment it has to be borne in mind that most of the best-practice institutions fit into a historically grown institutional framework, i.e. they are part of larger support systems in which they play a defined, partial role. While this is also the case in many emerging economies, the division of tasks between these economies' different agencies typically remains some way from fully developed (Intarakumnerd et al. 2002).
2 Specific Challenges for R&D Funding in Emerging Economies

In summary, the available literature suggests that public R&D funding institutions in emerging economies are facing particular challenges.

Firstly, public R&D funding institutions seek to support the build-up of a public research system which has emergent but not yet fully developed capacities to generate scientific merit at an internationally competitive level and where the direct economic benefit of basic research is less obvious than elsewhere.

Secondly, they seek to support commercialization in a context where the absorptive capacity of the industrial sector is much more limited than elsewhere and where application oriented results from the domestic research system tend to be sidelined by knowledge transfer through FDI.

Thirdly, they seek to set up accountable, future-oriented and competitive systems to address relevant local needs in a situation where the research landscape is fragmented and the system of intermediaries remains poor.

Consequently, the overall process of setting up or changing the set-up of a public R&D funding institution has to be handled with particular care in an adapted stepwise manner as outlined in Figure 3 below. While not necessarily to be followed chronologically, both the literature and our later findings suggest that all steps build on each other.

Figure 2: Typical R&D funding Challenges in Emerging Economies

<table>
<thead>
<tr>
<th>Institutional Infrastructure</th>
<th>Framework Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political System</td>
<td>Industrial System</td>
</tr>
<tr>
<td>Legislative</td>
<td></td>
</tr>
<tr>
<td>Executive</td>
<td>limited absorptive capacity</td>
</tr>
<tr>
<td>fragmentation</td>
<td>Public R&amp;D System</td>
</tr>
<tr>
<td>diffuse focus on local needs</td>
<td>only emerging performance</td>
</tr>
</tbody>
</table>

Demand

Consumers (B2C); Producers (B2B); Public Procurement

Source: Own figure
3 A Structured Approach to Identify Lessons Learned

In the following, this final report will review and summarize different findings from a number of specific case studies. To make sense of such a diverse picture, the authors have chosen an analytical approach based on a sequence of steps that are relevant for the establishment or the reform of all public R&D funding institutions, regardless of idiosyncratic circumstances.

Importantly, referring to this analytical framework does not directly imply the claim that all related policy processes do or should follow the described sequence of action. Instead, it refers to the fact that many considerations necessary to establish or reform R&D funding institutions logically build on each other, such as, inevitably, the decision on target groups needs to build on decisions regarding the overall mission, societal needs and specific objectives.

Against this background, the multiple and distinct lessons learned compiled in this international comparative study will be structured according to the main sections of the reference framework as outlined below. Only thus will it become possible to draw more general conclusions based on the diverse experiences made under quite different framework conditions.

In detail, the analytical framework distinguishes the following three main steps.

Firstly, policy makers agree on the key aim of the planned establishment of new R&D funding institutions or other actions to adapt the current system of funding. While the three objectives of scientific merit, commercialization and addressing local needs are not mutually exclusive, an emphasis will typically be put on one of them before action is taken.

Secondly, the specific framework conditions in the country in question will be considered to assess which type of funding mission is currently adequate and which types of instruments have a realistic chance of meeting the demand of either public or industrial researchers in the given situation. Further, relevant local needs will have to be identified in a participatory process which takes into account the interests of the future beneficiaries. Subsequently, the new or reformed funding organization's concrete approach will have to be defined clearly in terms of specific objectives, its target groups, as well as in terms of the role that it seeks to play in the already existing system of support institutions.

Thirdly, more technical issues will come into play. The R&D funding institution has to be given an organizational and a financial model suitable for the purposes defined above. At this stage, however, it is crucial to underline that the question which model is
most suitable will not only depend on the specified mission of the institution, but also on the institutional traditions of the country in question. Irrespective of the precise legal set-up, however, models can be considered as adequate when they serve to achieve the threefold objective of institutional independence, inclusiveness in strategy development and factual budgetary independence.

Further, the exact range of programs will have to be defined, even more strongly dependent on the organizations’ specified mission. Nonetheless, a few general statements can be made: First, it has rarely proven fruitful to unduly focus on an organization. The programs should reflect a certain mix with respect to both themes and target groups. Second, it has rarely proven useful to rely on one type of support only. The programs should reflect a certain mix with respect to ways of allocating financial or other benefits. Third, the system of allocation should be accountable and rule-based, even though its exact nature will have to vary in line with the main mission that the organization pursues.

With a view to this international comparative study, this stepwise framework has the following two central and obvious implications:

- A specific institution’s set of objectives and target groups as well as its co-operation with other institutions; step two can only be assessed with reference to its more general mission specified in step one,
- A specific institution’s organizational and financial model as well as its current set of programs and procedures (step three) has to be evaluated against the background of the assessment of the national situation as well as the objectives stipulated in step two.

Consequently, most lessons learned will in the first step have to remain specific and it is only on the basis of the sum of these specific experiences that later users of this report will be able to draw their own specific conclusions.

Nonetheless, this final report will seek to identify generalizable lessons to the extent possible. To that end, it is important to differentiate between two different groups of countries covered:

Firstly, international models of best-practice from which emerging economies can indeed draw inspirations in terms of many different forms of project and program design, organizational models as well as with a view to selection processes and allocation criteria. Whether these have a chance to be applicable in their individual situation will have to be thoroughly considered.

Secondly, models implemented in countries facing similar challenges from which emerging economies can learn much about the success encountered with different
missions and objectives and the experiences made with good-practice templates of programs and processes under the framework conditions of emerging economies.

In summary, the first type of studies will allow more conclusions with regard to step three of our analytical framework (novel ideas introduced in different, less relevant contexts), while the second type of study will allow more conclusions with regard to step two of our analytical framework (known ideas adapted to similar, relevant contexts).
A Structured Approach to Identify Lessons Learned

Figure 3: Analytical Framework to Understand Decisions in the Process of Establishing or Reforming an R&D Funding Institution

Similar Basic Rationales for Funding -> Different Framework Conditions -> Different Missions and Key Objectives -> Organisational and Financial Model -> Range of Programmes

- Scientific Merit
  - Scientific Capacity in Research
  - Absorptive Capacity in Industry
  - Prevalent Local Challenges

- Commercialisation
  - Relevant Key Objectives
  - Main Target Group
  - Role vis-a-vis other Support Institutions

- Link to Local Needs
  - De-jure Institutional Independence
  - Inclusiveness of Strategy Development
  - Factual Budgetary Flexibility

- Mix of Themes and Target Groups
  - Mix of Approaches & Support Types
  - System of Allocation (Rules-Based)

Source: Own figure, based on literature review and empirical findings of international comparative study
4 Findings Regarding Public R&D Funding Institutions

4.1 General Background

With a view to general societal issues that STI policy and R&D support organizations are facing in emerging economies the case studies’ authors quite often mentioned, issues like poverty reduction, education, climate protection, environmental protection, as well as the reduction of regional disparities.

In general, most studies confirmed that R&D support was directed improving capacity in the national basic research sector; from starting points as different as that of the Chinese research system, parts of which deliver internationally relevant, world-class research and those of the Thai of the Vietnamese research systems where the majority of researchers continue to struggle with the challenge of meeting the quality criteria of the global scientific discourse.

Regardless of the current status of the nation's research capacity, most governments will on certain issues seek consultancy from reputable domestic scientists. Depending on the capability of the national research system, such consultancy draws on a mix of domestic studies as well as the experts' knowledge of what has internationally been found. In most developing economies, currently, the focus still has to remain on the latter approach – in many cases to the detriment of the quality of the consulting.

Even though this study has not investigated this question in detail, it becomes implicitly obvious that many governments have realized this and therefore seek to support the development of those strands of basic and mission oriented-research that are most relevant for the respective nations and societies. Although some still invest substantial amounts of money in prestige projects like supercomputers, they aim to balance this spending with investments focused on national and global challenges. In this respect, the Chinese government's interest in learning from challenge oriented approaches like the German High-Tech Strategy or Europe 2020 is an important case in point – and has already had a strong impact on the Chinese Mid-to-long-term Plan for S&T that quite openly highlights national socio-economic challenges. Arguably, somewhat less has been achieved in the Latin American countries, although an increasing awareness for the issue seems to be obvious as well.

4.1.1 Innovation System

As a first central point, the empirical review underlines that for the competitive advantage of many firms in emerging economies, innovation is currently not central (e.g. in
Brazil, China, Mexico, Vietnam, Thailand). As a result of this the – at least perceived – lack of need for technological upgrading, the absorptive capacity of the business sector remains low. In many cases, R&D activities relevant for the business sector can be considered "development" (market adaptation) rather than "research" so that they do not provide a natural basis for science-industry co-operations. In contrast to the situation in emerging economies, developed economies such as Finland, the US or Germany, innovations are regarded as crucial both for companies as well as policy. Consequently, firm based R&D and public R&D funding institutions adapted to the respective national innovation eco-systems are important features of many developed countries.

Although the public research system continues to be the (in relative terms) dominant R&D performer in many emerging countries (Brazil, Mexico, Vietnam), infrastructure development remains necessary before high quality research results can be obtained. In particular, that holds true for countries with generally weak research systems such as Vietnam or Thailand. Even where the scientific sector already displays certain world-class strengths, e.g. in China, Brazil or Mexico, a large share of public research activities typically bears no direct relation to the economic activities that are constitutive for the country's economic strength as it is not sufficiently adapted to the practical needs of the business sector. Again, the situation regarding the public R&D system in developed countries is quite different: the public R&D sector in these countries – be it universities or the non-university R&D sector – is often quite capable, but in relation to the R&D investments of the business sector of minor importance. However, in countries like Finland or Germany, the public R&D sector is an important knowledge- and technology-provider for the business sector; the structural couplings between the two sectors are comparatively strong and research and innovation policy implement quite a lot of initiatives to support science-business interaction.

As the literature suggests, the case studies confirm that foreign invested firms continue to play a strong role as drivers of innovations in the business sector of emerging economies (e.g. China, Vietnam, Thailand). Their interaction with local firms and thus the spillover effects of their activities, however, are fairly limited. In a number of cases, moreover, they tend to be technologically more advanced than domestic universities, so that their regional science-industry co-operations tend to be limited on obtaining human capital (Thailand, Vietnam, until a few years ago: China). The only emerging nation in which this trend seems to be structurally changing is China. Small developed countries like Finland also rely on direct foreign investments, but the impact on the national innovation capability is not so pronounced as it is in many emerging countries.
4.1.2 Policy System / Key Challenges

Typically, there is a **division of labor between at least two main funding institutions** of which one focuses on promoting scientific research whereas another (or a couple of others) focus on boosting the innovative capabilities of the country's firms (NNSF/Innofund in China, FINEP/CNPq in Brazil, DFG/Different Ministries in Germany, NSF/Departments in the U.S., Tekes/Academy of Finland in Finland, TRF/NSTDA in Thailand). Very few countries have only one institution, either because of a tradition of very strong centralization (Mexico), or because of the novelty of the R&D policy issue as such (Vietnam).

In many economies, especially larger ones, **funding for R&D and innovation is provided on different administrative levels** (national, regional, municipal). Prominent examples of this are developed Germany and emerging China alike. In many cases, similar types of funding are available in parallel – in particular in the field of innovation policy.

In most emerging economies, the **overall set-up of the funding system has rarely been analyzed, i.e. evaluated, in a comprehensive fashion**. Most prominently, this concern was expressed in the Latin American cases but it is implicitly evident as well in Vietnam and Thailand. As a result, its adequacy, effectiveness, efficiency and impact at the level of the national economy remain largely unknown. In most systems, we find that the different national funding institutions display a strong path dependency in following their individual political and institutional trajectories.

Finally, many socio-economic and even innovation related disparities in emerging economies as diverse as e.g. China or Brazil are too large to be addressed and amended by R&D funding institutions alone. As mentioned above, funding institutions need to be embedded in a general research and education policy that invests substantially in infrastructure and human capital development. Only on that basis will many regions and/or sectors of the economy be put in the position to make proper use of funds offered and managed by R&D funding institutions.

With regard to the most prominent challenges that the respective policy systems and R&D funding institutions are facing in terms of structural governance issues, the case studies' individual authors typically commonly reported institutional redundancies of public organizations, inadequately designed or implemented initiatives and support measures, an insufficient adaptation of institutions to national and local needs, as well as a lack of orientation to regional economic development. Although some of these topics also apply to developed countries, their specific challenges regarding R&D and innovation policy tend to focus more strongly on issues related to the knowledge-based
society in general with priorities on aspects like researcher mobility (e.g. attract highly-talented migrant R&D workers), impact and quality of research, R&D infrastructure or the further development, adaptation and implementation of concrete innovation support measures by national or regional R&D funding institutions.

4.2 Design of Public R&D Funding Institutions

4.2.1 Vision and Mission / Detailed Funding Objectives

In general, less than satisfactory experiences have been made with broad "all embracing" missions (e.g. in Mexico or Brazil). In particular, some countries reported the tendency that R&D funding institutions were gradually endowed with an ever broader mandate for which they were not necessarily well equipped as an institution (e.g. Mexico). We thus find that the organizational model of the institution should match its mandate, and that there is a limit to the breadth of the mission that can be effectively addressed by one organization.

Quite clearly, case study based evidence suggests that support for basic, societal challenge oriented is very often aimed at ensuring the full financing of projects which are by nature pure public domain, while direct support for innovation is mostly about setting incentives to prompt and guide the private sector to develop into a publicly desirable direction - while maintaining and spurring individual entrepreneurial initiative. Naturally, therefore, both approaches have to rely on differently qualified employees, different processes for the selection of projects as well as, in consequence, different organizational and financial models. In practice, these different requirements imply that a R&D funding organization (or at least each of its major departments) should be set up with a clear specification in terms of either to promote scientific merit or to promote innovation. In line with this argument, several case studies suggest that good experiences have been made with focused missions by means of which the goals of the individual institutions have been clearly defined (e.g. with the National Science Foundation in the US, and German Research Foundation for basic research but also with the Chinese Innofund with a focus on innovation).

Before setting up a new funding organization or department, it is important to reconfirm the soundness of the assumptions motivating the set-up. On a global level, most organizations were found more or less well aligned with their respective countries' key challenges. On a practical level, however, some studies (e.g. of NAFOSTED) seem to suggest that organizations were set-up too speedily with the result that their offers did not meet the factual needs of the research and/or the business sector.
Hence, focusing an organization's mission on challenges relevant for the country's national innovation system has proven to be useful. With a view to detailed priority setting, it should be borne in mind that a long time may pass between the governmental decision on priorities and the time when the new organization or department becomes operational (e.g. nearly five years in Vietnam). By this time, some of the originally defined priorities may be outdated.

Instead, good experiences have been made with giving organizations the flexibility to adapt their missions in response to their experiences with the demand for their funding measures (e.g. Chinese Innofund, Vietnamese NAFOSTED). Unfortunately, the observed flexibility cannot in all cases be considered as strategically planned and in some cases does not originate from within the support organization itself but takes the form of adapted guidelines from the responsible government department. Nonetheless, the case studies can be considered as providing a sufficient basis to conclude that most flexible approaches towards strategic orientation are superior to closed and fixed orientation, as they may help to support a culture of self-reflexive discussions within the organization and its leadership as much as they provide the practical opportunity to keep R&D funding institutions relevant for evolving national innovation systems.

Due to the high degree of path-dependency, many organizations' missions are fairly broadly phrased or have not been updated for a longer period (e.g. Mexico, Brazil and Vietnam). There is, however, tentative evidence that the clear formulation of goals goes along with a more precise specification of support measures further down the line. Against this background, vague statements should be avoided whenever possible.

On the basis of the missions defined by policy or the respective organizations being in charge of R&D funding, overall as well as detailed objectives have been formulated. The following table provides an overview of the funding objectives of the analyzed organizations:

Table 1: Funding objectives of the different R&D supporting organizations

<table>
<thead>
<tr>
<th>Organization/ Country</th>
<th>Overall objectives</th>
<th>Detailed objectives</th>
</tr>
</thead>
</table>
| **Tekes, Finland**    | • Productivity and renewal of industries  
                        | • Wellbeing of people and the environment  
                        | • Capabilities for innovation activities (skills, networks, internationalization) | • Specific objectives outlined for customer segments: Start-ups and SMEs seeking growth from internationalization; SMEs seeking growth in domestic markets  
                        | • Furthermore: Increase innovation-driven growth of SMEs and promote the internationalization of their R&D and access to global networks  
<p>|</p>
<table>
<thead>
<tr>
<th>Organization/Country</th>
<th>Overall objectives</th>
<th>Detailed objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Start-ups and new fast-growing enterprises: support in obtaining funding in the capital market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Focus on moderate growth enterprises: R&amp;D project support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Large companies: R&amp;D support, global value chains/networks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Public research: focus on multidisciplinary teams and foundation of research-driven business activities</td>
</tr>
</tbody>
</table>
| NSF, USA              | • Focus on advancing basic research and on education related to science and engineering  
|                       | • NSF-sponsored research clearly generates knowledge at the global scientific frontier | • Research focus on national and transnational priorities (e.g. advanced manufacturing, climate change, cyber-security) and interdisciplinary and transformation research goals  
|                       |                   | • Furthermore, interest in the commercialization and use of research results (e.g. sponsoring Engineering Research Centers)  
|                       |                   | • Support of centers with industry components: Industry/University Research Centers, SBIR/STTR programs  
|                       |                   | • Strengthening innovations ecosystems through technology transfer and research partnerships among institutions |
| DFG, Germany          | • Promote (basic) research at different levels: - Support individual, excellent research projects, - Facilitate the formation of research groups, - Promote institutional excellence at universities | • Provide research funding for the formation of research groups that unite a critical mass of specific competencies  
|                       |                   | • Improve scientific merit of German research by supporting international cooperation  
|                       |                   | • Extra funding for transfer projects (although not the overall mission of DFG) |
| Thai Research Fund, Thailand | • Support of basic and applied research in various research areas  
| | • Three main goals: global excellence, national competitiveness and local development  
| | • Most funding objectives relate to curiosity driven research based on academic excellence | • Support research projects of importance for national development both those serving as a foundation for a knowledge-based society and those of direct practical use  
| |                   | • Foster professional researchers and build a strong research community  
<p>| |                   | • Promote the dissemination of research results and their practical utilisation |</p>
<table>
<thead>
<tr>
<th>Organization/ Country</th>
<th>Overall objectives</th>
<th>Detailed objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONACYT, Mexico</td>
<td>• Promote the scientific and technological development by supporting high-quality scientific research&lt;br&gt;• Promote training of human resources at a high level&lt;br&gt;• Stimulate linkages between production processes and the scientific community&lt;br&gt;• Promote technological innovation in enterprises&lt;br&gt;• Strengthen private sector activities, support R&amp;D infrastructures, regional development</td>
<td>• Support for individual researchers&lt;br&gt;• Formation of highly qualified human resources&lt;br&gt;• Support knowledge- and technology transfer: give incentives for private companies to invest more in R&amp;D by supporting them with tax exemptions, subsidizing salaries for scientists, credit lines, seed funding and cooperative research projects with research institutions&lt;br&gt;• Using S&amp;T for regional development and strengthening regional institutions</td>
</tr>
<tr>
<td>Innofund, China</td>
<td>• Increase the technological innovation capability of small technology firms&lt;br&gt;• Facilitate the transfer from research results in products (improving the commercialization of research)</td>
<td>• To accelerate the market transformation of scientific and technological innovations of SMEs in the fields of [selected] key technologies&lt;br&gt;• To promote employment and encourage technology entrepreneurship, especially among graduate students and support start-up companies&lt;br&gt;• To construct public technical service platforms that benefit SMEs and which allows them to share special services.&lt;br&gt;• To improve the venture capital situation for SMEs</td>
</tr>
<tr>
<td>NAFOSTED, Vietnam</td>
<td>• Increasing scientific quality of universities, institutes and scientists (basic research).&lt;br&gt;• Support for projects which transfer research results to products&lt;br&gt;• Supporting enterprise applied R&amp;D (support of trial production projects)&lt;br&gt;• Increase international cooperation and international visibility</td>
<td>• Create a few research institutions which can meet international standards (e.g. support of scientific publications in ISI listed journals)&lt;br&gt;• Focus on practical utilization of research results for the social and economic benefit of Vietnam&lt;br&gt;• Support investments in those types of R&amp;D that are commercially beneficial for the companies and the country&lt;br&gt;• Supporting registration fees for patent applications</td>
</tr>
</tbody>
</table>
### Organization/Country

<table>
<thead>
<tr>
<th>Organization/Country</th>
<th>Overall objectives</th>
<th>Detailed objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINEP, Brazil</td>
<td>• Improving the competitiveness of firms, increasing scientific capabilities of public research organizations (PROs), supporting the cooperation among firms and PROs</td>
<td>• Encouraging networking and knowledge-transfer between industry and research community</td>
</tr>
<tr>
<td></td>
<td>• Support of all phases of scientific and technological development ranging from basic sciences to applied sciences and development and improvement of products, processes and services</td>
<td>• Support of commercialization of research (increasing cooperation between universities, researchers, innovators and investment funds)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Funding public research organizations (PROs) and universities to maintain, set up or improve research infrastructures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support of incubation of new technology based firms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Offering companies services along the innovation process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support of foundation of science and technology parks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support of structuring and consolidation of S&amp;T infrastructures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Address socio-economic needs within the frame of regional budgets (for the North and North-East) local production systems and the setup of training facilities in PROs</td>
</tr>
</tbody>
</table>

Source: own compilation

When analyzing the different objectives it can be stated that two types of organizations have been established: on the one hand organizations which pursue a broad and quite general mission (e.g. Mexico, Brazil, Vietnam) and on the other hand organizations with a focused and quite specific mission like the DFG in Germany, NSF in the US and also Innofund China.

### 4.2.2 Organizational Models

Regarding the organizational models of the R&D funding institutions in the three developed countries in our comparative analysis indicates that all three organizations are legally independent. The National Science Foundation in the US for instance has a high degree of strategic and financial independence to sponsor R&D activities within broad parameters set by its authorizing legislation, the National Science Board and oversight authorities. The German Research Foundation is also quite independent and has the status of an association under private law. As an organization, the DFG thus acts independently through its statutory bodies, in particular through its Executive Board. Tekes in Finland enjoys extensive independence as a government agency led by the director general and Tekes board which is regulated by legislation.
In contrast to the independent support organizations of the technologically leading or
developed countries, many R&D funding institutions in emerging economies are
organizational sub-units of ministries or other government bodies. Among R&D
support agencies in emerging economies, CONACYT (Mexico) is the only organization
which is constituted as a legal entity without a superior agency. In most other cases
R&D funding organizations, even though formally independent, still report closely to
public authorities (e.g. Brazil, Vietnam, Thailand). In some cases they are even formally
part of public administrative agencies (e.g. China). Even when institutions are de jure
independent, such as CONACYT, they often remain de facto dependent, e.g. through a
dominant representation of government on their boards.

Most prominently, this is a well known issue with funding for innovation – that in
many fields it touches on issues of industrial policy which are classically placed under
the responsibility of national ministries. In fact, this structure of comparatively indepen-
dent organizations which fund public research and comparatively dependent organiza-
tions which fund innovation (quite often the ministries directly, like in Germany) can be
found in both highly developed and emerging economies alike.

One main problem of such subordination is that sub-units of certain ministries will
tend to limit their strategic considerations to the mandate of these exact minis-
tries – and that as a consequence, R&D and innovation policy will run the risk of be-
coming biased or fragmented along the lines of administrative responsibilities. For ex-
ample, placing the organization under the Ministry of Education may lead to an undue
focus on universities and neglect of other important players in the innovation system
(as happened in Mexico). In principle, a direct subordination to a Ministry of Science
and Technology could lead to a similar effect as it would in turn prompt a neglect of
educational issues. Furthermore, there is tentative evidence that units of govern-
ment tend to have a stronger tendency to apply mainly political rather than evi-
dence-based criteria to the selection of projects – even though these two perspec-
tives are of course not mutually exclusive. On that basis, we conclude that R&D fund-
ing institutions should best be set up as independent organizations.

As already mentioned under the heading of "missions", there is evidence of strong
issues within "mega-institutions" that try to address too many objectives in par-
allel (e.g. CONACYT, FINEP, increasingly NAFOSTED). As can be expected, it
seems to prove quite challenging to set up processes and administrative logics that are
e.g. equally suitable to the very different tasks of supporting public research, innova-
tion, or science-industry co-operation (technology transfer) alike.
Furthermore, some case studies indicate that it may be helpful for the smooth internal operation of an R&D funding institution when different functions such as "project examination", "allocation of grants", and "project supervision" are placed in different departments (as practiced in Chinese Innofund) – as this ensures independence and allows the organizations' managers to professionalize the respective activities. Such differentiation, however, should not be driven too far and a clear central responsibility for each project line must be defined.

4.2.3 Funding Model

First of all, the case studies indicate indirectly that a critical mass of funding needs to be available to the R&D funding institution so that a meaningful model of allocation with a good balance between administrative cost and benefits allocated can be implemented (see table below for figures on the organizations' budget indicating this issue for e.g. the Thai Research Fund). On the other hand, China has had good experiences with setting-up organizations with comparatively low budgets and then letting them grow as organizations in line with their budget. In those (common) situations, where it is both politically and administratively non-feasible to straightforwardly replace the existing funding structures, it can be expedient to pilot new approaches by setting up small-scale novel institutions besides the existing ones. Thus, their viability as well as strengths and weaknesses in the specific context can be tested and their legitimacy confirmed before more substantial allocations are diverted from the existing to the new structures. In China, this process can be observed for the set-up of and later transfer of funding to both the Innofund and the NNFC – which have replaced and complemented more traditional ministerial funding.

Moreover, a number of the described financial models are undoubtedly overly complex in that they are on the one hand fed from a too diverse set of sources while on the other hand allocations are distributed to too many different sub-budgets, before the actual process of selection takes places. Additionally, complexity can arise from the fact that funding from some sources has to be deployed in a purpose-bound manner while other monies feed into central budgets of which there are oftentimes more than one. As a result, the network of funding channels becomes difficult to understand both from the outside and from the perspective of those executive managers within the organization that are supposed to manage and reform it (e.g. FINEP in Brazil or CONACYT in Mexico). In particular, this seems to be an issue within organizations that are already quite old and have an overly broad mission that has developed over time. As a result, we would raise a note of caution that the emergence of financial complexity should be closely monitored by the organizations' executive officers and, if need be, curbed while there is time.
Furthermore, many R&D funding organizations have an issue with a lack of de facto budgetary independence as they are either directly dependent on tax income (which is difficult to predict) or on annual budgetary decisions (which are difficult to alter once taken). CONACYT for instance depends on governmental and sectoral budget decisions, which means budgets fluctuate and the amount of available resources varies from year to year. In one of these situations, it can be either difficult for funding organizations to strategically plan new programs – as they do not know if the existing ones can at all be financed – or to close down non-performing measures – for which fiscal commitments have already been made.

Within this context, the financial model of Tekes in Finland deserves to be mentioned. Tekes' budget is decided on annually in national budget negotiations and thus prone to fluctuations, but Tekes ensures multi-year project funding by internally reserving the full amount of money needed for the planned period of performance of the project before its respective department takes a positive funding decision. Thus, the individual projects are paid depending on their progress and cannot be jeopardized by budget fluctuations. In the case of multi-year projects funded in the US, in contrast, the NSF also makes obligations for funding, but these remain contingent on congressional budgeting. Should congress decide to discontinue a certain project line, it can thus happen that multi-year projects have to be terminated before the envisaged period of performance has been completed. Inevitably, many of the planned results will thus not be achieved and taxpayer money will be wasted. In the Finnish system, Tekes might have to limit the number of projects approved in the beginning (as the initial multi-year obligation per project is high) but will in turn be able to guarantee that funding for the approved projects can be continued from non-contingent obligations even when the respective budget line is discontinued half-way through their period of performance.

By means of suggestions, the case studies indicate that a proprietary, independent budget is the key to a funding organization's strategic and operative flexibility. On the one hand, it allows the organizations' managers to flexibly adapt their portfolio of measures support according to the funds factually available while on the other hand it allows for example the individual case handlers to carry forward non-allocated funding into the next year and thus deal flexibly with the available resources. As the case studies illustrate this lesson has already been taken into account in Brazil and Vietnam.

When making decisions about the distribution of funding within the organization, several case studies illustrate that in certain fields of action national-level funding can and tends to be complemented with funding from other levels of government or from additional private sources of funding (on a regional level e.g. by China's Innofund but in more general terms also by CONACYT and FINEP). Taking all options of such co-
financing into account seems an important and appropriate basis for all financial models of national-level R&D funding organizations.

Finally, most case studies from emerging economies suggest that public R&D funding organizations are subject to public audit procedures – which are comparatively transparent and professionalized against the background of the overall innovation systems that they are operating in (e.g. in Mexico, Brazil and Vietnam). Nonetheless, they are not at all times sufficiently comprehensive and of a fairly technical nature. As such, they cannot compensate the lack of evaluations stated above.

The following table gives an overview of the different funding models and indicates the range of the organizations analyzed in terms of budget, sources of funding, degree of budgetary independence and budget allocation.

Table 2: Comparison of different funding models

<table>
<thead>
<tr>
<th>Organization/Country</th>
<th>Available budget</th>
<th>Sources of funding</th>
<th>Degree of budgetary independence</th>
<th>Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tekes, Finland</td>
<td>$765 million (2011)</td>
<td>Ministry of Employment and Economy</td>
<td>High</td>
<td>Tekes board makes funding decisions</td>
</tr>
<tr>
<td>NSF, USA</td>
<td>$7.03 billion (2012)</td>
<td>Federal government through congressional appropriations</td>
<td>High</td>
<td>NSF independently allocates funding on merit criteria</td>
</tr>
<tr>
<td>DFG, Germany</td>
<td>$3.06 billion (annually)</td>
<td>Funded by federal and regional ministries</td>
<td>High</td>
<td>Project-based</td>
</tr>
<tr>
<td>Thai Research Fund, Thailand</td>
<td>$170 million (2011)</td>
<td>Annual government allocation (20%), own endowment fund (65%), other sources (15%)</td>
<td>Rather high (government allocation is much smaller than endowment fund)</td>
<td>Block grant</td>
</tr>
<tr>
<td>CONACYT, Mexico</td>
<td>$1.06 billion (2011)</td>
<td>Federal budget, sectoral contributions</td>
<td>Low</td>
<td>Project-based, system of funds</td>
</tr>
<tr>
<td>Innofund, China</td>
<td>$600 million (varies year-to-year)</td>
<td>Ministry of Finance</td>
<td>Low (Funding has to be allocated in line with current guidelines)</td>
<td>Project-based</td>
</tr>
<tr>
<td>NAFOSTED, Vietnam</td>
<td>$9.6 million</td>
<td>Ministry of Finance</td>
<td>Low</td>
<td>Project-based</td>
</tr>
<tr>
<td>FINEP, Brazil</td>
<td>$876 million</td>
<td>Federal Ministries, taxes, levies (sectoral funds)</td>
<td>Medium</td>
<td>Project-based, system of funds</td>
</tr>
</tbody>
</table>

Source: own compilation
4.2.4 Funding Instruments

According to their objectives, the analyzed R&D funding organizations have implemented different schemes featuring specific characteristics both content wise and formally. Nearly all of the instrument/programs which focus on basic research are offering grants, either for individuals (Ph.D. students, researchers) or public research organizations. The maintenance and operation of public R&D infrastructures is typically carried out on the basis of public calls or project-based, not so much within the context of institutional funding (at least with regard to the organizations in our study). Another popular funding mechanism are R&D loans which offer reduced interest rates when it comes to the financing of R&D projects. With a view to risky technology oriented projects in their early phase, special venture capital funding instruments have been implemented to reduce the risks for the company or the founder and at the same time make the company attractive for profit-oriented VC companies investing in the later phases. In general, the following types of funding actions can be distinguished:

- Loans for R&D projects in firms
- Grants for R&D projects in firms
- Funding for R&D projects in public research (grants)
- Investment in R&D infrastructure (project-based, rather than institutional-funding)
- Loans for joint R&D projects of firms and public research
- Funding for organizations providing services
- Funding for venture capital
- R&D Contracts (public procurement)

Table 3: Funding instruments implemented by the different organizations

<table>
<thead>
<tr>
<th>Organization/Country</th>
<th>Main Instruments</th>
<th>Specifics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tekes, Finland</td>
<td>R&amp;D grants</td>
<td>Both, proactive funding in line with overall strategic objectives and reactive funding based on customer-demand; funding of development and operation of SHOK research centers.</td>
</tr>
<tr>
<td></td>
<td>R&amp;D loans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Funding for young innovative enterprises</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Funding for strategic research</td>
<td></td>
</tr>
<tr>
<td>NSF, USA</td>
<td>Grants</td>
<td>Grants for research and educational programs are provided as single- or multi-year awards (71% of NSF's obligations).</td>
</tr>
<tr>
<td></td>
<td>Cooperative agreements</td>
<td>Cooperative agreements focus on the support of research centers and multi-use facilities where there is a substantial agency engagement (23% of obligations).</td>
</tr>
<tr>
<td></td>
<td>Contracts</td>
<td>Contracts are used to procure studies, services and other products for NSF or other government use.</td>
</tr>
<tr>
<td>Organization/Country</td>
<td>Main Instruments</td>
<td>Specifics</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| DFG, Germany              | • Individual research grants  
• Collaborative research centers  
• Research training groups  
• Institutional strategies for Excellence | Research grants program enables researchers from all scientific fields to apply for funding of individual research projects at any time. Collaborative Research Centers are established at universities for a period of up to 12 years with the aim to pursue interdisciplinary research. Research training groups can be established by universities to promote young researchers; emphasis is on offering excellent qualification opportunities to Ph.D. students. Institutional strategies for excellence aim at strengthening Germany as a location for cutting-edge research at universities. |
| Thai Research Fund, Thailand | • Grants: Basic research and career development projects  
• Grants: Royal Golden Jubilee Ph.D. Program (RGJ)  
• Grants: Area-based Collaborative Research (ABC)  
• Grants: Industrial Research Associate Program (IRAS) | • Fostering basic research capabilities: Funding for projects and career development in all scientific fields; funding for projects that are related to specific strategic research issues  
• RGJ: Scholarships for Ph.D. students; program contributes to excellence in Ph.D. education and internationalization simultaneously  
• ABC: Participatory action-based research: funding research which addresses the needs of local communities  
• IRAS: Collaboration between universities and industry |
| CONACYT, Mexico           | • Subsidies  
• Credits  
• Training  
• Advice  
• Grants  
• R&D infrastructure | Instruments are difficult to separate as there is a wild mix of incentives under various headlines. Three main instruments:  
• National System Researchers (aim: increase and improve scientific output)  
• Scholarship Program (aim: support the development of human resources)  
• Sectoral funds (aim: research for sector specific needs) |
| Innofund, China           | • Innovation projects grants  
• Venture capital investment  
• Subsidies for improving the innovation environment | Four types of funding categories have been implemented:  
• Grants for science and technology based SMEs innovation projects  
• Subsidies for organizations that offer services for technology based SMEs  
• Bank loan subsidies for medium-sized firms  
• Venture capital fund for science and technology based SME entrepreneurship |
### Findings Regarding Public R&D Funding Institutions

<table>
<thead>
<tr>
<th>Organization/Country</th>
<th>Main Instruments</th>
<th>Specifics</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAFOSTED, Vietnam</td>
<td>• R&amp;D Grants</td>
<td>• Basic Research Program: funding for basic research to scientists who are affiliated with one public R&amp;D or education institution in Vietnam</td>
</tr>
<tr>
<td></td>
<td>• Loans</td>
<td>• Research Support Activities Program: researchers can apply for funding to attend conferences, workshops, do internships (in Vietnam or abroad)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• International Cooperation Program: co-funding of collaborative scientific research between scientists from Vietnam and Flanders (basic research)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Enterprise Support Program: Enterprises can apply for funding to invest in science and technology, innovation, improvement of product quality and production effectiveness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Emerging Issues Program: Funding of research issues that need immediate action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Loan Program: Public loans to individuals, organizations and enterprises that apply research results and emerging technologies</td>
</tr>
<tr>
<td>FINEP, Brazil</td>
<td>• Reimbursable funding for companies (reduced interest rates)</td>
<td>• Support innovation in companies (Inova Brasil)</td>
</tr>
<tr>
<td></td>
<td>• Venture capital support</td>
<td>• Support for Public Research Organizations (PROs) (PROINFRA)</td>
</tr>
<tr>
<td></td>
<td>• Non-reimbursable financial support</td>
<td>• Research in strategic sectors (FNDCT)</td>
</tr>
<tr>
<td></td>
<td>• Maintenance and modernization of research infrastructures</td>
<td>• Support of cooperation among firms and PROs (SIBRATEC)</td>
</tr>
</tbody>
</table>

Source: own compilation

A broad legal mandate gives the organization full leverage to deploy different types of measures in the combination that a particular problem in hand requires. To the extent possible, **legal limitations on the type of support that an organization can provide should be avoided** (a positive aspect of e.g. the broad mandate of FINEP but also true with regard to the various instruments applied by Innofund). If that opportunity is missed, there is a danger that in logical terms related activities will be artificially split between e.g. a funding, a loan, and a VC institution.

On the other hand, **each individual support program should have a clear and recognizable character** and not mix too many different objectives or types of support.
With a view to some types of funding such as continuous basic funding it should be duly considered if those can remain the task of government agencies (ministries) and need not be part of the mission of independent R&D funding organizations. The reason for this is twofold. Firstly, the set of recipients of basic funding is typically either fixed or politically negotiated. A specific process and select from applications is thus not needed. Secondly, the allocation of continuous basic funding does not require monitoring in the same way than program funding. Instead, much of the negotiation related to basic research funding have a strongly political dimension that has to be communicated and executed by legitimate representatives of the state. In summary, the two main strengths of independent funding organizations: criteria-based selection and independent monitoring cannot really come to play while some key competences of public administrations are strongly required. As in other cases, this recommendation does not constitute a general norm but a point of consideration that may be considered in different ways under different framework conditions.

In principle, on the contrary, the idea of implementing a mix of different types of funding programs through the same institution seems warranted, even if this requires institutional capabilities that remain to be developed in a number of the surveyed organizations. On the one hand, hardly any "key challenge" within a nation's innovation system (e.g. lack of science-industry relations) can be addressed through one type of measure. On the other hand, however, measures that address the same challenge need to be coordinated which is best possible when they are administered within the same organization.

For similar reasons, the parallel eligibility of both public and private recipients is in many cases desirable, in particular for measures aiming to improve commercialization and address local needs. FINEP in Brazil for instance disposes a wide array of funding instruments and embraces public and private research activities. Meanwhile, a similar statement can be made about NAFOSTED and TRF that have added funding lines for industry. Furthermore, innovation oriented funding institutions like Tekes or Chinese Innofund implemented different schemes both for large enterprises, SMEs and research organizations. Some types of basic research funding focused on scientific merit, in contrast, should only be allocated to public recipients – which remain the main beneficiaries of DFG and NSF funding.

In any case, science-industry co-operation in emerging economies is one of the issues difficult to improve by public financial incentives alone – as in many cases complementary institutional reforms are required to make the process operational and effective. Still, the case studies repeatedly highlighted that support for science-industry cooperation was applied in a too simplistic manner (e.g. by assuming that the mere
participation of industrial partners in R&D projects guarantees technology transfer) and based on outdated spill-over and linear transfer assumptions (e.g. 'ofertismo' in Mexico) that apply even less in emerging economies where the gap between research and innovation system is larger than elsewhere (cf. sections on innovation system for in particular Vietnam, Thailand, Brazil and Mexico). Apparently, there is a need to improve and deepen policy makers' understanding of the preconditions for successful knowledge transfer – a process that seems to be underway in China.

In general, the range of programs should not become too broad and outdated or unsuccessful programs should eventually be discontinued rather than remain in a process of liquidation indefinitely. Otherwise, the funding institutions managers run the risk that their offer of support becomes unduly spread out and dispersed and unattractive to the potential beneficiaries. A number of case studies have illustrated cautionary examples where the co-ordination between different areas of funding has anything but collapsed so that more than once there are measures to the same effect under only marginally different headings – but each with a too small endowment of funding (most explicitly mentioned for CONACYT, implicitly for others).

On the technical side, some case studies suggest that there is in inherent danger in support programs that run for a very long time (as e.g. some of FINEP) and individual allocations that are guaranteed for a long time as such a set-up does not provide real incentives to perform. Instead, other case studies suggest that a suitable way to implement long-term funding should rely on intermediate assessments and – in the case of multi-annual projects – compulsory applications for renewal after e.g. 2-3 years which are then once more thoroughly assessed (as practice by e.g. the Chinese Innofund).

4.2.5 Selection Criteria

Selection processes will have to vary with regard to the type of support provided and the degree of politicization of the topic in question. As was to be expected, therefore, the case studies provide ample evidence of both structured tendering as well as of rather spontaneous allocations.

While that is logical, there are also common accounts of a lack of continuity within tendering procedures which could in principle be expected to be consistent (e.g. in Mexico and Brazil). In this regard, it seems advisable to establish a clear approach towards assessment for each program and then stick to it unless good reasons – e.g. evaluations or real shifts in budget – suggest otherwise. If different objectives are to be aimed at, the more focused response might in some cases be to launch a new,
substitutive program rather than to widen an existing one indefinitely. Otherwise the whole funding system may become confusing for its potential beneficiaries.

Furthermore, it has to be borne in mind that very often the volume of funding is less decisive than the fact of receiving funding – a fact reported from in both developed and emerging economies, e.g. from China. That of course only works if the selection process is both credible and transparent. **Credibility, therefore, should be the concern of both the executive management and the individual case handlers in all public R&D funding organizations.** This is of crucial importance as it sets the organization apart from being just one more exchangeable source of public money. At least officially, many fund managers have committed to this from Mexico to China.

While projects should be checked for quality and originality, case studies, of e.g. the Chinese Innofund, suggest that it is **equally important not to set the initial threshold too high – to avoid that risky projects in their earlier stages have no chance of being funded.** Instead, decisions on further – and potentially higher – allocations should not be made on a one-off basis at the beginning, but also be based on later interim evaluations and applications for renewal (see section above). Thus, the threshold can be gradually raised throughout the project.

Insofar as possible, central **selection criteria should be based on the support programs' stated objectives.** In general, therefore, they can only then be precisely and suitably defined when the concerned support program has clearly stated objectives in the first place. The broader a program had been formulated, the more frequently did the case studies suggest that excellence was not always the decisive factor for project selection – arguably since vague specifications left too much room for a personal, context-specific interpretation (positive examples from China and Thailand, negative from Vietnam and Mexico).

Finally, regional correspondents from Asia to Latin America agree that the **involvement of independent expert panels** in the selection of projects is an asset, while the general absence of such panels is usually not a good sign. The NSF for instance has implemented a three-step procedure for processing proposals in which multiple reviewers review each proposal using the NSF merit criteria. The German Research Foundation involves external peer reviewers which assess the quality of the proposals with regard to scientific excellence and originality. Efforts to same effect can be documented for Innofund in China and NAFOSTED in Vietnam. In general, external reviewers or panels are important to both avoid an overt politicization of the institution's activities and to bring in views from practitioners and potential beneficiaries which of course is not in itself free of inherent challenges. In other words, to avoid these panels becoming
mere arenas for vested interest groups some organizations have sought to define clear and generalizable criteria for the selection of experts, e.g. regarding their qualification (e.g. Innofund).

For certain types of local-needs-based support programs, a bottom-up approach responding to the expressed needs of potential recipients is indispensable. Depending on the region, it is also clear that regional development based funding approaches will in emerging economies often be less excellence-based in a narrow sense. Nonetheless, the objective to respond to local needs should not lead to a complete dilution of (basic) selection criteria with a view to quality and originality. A good example in this regard is given by the complementary funding approach of the Chinese Innofund which provides additional national funding to a selection of projects which have already been considered fit for regional support by their respective regional governments. Thus, a sufficient match with local needs can already be considered ascertained based on the regional governments decisions, and the national Innofund can concentrate on applying additional, excellence based criteria.

From a technical perspective, access to the selection process should be flexible and open, so that applicants do not have to ‘wait for the next opportunity’. To reduce administrative effort and cost, however, the actual decisions about allocations should be bundled and taken in regular intervals rather than continuously. Additionally, this process allows the experts to compare different proposals and to decide accordingly. In general, decision times should not be too long, a problem encountered by e.g. the Chinese Innofund. When it takes more than a year for funding to be approved, the respective R&D project will oftentimes have succeeded (or failed) without it.

In addition, several case studies highlight that overly complex and bureaucratic technical stipulations can be a hindrance to the targeted allocation of funding. Innofund for instance has defined 8 criteria for companies who apply for funding. Furthermore, the Chinese companies are committed to prepare extensive application materials. If the recipient has to fulfill a large number of formal criteria this will either keep him/her from applying in the first place or prompt him/her to fulfill these criteria on paper – without saying very much about his/her actual qualification for support.

As is the case regarding financial audits (see section above), selected case studies indicate that some R&D funding institutions in emerging economies have indeed started to implement increasingly reliable systems to monitor the results / the output of their support programs (e.g. China). With a view to the lack of evaluations stated in the second section, this should be welcomed as a first step towards impact assessment and promoted further. Good-practices among the developed countries
can be observed in Finland, where Tekes constantly monitors and assesses the results and impacts of the projects that it funds. For monitoring purposes, Tekes collects information on project effectiveness at the beginning and the end of each project and three years after its conclusion (with a view to their impact). Furthermore, external evaluations and effectiveness studies are carried out. Like Tekes, the German Research Foundation conducts and commissions evaluation studies at regular intervals aiming to assess the outcome and impact of its support from several perspectives.

5 Summary

Based on a structured approach to identify lessons learned regarding public R&D funding in both single developed countries and emerging economies, the findings of the different case studies indicate that the interplay of various organizational characteristics contribute to the "success" or vice versa failure of an organization and possibly the national research and innovation system as such. However, this implies that certain "good-practice" elements of R&D funding organizations in several emerging economies have already been implemented, rather than being observable solely in developed countries.

The following figure gives an overview of the most important characteristics in terms of success factors or critical features of R&D funding organizations and the assignment of the different countries or cases.

Figure 4: Structural characteristics of the R&D funding institutions compared

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mexico (MX)</th>
<th>Brazil (BR)</th>
<th>Vietnam (VN)</th>
<th>Thailand (TH)</th>
<th>Germany (DE)</th>
<th>Finland (FI)</th>
<th>Belgium (BE)</th>
<th>China (CN)</th>
<th>United States (US)</th>
<th>Source: own compilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad institutions, general mission</td>
<td>MX</td>
<td>BR, VN</td>
<td>TH</td>
<td>DE, FI</td>
<td>US, CN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subject to directives</td>
<td>VN, CN</td>
<td>MX, TH</td>
<td>BR</td>
<td>US, FI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependent on public budget</td>
<td>VN, CN</td>
<td>MX</td>
<td>BR, TH</td>
<td>US, FI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sparsely differentiated organization</td>
<td>VN</td>
<td>CN, DE</td>
<td>US, FI</td>
<td>BR, TH</td>
<td>MX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad, complex portfolio of instruments</td>
<td>MX, BR</td>
<td>VN</td>
<td>TH, CN, FI</td>
<td>US, DE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing portfolio</td>
<td>VN</td>
<td>CN, MX</td>
<td>BR</td>
<td>DE, US, TH</td>
<td>FI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak specifications of programs</td>
<td>MX, BR, TH, VN</td>
<td>CN</td>
<td>DE, US, FI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No systematic allocation</td>
<td>MX</td>
<td>TH</td>
<td>CN, BR, VN</td>
<td>DE, US, FI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Regarding the general mission of the analyzed organizations it has been pointed out, that broad institutions with "all embracing" mission like in Mexico or Brazil are not particularly successful, especially when their mandate became broader without being necessarily equipped as an institution. Good experiences on the other side have been made with focused organizations and a clear defined mission. The NSF in the US and the German Research Foundation are good practices, but also Innofund in China.

Furthermore, our analyses indicate that a certain degree of independence, particularly strategic clearly contributes to achieve the main objectives for which the organization has originally been established. Vietnam and China are examples where the funding organizations have a strong tendency to apply mainly political rather than evidence-based criteria in the course of their funding routines. Among the emerging economies CONACYT in Mexico is the only organization which is constituted as a legal entity without a superior agency. The funding organizations in Brazil, Vietnam and Thailand are formally independent but subject to public authorities.

Like the strategic independence the degree of autonomy regarding budgetary (in)dependence appears to be crucial. We observed that many R&D funding organizations in emerging economies are budgetary dependent on tax income or on annual budgetary decisions. The funding organizations in Vietnam, China and Mexico for instance depend on governmental and sectoral budget decisions, which implies that budgets fluctuate and the amount of available resources varies from year to year. Taken also into account the experience from developed countries, the case studies indicate that a proprietary, independent budget is the key to a funding organization's strategic and operative flexibility.

Regarding the organizational structure in terms of specialized departments our case studies indicate that it may be helpful when different functions within the process of allocation are placed in different departments as this ensures independence and allows the organizations' managers to professionalize the respective activities.

In line with the breadth of the mission to be fulfilled by an organization, the amount, complexity and change of the instruments designed and implemented increases. Mexico, Brazil and Vietnam are cases where the range of programs is quite broad, with a mixture of instruments providing funding for own institutes, infrastructure funding, project funding, etc. A certain dynamic of funding instruments, like in Vietnam, China or Mexico may be an indication of a changing role of the funding organization – and the compulsion to focus on new funding purposes – or the failure of a measure and the substitution by new ones. On the other hand, the FINEP case suggests that support programs that run for a very long time with individual allocations being guaranteed do
not provide real incentives to the target group in its entirety. Regarding the specifications of a measure or program, the good practice cases (USA, Germany and Finland) indicate that each individual support program should have a clear and recognizable character and not mix too many different objectives or types of support.

Finally, in the course of the analysis of the selection process our cases proved that according to the type of support provided and the degree of politicization of a certain topic, both structured tendering as well as spontaneous allocations are practiced. Countries like Germany, the USA and Finland, but to a certain extent also China, Brazil and Vietnam have implemented an allocation system with selection criteria based on the support programs' stated objectives. While the involvement of independent experts in the selection of projects is quite sophisticated in Finland, the US and Germany, efforts can be documented in China and Vietnam.

References


