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Knowledge, Technologies and Innovation for Development in the Agenda 2030: Revisiting Germany's Contribution

Discussion Paper

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Knowledge, Technologies and Innovation for Development in the Agenda 2030: Revisiting Germany's Contribution

Commissioned by the GIZ Sector project "Development Orientated Trade and Investment Policy and Promotion" on behalf of the BMZ

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List of Abbreviations

AAAA	Addis Ababa Action Agenda
BMZ	Federal Ministry for Economic Cooperation and Development
BMBF	Federal Ministry of Education and Research
BMWi	Federal Ministry for Economic Affairs and Energy
CIM	Centre for International Migration and Development, a joint operation of GIZ and the German Federal Employment Agency
CDP	UN Committee for Development Policy
DAAD	German Academic Exchange Service
DEG	German Investment Cooperation, a subsidiary of KfW
DESA	UN Department of Economic and Social Affairs
DFG	German Research Foundation
DUI	Doing, Using, Interacting (mode of innovation)
FDI	Foreign Direct Investment
KfW	German government-owned development banking group
LDC	Least Developed Countries
MDGs	Millennium Development Goals
MNC	Multinational Companies
NIS	National Innovation Systems
ODA	Official Development Assistance
ODC	Other Developing Countries, used by UNCTAD to distinguish developing countries from least developed countries.
PPP	Public Private Partnerships
SMEs	Small and medium-sized enterprises
SDG	Sustainable Development Goals
STI	Science, Technology and Innovation
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development

Foreword by the authors

It was a great privilege to be asked by the GIZ on behalf of BMZ to write a discussion paper on Germany's contribution towards the Agenda 2030 from a knowledge, technology and innovation perspective as well as a great responsibility. Much deliberation and reflection has taken place in the last six years around this topic, but this work has by no means reached a conclusion as there is much more that can yet be done.

We support the view that a broader understanding of the role of science, technology and innovation is needed, and that building the capacity and capability of innovation systems in developing countries is vital. This is precisely what the Agenda 2030 and the Addis Ababa Action Agenda are demanding from the international development community and developing countries. The long-overdue global consensus on the role of science, technology and innovation as a cross-cutting theme is an exciting development, one which requires a re-think of traditional sectoral or topical development programmes and how they can benefit from this theme.

Our work in this field has made us well aware of Germany's long-standing track record as a development partner in science, technology, knowledge and innovation support for developing countries. This has been occurring not only on the official public policy level, but also on a broader level where universities, science and technology organisations, economic development programmes and private companies are interacting, sharing, learning and exploring with counterparts in developing countries. The sheer diversity, depth and scale of the options that Germany can now offer may even appear to developing countries to be overwhelming and hard to navigate.

Although many elements of the German Innovation System are plainly visible and well known, beneath the surface there are elements that even our German counterparts sometimes overlook or take for granted. The German Innovation System is a complex one that is still evolving. It has a long history, and many of the current system features were shaped by intentional and unintentional decisions made long ago. Developing countries need help to fathom which ideas can be transferred and learned from, and which ideas are not suitable to their particular context. Furthermore, there are many factors that are not so obvious, which makes it harder to learn from or transfer ideas from Germany to developing contexts. In this respect we should always be aware that Germany's science and technology activities are organised on a highly decentralised way, whereas in many developing countries science and technology decisions are often more centralised.

As Mesopartner we often work both on the side of the developing country and on the German side to broker relations, build networks, enable exchange and support knowledge and technology transfer. We have seen the extent to which German technology, support and expertise have made a difference in the countries in which we work, even when science, technology and innovation are not the main issues being dealt with. But we have also seen the shortcomings of too great a focus on hardware, training, patents and blueprints and too little emphasis on human capacity, partnerships, networks and adaptation to the local context.

We trust that this discussion paper will contribute to a reflection process in Germany that will draw in not only the official actors in science, technology and development, but also those in the private sector and academia. We have offered some conclusions and insights as starting points of a wider discussion, but this is only a start. We anticipate seeing a longer-term, broader approach to strengthening the innovation systems and technological capabilities of developing countries, and look forward to the discussion on how more of the German Development Cooperation's potential can be leveraged to build these capacities in developing countries.

We thank Leonor von Limburg from the GIZ for her guidance and contributions.

Chapter 1.

Introduction

This study was commissioned by the GIZ sector project Development Oriented Trade and Investment Policy and Promotion on behalf of the German Ministry of Development Cooperation (BMZ). The objective of this study is to explore the role of Germany in fostering the development, diffusion and transfer of technology in the framework of the 2030 Sustainable Development Agenda.

This report is structured as follows:

- **Chapter 1** introduces the reader to key concepts used in the study, and is structured into three subsections.
  - **Section 1.1** examines the context from which this paper emerged, namely the role of Germany in contributing to the objectives set by the Addis Ababa Action Agenda (AAAA).
  - **Section 1.2** explains the reasoning behind expanding the science, technology and innovation approach to a broader innovation system approach.
  - **Section 1.3** highlights key elements of the AAA Agenda and poses reflective questions that will be considered in the remainder of the study.
- **Chapter 2** explores in detail the innovation systems approach, building technological capability, strengthening absorptive capacity and the Do Use Integrate modes of innovation.
- **Chapter 3** provides an overview of the German innovation system. To understand the current incentives and institutional arrangements, it is necessary to look back at how some of the key characteristics emerged over time. The salient features of the German innovation system are then briefly discussed and how the system is embedded in the broader economic and social framework. This chapter concludes with a discussion on the inconspicuous or non-salient features of the German innovation system. These are harder to detect but are visible to those who work in or near the system.
- **Chapter 4** focuses on the promotion of innovation systems in developing countries.
- **Chapter 5** explains Germany's role in supporting innovation systems in developing countries. The preceding discussions are considered and a way forward for the German Development Cooperation is proposed.

1.1 The cross-cutting role of STI in implementing the Development Agenda

Over the past decades progress in science, technology and innovation (STI) has led to improvements in living standards, with the role of STI in fostering economic growth and sustainable development becoming increasingly evident. Most developing countries, however, have neither the research capacity to develop new technologies and adequate STI systems, nor access to international networks to support the effective acquisition and adaptation of technologies. National STI systems in most developing countries are far from reinforcing the capabilities that they need to catch up with technological progress. UNCTAD (2014:9-10) reports that while in some instances gaps have narrowed in the last 30 years (for instance in secondary school enrolment and total R&D expenditure/GDP), in other instances gaps have notoriously widened, particularly in scientific and technological output.[1]

The UN acknowledged in 2011 that despite their progress towards eradicating poverty, the Millennium Development Goals (MDGs) failed to emphasise the importance of the development of technological and innovation capabilities in developing countries. In the preparation of the Sustainable Development Goals (SDGs), critical reviews of the performance of the MDGs highlighted the insufficient recognition of local knowledge-related technological and governance capabilities that affect the absorption and innovative capacity in developing countries. The UN concluded that the development of technology and innovation should be considered as an important international priority in the post-2015 agenda (UN, 2011:11-12).

Developing countries are increasingly interested in strengthening their national science, technology and innovation systems, and have insistently demanded support from the development community in building up capacities to facilitate the development, dissemination and transfer of technology. An important political driving force was the group of 77 (G77), a coalition of 134 developing countries that emphasised the importance of being not only a recipient but also a developer of business and economic knowledge. The group emphasised the importance of science, technology and innovation development as one of the key cross-cutting elements of the 2030 Agenda for Sustainable Development. In the AAAA, both developed and developing countries had to make commitments to uphold and implement their end of the cooperation.

As a result, STI systems became a central element of the Means of Implementation of the Development Agenda 2030 as well as of the AAAA. Technological learning and the increase of innovative capacity in developing countries has been defined as a critical cross-cutting issue for the achievement of the SDGs. Many of the SDGs refer to the importance of technology development and STI as drivers of poverty reduction, clean energy, decent growth, sustainable cities and climate change action. In the Agenda 2030, Goal 9 explicitly states the importance of STI for infrastructure development, sustainable industrialisation and innovation.

1 Fagerberg and Godinho (2005:514) distinguish between "catch-up" and "convergence". "Catch-up relates to the ability of a single country to narrow the gap in productivity and income vis-à-vis a leader country, while "convergence" refers to a trend towards reduction of the overall differences in productivity and income in the world as a whole".

Goal 9 has three sub-objectives, namely:

1) Enhance scientific research and upgrade the technological capability of industrial sectors
2) Encourage innovation and substantially increase the number of research and development workers
3) Support domestic technology development, research and innovation in developing countries

Additionally, Sustainable Development Goal 17 on global partnership also emphasises the importance of enhancing international cooperation on access to technology, science, innovation and knowledge sharing.

The importance of STI and technology in the SDGs has also been institutionally backed. A technology facilitation mechanism[2] and a technology bank are two lighthouse projects in this respect to assure innovation funding as well as a strong coordination and learning platform between UN member states and across the SDGs (see text box).

Textbox 1-1:

Institutionalisation to foster technology transfer in the Agenda 2030

The Technology Facilitation Mechanism (TFM):

It shall ensure a comprehensive approach to STI by improving coherence and coordination on STI issues throughout all SDGs. This should be done through

- A United Nations interagency task team on STI for the sustainable development goals
- A collaborative annual multi-stakeholder forum STI for the sustainable development goals
- An online gateway for information on existing STI initiatives, mechanisms and programmes

Further objectives are the mapping of running initiatives to eliminate duplications, share practices and experiences, and to review existing approaches to STI.

The Technology Bank (TB):

Headquartered in Istanbul, it shall promote especially Least Developed Countries (LDCs) to bridge their large technology gaps through the promotion of capacities and researchers in the access to information. The TB will comprise different components:

- An STI Supporting Mechanism (STIM) that will help LDCs articulate their STI policies in coordination with other donors
- An Intellectual Property Bank (IP) that should help build domestic capacities to absorb transferred patented IP to LDCs

Support in other technology-related initiatives and areas such as Trade-Related Aspects of Intellectual Property Rights (TRIPs) agreement, expertise projects to foster development in STI and R&D etc.

2 See http://sustainabledevelopment.un.org/TFM

During the 3rd international UN Conference on "Financing for Development", the member countries not only set certain criteria for financing the implementation of the SDGs but also defined more than 134 intervention areas in the Addis Ababa Action Agenda structured along eleven different priority areas. The agreement provided guidelines on how the international community should coordinate their own development support to promote a more endogenous approach to development. Furthermore, it also calls on providers of ODA to further increase the effectiveness of their development cooperation and to share knowledge about their respective efforts. The Technology Facilitation Mechanism shall play an important role in promoting the exchange of relevant experiences across and between the countries. In this respect the AAAA agenda from the Conference states in detail: *"The creation, development and diffusion of new innovations and technologies and associated know-how, including the transfer of technology on mutually agreed terms, are powerful drivers of economic growth and sustainable development."* (UN, 2015).

It is in this context that this study was commissioned. It illustrates how Germany can fulfil its role towards the SDGs currently and in the future. This study therefore not only considers the requirements of developing countries and the mechanisms by which to actively strengthen their technological capabilities, but also investigates some of the passive, or tacit, characteristics of the German economy that could provide support to developing countries in strengthening their absorptive and technological capabilities. Chapter 3 elaborates on features of the Germany economy, particularly the STI system.

1.2 The shift from a narrow STI focus to a broader innovation systems perspective

It is necessary to highlight an important shift that has taken place in the global dialogue on strengthening the technological capability of developing countries.

The AAAA states explicitly that the means of strengthening the STI capabilities of developing countries is by strengthening of their innovation systems in a broader sense. It is not about technology *per se.* While in the past the focus in strengthening STI was mainly on growing the stock of science and technology institutions as well as on technology transfer in the form of equipment (and training), the focus in the future should be on *"the quality of interactions among the innovation actors in what might be called the 'innovation system'"* (UN, 2016:125). The AAAA thus emphasises not only the importance of a broader understanding of technology, technology transfer and STI, but also a clear understanding that technology is also only a means to an end. A wider understanding of technological upgrading thus plays a crucial role for achieving all SDGs.

This is not a mere play on words nor a simple re-arrangement of terms. And neither is it an entirely new argument, as scholars have been arguing for this for a long time[3]. Instead of a pre-occupation with the existence of and adjustments to the internal structures of institutions and formal elements of the STI system, the emphasis is more on the dynamics of the relationships between a broad range of social actors. The intention is not to solve problems in developing countries directly, but to strengthen the self-help capability of developing countries so that solutions to pressing problems can emerge from within.

[3] See for instance Hillebrand et al. (1994)

Hillebrand, Messner and Meyer-Stamer (1994) described this technological capability as being able to scrutinise and grasp what technology components are available, to assess and select a technology, to apply it, to adapt and improve it, and finally to develop technologies independently. They state that *"Technological capability is a key pre-requisite to the capacity for self-help, and hence support in building technological capability constitutes a core component of technological cooperation"*. The importance of technological capability and absorptive capacity is discussed in more detail in Chapter 2.

However, the implications are that developed countries would have to change from a narrower focus on how they coordinate, design and promote STI and innovation towards a broader innovation systems focus. See Textbox 1-1 for a brief description of the narrow STI focus.

Leading scholars of innovation systems[4] agree that there are two perspectives of innovation systems:

1) A narrow perspective where innovation is equated to science and technology, with a strong emphasis on product and process innovation. It is a continuation of the STI tradition, which has as its main focus innovation that results from research and development (see Textbox 1-2)
2) A broader perspective encompassing learning, innovation and competence building at different levels of aggregation, with a stronger emphasis on iterative development and interdependence between different elements in which institutions play the central role.

Of importance for international development cooperation is that the second perspective is more about strengthening a broader innovation system in the Doing, Using, Interacting mode (the so-called DUI mode). It is being increasingly referred to in the literature on the technological upgrading of developing countries (Parrilli & Alcalde Heras, 2016; Jensen, Johnson, Lorenz & Lundvall, 2007). The DUI mode is focused more on learning and the dynamics of the relations between a wide range of institutions and individuals spanning the different spheres in a society. The DUI mode is discussed in more detail in Chapter 2.

Whereas in the first perspective technical development cooperation focuses on publicly funded STI institutions in developing countries, the second perspective requires a shift towards enabling self-discovery with much less emphasis on formal institutions.

4 See for instance the opening chapter of Handbook of Innovation Systems and Developing Countries, edited by Lundvall, Joseph, Chaminade and Vang (2009)

Textbox 1-2:

The lingering prevalence of the linear STI paradigm

Over the past century a science and invention-driven understanding of how knowledge is created was dominant. There was a bias towards knowledge that was created in a linear fashion, with the foundations of scientific knowledge being research and development, which then led to applied science and in some cases to the development of new products and processes. Justification of investment in R&D infrastructure was based on the prevalence of market failures and the belief that R&D was a public good that was systematically underprovided in market economies. R&D was an almost elitist occupation, controlled by scientists, engineers and policy makers. The emphasis was on inventions that were new to the world, rather than on innovations that were new to the context. Innovation was seen as the last step in a development process that involved mainly the commercialisation of discoveries that were based on scientific and applied research. Despite a strong shift from this narrow perspective on STI, a bias still exists as STI capability is still often measured in terms of PhDs, patents and R&D spend.

The topic of innovation systems is elaborated on in Chapter 2. For the moment it is sufficient to state the obvious, which is: **Focusing on the interaction between a diverse range of social stakeholders in developing countries is much more complex than simply transferring technologies and strengthening mainly public sector institutions. Furthermore, the dimension of time and context must be considered as the conditions for technological catch-up have also changed** (Fagerberg & Verspagen, 2007).

1.3 Reflection on key STI elements of the Addis Ababa Action Agenda and the Agenda 2030

Following the introduction to the broader innovation systems approach in Section 1.2, it is now necessary to reflect on the seven priority areas described in the STI chapter of the AAAA (UN, 2016) and related cross-cutting elements in the Agenda 2030. We pose some critical questions in each area that must be considered by the German stakeholders working with counterparts in developing countries. Although we could not find clear answers to these questions within the scope of this study, we used some of these questions as guidelines to decide which content to include in Chapters 2, 3 and 4.

"Promoting ICT, access to technology for all and social innovation"
(Chapter II.G, priority area 2)

The emphasis of priority 2 is on the importance of bottom-up approaches, ICT infrastructure and private-public partnerships. Likewise, in the Agenda 2030, SDG 9.c aims at "significantly increase access to information and communications technology and strives to provide universal and affordable access to the Internet in least developed countries by 2020".

Key questions in this respect are:

- How can this be done in governance structures that are often centralised and public-sector dominated?
- How relevant is access to, and the infrastructure of, ICT and also the way in which the potential for learning and local knowledge creation is being used in view of increasing access to ICT?

"Developing national policy frameworks for science, technology and innovation."
(Chapter II.G, priority area 3)

The emphasis of priority 3 focuses on administrative structures, design of national strategies, quantitative indicators such as R&D expenditure, value-added technology-related industry, number of STI cooperation agreements, institutional capacity measures, etc.

Also SDG 9.5 focuses on R&D expenditures through enhancing "scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending."

Questions that emerge in this respect include the following:

- Are national policy frameworks and strategies really able to promote innovation systems?
- Are R&D expenditures relevant for measuring knowledge flows in certain countries and in locations within these countries?
- Are value addition and institutional capacity not rather a result of learning efforts just as a harvest is the result of sowing?
- Do we not instead have to find answers to questions of how to plant the seeds in this respect?

"Creating a more enabling environment for science, technology and innovation."
(Chapter II.G, priority area 4)

Priority area 4 emphasises the importance of a variety of complementary policies (e.g. competition, education, investment, IPR, gender, etc.) that require coordination. SDG 9.b also mentions "domestic technology development, research and innovation in developing countries including the ensurance of a conducive policy environment for, inter alia, industrial diversification and value addition to commodities".

Important questions to explore are:

- Despite the many opportunities for interventions, what are the key aspects that need to be considered to really promote innovation system logics?
- What is required from an education system, investment and entry points?
- How is a lack of management and coordination capability overcome in many developing countries?

"Institutions and mechanisms to strengthen science, technology and innovation."
(Chapter II.G, priority area 5)

Priority area 5 stresses the need to increase knowledge-sharing platforms and learning initiatives between stakeholders in business, policy-making, knowledge and civil society. It also states the need for additional financial incentives to encourage these networking activities, and discusses the challenges regarding the lack of data and capacities to monitor the use of innovation funds and instruments. It considers the need to better monitor the effects of STI cooperation between countries, which is often financed through ODA.

In addition, SDG 17.6 focuses especially on "enhance[ing] North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance[ing] knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism."

An important question to explore is:

- Are the indicators selected for measuring the impact of cooperation oriented towards the increase of the competitiveness of the economic sectors, or do they mainly measure supply side or input factors? The AAAA and SDGs are criticised for rather still following a traditional indicator system that measures "WIPO patents" instead of concrete learning.[5]

"Technology transfer" (Chapter II.G, priority area 6)

The focus of priority area 6 is on the transfer of marine technology, environmentally sound technology, and the development and diffusion of technology. It also mentions the complex process, "which *represents more than just the moving of equipment and other so called "hard" technologies, but soft aspects like know-how, goods, services, and institutional procedures" (UN 2016, p. 132).*

Likewise, SDG 17.7 aims at "promot[ing] the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed" and SDG 14.a states to "increase scientific knowledge, develop research capacity and transfer marine technology [...]."

Questions to consider in this respect are:

- How can we make sure that especially the soft skills will be developed, in contrast to the hard technologies, which are easy to access?
- What about green or conventional process technology which may be required to create industrial capabilities, but which is not related to marine or which is not 100% environmentally sound?

5 See https://www.globalpolicywatch.org/blog/2015/11/11/sdg-indicators-counting-the-trees-hiding-the-forest/

"Capacity building." (Chapter II.G, priority area 7)

Priority area 7 focuses on achieving better coherence and increasing the effectiveness of capacity development in developing countries, and also includes more robust reviewing and auditing of the effects of ODA.

Similarly SDG 17.8 focus is on capacity building through "fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology."

What also emerges here is the following question:

- Where does one start with capacity building and on what does one focus when it comes to strengthening local, national and sectoral innovation systems? Especially in LDCs there are opportunities to start capacity building everywhere. This can lead to many activities that do not strengthen the innovation system or technological capability in particular.

Apart of these priority areas, the UN resolution from September 2015 also emphasises the importance of technology and technology transfer as important cross-cutting elements for the realisation of all SDGs.[6]

1.4 Conclusions

While the extent of the priority areas and SDGs mentioned in the sections above are impressive and span a wide variety of complementary activities, it must be stated that these are framed as mainly supply-side measures that assume to some extent that:

a) better STI capability in developing countries would lead to better local development, and
b) the capability to absorb and apply this knowledge would allow not only domestic problems or constraints to be addressed, but that the evolution of the local technological capability will be possible.

In our opinion the agenda does to an extent highlight the need for an interplay of actors and tacitly acknowledges the complexities of the processes. Nonetheless it does not focus enough development efforts on strengthening the absorptive capacity and technological capability that enable self-discovery and the emergence of local solutions based on local and international technological know-how.

The following chapters attempt to provide some answers to the questions raised above. In particular, the aim is to contribute from a German as well as a developing country perspective to a more sensitive and differentiated approach to strengthening innovation systems in developing countries. A cautionary note: it should not be assumed that everything in Germany is perfect and worth copying. Many German stakeholders are continuously striving to improve initiatives, coordination and incentives, so even the German system is still evolving.

6 See http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Although the outcomes of many institutional formats and relationships between stakeholders are often described as exemplary or inspirational, the painful and contested process that led to these long-standing relationships (such as public-private dialogue) should not be forgotten. The context from which many of these features emerged was unique, and times have changed. Lastly, it is worth noting that while much of the modern infrastructure of Germany today is the result of careful design, some of it can also be ascribed to luck, serendipity and the influence of many external factors. The German innovation system is discussed in detail in Chapter 3 of this report.

Chapter 2.

From a narrow STI perspective to a broader innovation systems approach

This chapter introduces the key elements of an innovation systems approach. The AAAA referred to the strengthening of innovation systems in developing countries. Sometimes when reading some of the SDG-related material it is not clear whether STI broadly includes innovation systems, or whether the concept of innovation systems is clear at all. As Germany has a lot to offer in this regard, we decided to briefly explain some of the key insights that underpin the promotion of innovation systems.

The following issues are addressed in this chapter:

- The basic concepts central to the study of innovation systems will be introduced, highlighting some of the characteristics that distinguish this approach from a narrow STI perspective.
- A broader understanding of technology transfer.
- Building technological capability.
- Strengthening absorptive capacity.

2.1 A more systemic understanding of innovation

The innovation system approach searched for ways to better understand the feedback and learning loops in which knowledge and innovation are created in societies. Early scholars came to the conclusion that there are not only market failures in regard to the expenditure of R&D, but also system failures in which knowledge is not transferred or does not lead to learning loops that are based on market demands. While support for R&D-based STI policies was one issue, overcoming system failures essentially required a better understanding of how demand-driven and product-related knowledge is created in specific contexts, how learning emerges and what complex interactions between science, institutions, businesses and policies lead to the most effective way to develop new products and new processes. This was also where the term "innovation systems" emerged.

Christopher Freeman was one of the early scholars who laid strong foundations for the study of innovation systems. Freeman (1987:1) defined an innovation system as *"the network of institutions in the public and private sectors whose activities and interactions initiate, import and diffuse new technologies."* Lundvall (1992:10) accordingly, that the most important process is learning. The fact that knowledge differs in crucial respects from other resources in the economy makes standard economics less relevant". Lundvall (1992) argued that the "structure of production" and the "institutional set-up" are the two most important dimensions that jointly define an innovation system.

Most research into innovation systems draws on evolutionary and complexity theories, building on the seminal work by Nelson and Winter (1982) and others, where economic growth and technological change are seen as endogenous to the system (Nelson, 2015; Romer & Link, 2008; Nelson & Winter, 2002). **The emphasis is mainly on the dynamics, process and transformation of knowledge and learning into desired outputs within an adaptive and complex economic system.**

The innovation system approach spells out quite explicitly the importance of the systemic patterns of interactions between the various components of inventions, research, technical change, learning and innovation (Freeman & Soete, 2009; Soete, Verspagen & Ter Weel, 2009). Thus the interplay between knowledge application and absorption, and different kinds of innovation and learning by doing as an interactive process is more important.

In a recent handbook that deals with innovation systems in development, to which many of the leading scholars of innovation systems contributed, the editors proposed a revised definition of innovation systems that encapsulates more than 20 years of development of the field: *"The national innovation system is an open, evolving and complex system that encompasses relationships within and between organisations, institutions and socio-economic structures, which determine the rate and direction of innovation and competence building emanating from the process of science-based and experience-based learning"* (Lundvall *et al.*, 2009).

In a paper commissioned by the GIZ, Kraemer-Mbula (2011:4) describes innovation systems as the landscape in which capabilities inside a country or a territory can emerge. Her definition emphasises the importance of the development of tacit knowledge and the informal ways in which it emerges. She emphasises that it is the context that matters, as does the "ecology of organisations" and the interaction patterns between public and private actors. Thus the innovation system approach does not just look for the existence of institutions and policies and R&D expenditure, because this does not tell whether knowledge and applied knowledge for and with the private sector is developed in a creative and innovative way. Instead, it analyses the type and learning-oriented quality of interlinkages between certain business clusters, associations, NGOs, unions, universities, R&D institutions and political and policy structures. Accordingly, promoting innovation systems requires much more differentiated policies; a highly sophisticated understanding of policy interactions and network-driven requirements by ministries, support institutions; a much deeper understanding of market demands; and related joint technology-push and demand-pull cooperation relations between private and public sector representatives.

According to this understanding, the innovation system which emerges in the specific context is never static and is always in a continuous process of change. Nonetheless, the ecology of organisations and policies is still shaped by past decisions (it is path dependent) and a wide range of environmental factors.

UNCTAD (2014:23) succinctly summarises this discussion: *"An innovation system is the key to capturing tacit knowledge because it is developed over time through practice and interactions in environments specific to a particular technology. The effectiveness of an NIS will, therefore, be largely defined by how it incentivises and supports such learning interactions."*

2.2 Technology

Before we proceed it is necessary to expand on the concept of technology[7]. Innovation is frequently thought of as a new product or hardware artefact, or an improved process made possible by new technology. This narrow definition limits technology mainly to hardware, and sometimes to user training or user manuals – it neglects the other aspects of technology.

This section describes technology from a broader perspective, as the analysis of an innovation system requires an in-depth understanding of the role of a broader definition of technology.

We have just mentioned that the narrow definition of technology refers to technical artefacts or hardware. However, complementary factors, without which the employment of technical artefacts makes no sense, are above all qualifications, skills and know-how (of the people who work with artefacts), and organisation (i.e. the process of tying artefacts into social contexts and operational sequences)[8]

Meyer-Stamer (1997) formulates three conclusions based on the definition provided above:

1. Technology should not be seen in isolation from the environment in which it emerges, or from the organisational structures in which it is used. Technology does not come about in a vacuum; it always develops in concrete social contexts. It is therefore never neutral, and is always developed on the basis of given (economic, social, political) interests.

2. Technology often embodies organisational factors. A closed process in the chemical industry or a production line in the metal-processing industry, for instance, consists not only of technical knowledge of individual processing sequences, but also implies organisational knowledge of possible transitions between these sequences.

3. Any narrow definition of technology that looks at hardware alone, accompanied by the view and approach that go along with it, can thus be tantamount to a guarantee that projects will fail – in development cooperation no less than in many international high-tech corporations.

In the discussion on development policy and the field of development cooperation in recent years, there has been a general acceptance of the broad definition of technology, one that does justice to the problems outlined here. For instance, Dosi and Nelson (Dosi & Nelson, 2010) explain that "In the most general terms, a technology can be seen as a human-designed means for achieving a particular end – be it a way of making steel like the oxygen process, a device to process information such as a computer, or the ensemble of operations involved in heart surgery. These means most often entail particular pieces of knowledge, procedures, and artifacts." This argument makes it clear that technology is not just hardware and training, but that it includes all the ways in which humans design solutions to achieve particular goals. That is why we can call the ability to organise a team a "social technology".

7 This section draws strongly on Cunningham (2012), which is based on the original work of Hillebrand, Messner and Meyer-Stamer (1994).

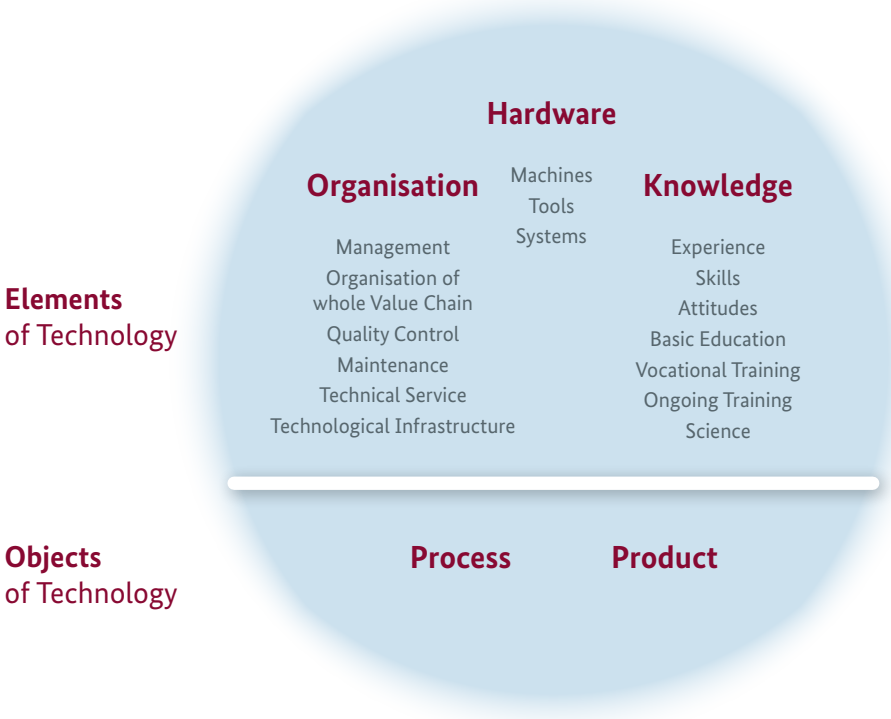
8 Many people use "technology" as a substitute for hardware artifacts and forget that the use or application of the artefact also requires the technology of knowledge.

The definition proposed by Meyer-Stamer (illustrated in Figure 2-1) emphasises four components originally described by Hillebrand *et al. (1994):*

- **Technical hardware:** a specific configuration of machines and equipment used to produce a good or to provide a service.
- **Know-how:** scientific and technical knowledge, formal qualifications and tacit knowledge.
- **Organisation:** managerial methods used to link hardware and know-how.
- **The product:** the good or service as an outcome of the production process.

Figure 2-1:

A broader definition of knowledge



Source: Hillebrand et al. (1994)

Meyer-Stamer (1997) contends that the advantage of the broad definition above is that it can help to avoid fruitless discussions as it prevents, for instance, any equating of technical artefacts with technology. To this extent it mirrors experience gained, for example in development cooperation – in view of this definition it is obvious that technology cannot be transferred in package form.

At the same time, against this background it is easier to comprehend that technology is involved whenever production goes on, even when seemingly primitive technical artefacts are used in the process, for "no country is without technology, not even the most primitive" (Enos, 1991:169). However, it is important to bear in mind that the absorptive capacity of countries, regions within countries and between different firms differs vastly.

2.3 Technology transfer

It is now possible to continue with the unpacking of the concept of technology transfer. Each instance of technology transfer takes place either through direct business transactions or through FDI, trade or technical and development cooperation. It relies on the level of (tacit) knowledge creation and the absorption capacity of the receiver of the knowledge. Absorption capacity plays a key role in the understanding of the use a country or its stakeholders can make of the knowledge that is available globally or locally, the knowledge that is embedded in a product or process, or the knowledge that is offered via services such as technical or consulting engineering or is made available as a result of R&D. Every effective technology transfer instance with a development objective needs to place much more emphasis on the absorptive capacities and tacit knowledge of the partner country's systems (Parente & Prescott, 1994).

From an innovation system perspective this might even mean that promoting traditional and linear STI approaches based on R&D support and patenting can actually be misguided in certain contexts, even if this is what counterparts in developing countries ask for. Instead of following the linear logic of basic research and invention, it might be more meaningful to start by recognising existing knowledge and networks, and fostering their development. The introduction of new products and services into a market may on occasions be a more effective mean of fostering innovation than investing mainly in R&D. Non-applied research activities have demonstrated in many countries an isolated and parallel approach to technology development. One can start out with the products and services by using the existing technology and build up the knowledge and technology base based on the previous knowledge stage. This goes to show that innovation development is an evolutionary process which is highly dependent on the accumulated absorption capacity of the recipients. This process is not only about physical technologies and how they are used, but also about social technologies (ways of organising people towards a common goal) and the ability of stakeholders to create plans that combine different physical and social technologies (Nelson, 2015). The importance of the DUI mode innovation development, which is not necessarily on the cutting edge and new to world technology, is emphasised by Altenburg (Altenburg, 2009). This is discussed in more detail in Chapter 4.

Also helpful in this context is the distinction between the STI and the DUI mode of innovation development introduced in Chapter 1, which highlighted the shift towards giving a stronger role to practical knowledge accumulation in the explanation of innovation and technological development. According to Parrilli and Alcalde Heras (2016), the science and technology-based innovation mode (STI) is mainly focused on high R&D expenditure, investment in highly skilled scientific human resources and advanced technologies and infrastructures. It generates patents, new inventions and publications, and can thus be measured more easily using quantitative measures. The combination of different analytical knowledge bases with a practical, engineering-based purpose is not the main objective.[9]

In contrast, the learning-by-doing, using and interacting mode (DUI) stresses the importance of innovation based on practice, experience and interaction. Innovation in the firm is mostly generated by the capacity of the firm to develop informal and formal exchanges internal to the firm, but also through interactions with suppliers, customers, support organisations and related policies. Their interdependent efforts define the way in which knowledge is created through practice and concrete learning loops of this iterative DUI practice.

9 See also Jensen, Johnson, Lorenz and Lundvall (2007)

2.4 Building technological capabilities

Fagerberg (2008) describes the study by Kim (1997) as an authoritative study on the role of technological capability building as a precondition for successful catch-up. He quotes Kim's description of technological capability as *"the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies."* (Kim, 1997:4). According to this understanding, technology as the know-how required to develop and apply certain products refers not only to the transfer of know-how, but how knowledge contributes to economic learning in a given social context, country or sector.

Nelson (2004:365-366) confirms Kim's (1997) description and stresses that it is not just about copying what others have done, but about a deliberate process of developing and modifying the appropriate social technologies[10] and institutional arrangements. This process often requires learning from the leaders, and modifying and combining insights to better suit the requirements of developing countries. Nelson raises the point that it may be much easier to copy physical technologies than to master social technologies, which raises two problems for countries wanting to catch up. The first, which is to make physical technology work effectively, is a real challenge for developing countries as it requires a wide range of social technologies. He says that it is easier, for example to import a machine than to organise a firm and its management structure or to acquire specific inputs or do marketing. The second problem that he raises is the nation's broad institutional infrastructure, the operation of particular institutions such as educational and financial systems, and its system of public research and advanced training (Nelson, 2004)

Hillebrand *et al.* (1994) argue that technological capability is built on four pillars:

- The skill of the producers to imitate and innovate at product, process and business model levels. This is largely dependent on pressure to compete as well as pressure to collaborate with each other.
- The economic, political, administrative and legal framework conditions determine whether there are incentives to develop technological capability. In the past, it was often not recognised that these incentives were lacking in many developing countries, especially if an import substitution policy relieved companies of all pressure to be competitive or to innovate.
- Direct support by technology-oriented state institutions or specific types of knowledge-intensive service companies depends on the existing level of development, the competition situation and the characteristics of a technology branch in the given country. These organisations disseminate technical and expert knowledge between different actors, knowledge domains and industries, and play a critical role in the use and application of tacit and explicit knowledge.

10 Nelson stresses that these social technologies are not conventional technologies, but rather concern complex processes of how a wide range of people and organisations are organised and governed. Behind the scenes are processes to recruit, retain and even release different kinds of workers. This is all supported by another layer of institutions that supply education and other services, and so on.

- Indirect support by the public and private educational systems – in addition to a sound basic education, it is important that technical training of a suitable quantity and quality is available at secondary school level and also in the universities. The private sector often plays a role in short-term training aimed at particular technology applications. Overall the education sector must be able to identify and respond to changes in the application, development and use of technology in society.

The close interaction between these four pillars creates technological capability. Thus technological capability differs between countries and even within countries because the context and the dynamic of interaction differ. A single firm may in the short-to-medium term manage to get a sophisticated product into the market, but to sustain its position it will sooner or later need to tap into the education system, the knowledge networks of intermediaries and technology experts, or into supplier networks. Technological capability is not measured at the level of patents or products developed, but is best measured at the level of regional or international competitiveness of industries, entrance of new domestic and international competitors, and exports.

Drawing again from Hillebrand *et al.* (1994), this technological capability gives the ability to scrutinise and grasp what technology components are available, to assess and select a technology, to utilise it, to adapt and improve it, and, finally, to develop technologies independently. They state that *"Technological capability is a key pre-requisite to the capacity for self-help, and hence support in building technological capability constitutes a core component of technological cooperation".*

The description given by Lall (1992) is similar. He emphasises the following:

- The ability to master the necessary (financial) resources and use them effectively.
- Skills, including not only general education but also specialised managerial and technical competence.
- "*National technological effort*", which he associates with measures such as R&D, patents and technical personnel.
- National technological capability depends not only on domestic technological efforts, but also on foreign technology acquired through imports of machinery or foreign direct investments.

Innovation systems scholars Fagerberg and Godinho (2005) argue that countries that have managed to catch up tend to focus their higher education systems on engineering training, and have developed indigenous research efforts.[11] However, Nelson (Nelson, 2004) claims that these studies are often too highly aggregated.

[11] See for instance Fagerberg, Srholec and Knell (2007), Fagerberg and Verspagen (2007)

He proposes three important elements of innovation systems:

1. The first element is the real difference made by the movement of people over borders. It involves people from developing countries visiting (temporarily or in the longer term) developed countries, or advisors and experts moving temporarily or for a longer period to the developed country.

2. A second element highlighted by Nelson is that successful countries had active government support for the catch-up process, involving various forms of protection and direct and indirect subsidy.

3. A third and more controversial assertion by Nelson is that successful catch-up countries did not restrict too seriously the ability of their companies to copy and adapt technologies originating from developed countries.

Fagerberg (2008) confirms the views of Kim and Nelson, and identifies a set of capabilities which are of critical importance for catch-up, namely:

- The development of the innovation system (sometimes referred to as indigenous capabilities by scholars such as Nelson).
- The quality of governance, which allows the desired economic results to be realised.
- The nature of the political system.
- The degree of openness to trade and foreign direct investment (poor countries, due to a lack of absorptive capacity, are much less likely to benefit from FDI).

The final section of this chapter focuses on a topic many experts allude to, namely strengthening the absorptive capacity of a nation, but which is often poorly understood.

2.5 Strengthening absorptive capacity – knowledge

UNCTAD (2014:23) defines absorptive capacity as:

The ability to recognize the potential value of new or novel knowledge and technology, and to transfer and assimilate it with the objective of bringing to market a product or a service. It determines if and to what extent a firm, an industry or, indeed, an economy, can use existing and new knowledge to compete.

Some researchers think of absorptive capacity as a completely distinct concept from innovation systems. In our view technological capability describes the overall system dynamics: in essence at an aggregate level it creates an ecology, whereas absorptive capacity describes the capability of individuals and smaller teams (such as a management team) within this ecology to identify knowledge gaps or new uses of knowledge, and to identify and access external knowledge and then combine it with existing knowledge.

This argument is based on the seminal work of Cohen and Levinthal (1990) who argued that:

- Firms invest in basic research less for particular results than to be able to provide themselves with the general background knowledge to enable them to rapidly apply scientific and technological knowledge through their own innovations, or to respond quickly when competitors come up with a major advance. **Thus firms do research to increase their knowledge base and learning which enables them to innovate when they need to.**
- The relationship between the absorptive capacity of firms and the broader technological capability present in the environment causes firms to be highly sensitive to the context within which they operate. **This larger context not only provides inspirational ideas, but the implementation of the ideas depends on resources from this larger context, such as technical experts or specialists, professional, management and vocational skills, and even standards and financial or regulatory systems.**

Cohen and Levinthal (1990) contend that the absorptive capacity of firms is more likely to be developed and maintained as a by-product of routine activity when the knowledge domain the firm wishes to exploit is closely related to its current knowledge base. This is different when a firm wishes to acquire and use knowledge that is more distant from its ongoing activity. The firm must then dedicate effort and resources to create absorptive capacity. It is hard to imagine how this can be done without reaching out to networks of institutions, skilled and professional employees, and networks of suppliers who are all striving to increase their relevant knowledge.

Hidalgo (2015) explains that with the increasing sophistication of technology, the ability of organisations to have all the relevant knowledge in-house is diminishing. Therefore knowledge is being increasingly spread among larger numbers of actors, who need to work together dynamically to produce and transact. Knowledge tends to flow more easily where there is a certain density of diverse actors.

Zahra and George (2002) explain that absorptive capacity has two sub-sets of potential and realised absorptive capacities at the level of firms:

- Potential capacity comprises knowledge acquisition and assimilation capabilities, and includes the ability to strategically manage change.
- Realised capacity centres on knowledge transformation and exploitation.

Zahra and George state that absorptive capacity is a dynamic capability that influences the nature and sustainability of a firm's competitive advantage.

Absorptive capacity is about knowledge and the ability to gain more knowledge, often through a process of iteration.

Cunningham (2012) states that this knowledge may be acquired in two different ways:

1. In a solitary way where knowledge is gained through **experimentation** (as an individual or as part of a team) without much communication or interaction with other external actors, or through a process of **deductive reasoning**. Or it may involve a combination of tinkering and deduction (often referred to as deductive tinkering).

2. By **purposeful interaction with other external agents** involving personal or non-personal communication with other people, specialists and knowledge sources.

The first point is mainly about absorptive capacity of the organisation or individuals. However, the second is a combination of absorptive capacity of the team, and the broader environment in which the organisation can reach out to other experts beyond its own boundaries. Cunningham goes on to say that a large part of **the knowledge a firm need is available internally, namely the knowledge of its engineers, managers, technicians and other employees.** Their knowledge is partially acquired externally through previous formal training, and partially through a cumulative process of learning-by-doing. This internal knowledge, which is available at any given time, is the main innovation resource of a firm. It is often highly tacit, which explains why firms of a particular type cluster together in regions. However, not all firms are able to tap into this internal asset, mainly because many are managed in a way that does not allow them to reflect on their own patterns of behaviour or the trends affecting their performance (Zahra and George, 2002). When the day-to-day emphasis is on survival or routines, a tendency to under-invest in purposeful innovation activities may occur. This behaviour not only undermines the development of the internal knowledge base, but will also lead to underdevelopment of external networks that could lead to exchange or transactions with other knowledge sources.

Learning from others is only possible if the costs of interaction with peers and other organisations are low enough or if the density of networks makes this possible. Malerba (2005:387) states that *"knowledge is highly idiosyncratic at the firm level, does not diffuse automatically and freely among firms, and has to be absorbed by firms through their differential abilities accumulated over time."* This accumulation often emerges through an iterative cycle combining deduction, experimentation, application, reflection, learning and adaptation between people working on the same problems or opportunities. The implication is that in development we should focus on those firms, organisations and sectors that are able to innovate, and find ways to accelerate their learning journey. At the same time, we must build bridges (or reduce the costs) for the rest of the economy and so that future entrants can upgrade and step up and be more innovative and efficient than the incumbents.

2.6 Summary

The challenge for development is that the process of increasing absorptive capacity must start with where the actors in the developing country actually are, and not from what may be possible. It must start with those stakeholders who are aware of what they know, and perhaps what they don't know. However, they must be keen to discover more in order to strengthen their own absorptive capacity.

Soete *et al.* (2010) provide a summary of the main insights brought about by the innovation systems literature which we use to conclude this chapter.

The innovation system highlights the following:

- The importance of a broader set of innovation inputs than just research and development (R&D)
- The importance of institutions and organisations that emerge from a specific economic and social context
- The role of interactive learning
- A dynamic perspective rather than a static allocative one
- The role of interaction between agents
- The importance of social capital.

This chapter explored how the innovation systems approach focuses on a range of indigenous institutions and organisations that are all involved in building technological capability and strengthening absorptive capacity. Central to this are science and technology institutions and how they interact with a range of enterprises to discover what is possible. Lundvall (1992) accordingly, that the most important process is learning. The fact that knowledge differs in crucial respects from other resources in the economy makes standard economics less relevant. Lundvall (1992) goes as far as to describe knowledge as the most fundamental resource in the modern economy, with learning being the most important process. It requires development cooperation to shift its emphasis from a particular technological problem to the broader system which enables learning in a dynamic way. Furthermore, in a complex system such as the innovation system, taking one element and optimising it does not necessarily lead to a strengthening of the whole; in fact, it could harm it. The focus is not on the individual elements, but on the dynamics of interaction.

Lastly, the chapter looked at how absorptive capacity can be strengthened. Central to the strengthening of absorptive capacity are previous levels and diversity of knowledge, and the opportunities (or costs/risks) for people to acquire and explore new knowledge. A key argument that is made is the inability of leaders or managers to recognise or harness the knowledge already in the system. Finally, it was stated that knowledge and the ability to learn is highly idiosyncratic and spread unevenly throughout an economy. The rest of the economy learns slowly but surely from the leaders, those who are better able to innovate, think deductively and experiment.

Chapter 3.

The German innovation system

Germany and its innovation capacity are often described as being very efficient, dynamic and systemic in the way that the country develops, adopts and disseminates new technology throughout the economy. What must be borne in mind is that the present economic, institutional and policy landscape evolved over time and is still evolving. There have been many opposing ideas, conflicting policies and fragmentation as this system was developing to its current state. As perfect and integrated as it looks from the outside, even German experts are still arguing over the composition, replication and inefficiencies in the system.

This chapter gives some insight into the German innovation system, and provides a deeper understanding of how the development of physical technologies went hand-in-hand with the emergence of social technologies (and vice versa), with new forms of organisational settings, institutional arrangements and cultural considerations. The high-technology capabilities, especially in sectors with a long German history, have enabled and also forced many companies and employees to increase their absorptive capacities.

Sections 3.1, 3.2 and **3.3** provide deeper insight into the dynamics of the German innovation system and also the context in which it has evolved. It is necessary to go into some historical details to understand the different context in many developing countries. Section 3.1 gives an historical overview of the development path as well as key institutional and policy changes that played an important role in shaping the present system.

Section 3.2 gives an overview of the key systemic characteristics of the present system that are easier to identify and explain to an observer from a developing country. Understanding the interaction between the private and public sector as well as the comparative advantages of Germany in encouraging successful diffusion and transfer of knowledge and technology requires key features to be emphasised, for instance decentralised support policies, the existence of a competitive and well-organised private sector, as well as a knowledge-creating and knowledge-diffusing institutional support infrastructure. The interrelation between and co-evolution of these features are key characteristics of the competitiveness and resilience of the German economy.

Section 3.3 examines the inconspicuous aspects that often only become visible and understandable when a closer look is taken of how knowledge, ideas and networks are interwoven to create sophisticated technologies and capabilities.

3.1 The roots of the German innovation system

Innovation systems do not simply emerge out of nowhere, but from the co-evolution of physical, social and economic technologies, also referred to as business plans (Beinhocker, 2007). This emphasises the fact that context matters and that copying or blueprinting parts from another a system could lead to failure if the copied elements are not adapted and properly integrated into the local context.

To understand the evolution of the German innovation system it is necessary to highlight four different eras in the development of the present system:

- The industrialisation era, which led to the establishment of business sectors, many of which are relevant today.
- An era starting shortly after the Second World War when several scientific, research, technology and innovation institutions were established.
- The 1970s and 1980s and the era of structural change processes that led to more decentralised governance and the development of regional competitive advantages.
- The more recent era of the 1990s and 2000s, with the emphasis on more network-driven support programmes.
- Most recently the emergence of Industrie 4.0[12] and its strong future orientation.

Textbox 3-1:

Highlights of the German innovation system:

- The industrial sector in Germany plays a more central role as a driver of growth, prosperity and employment in comparison with many other EU countries.
- Experience over 150 years in highly development-relevant industrialised sectors and diversification of products. Many of these sectors still form the basis of more modern capabilities.
- Germany is the largest exporter in the world with 87% of manufactured products.
- Germany is the largest country in terms of world market share in R&D-intensive goods (14.9%)
- The country is internationally competitive in the production of high-tech industrial technologies and diversity of products.
- It is the third most complex economy in the world with regard to technological capabilities and diversification.
- German enterprises make a very strong financial contribution to R&D expenditure (around 70%) (Fraunhofer, 2003).
- Highly competitive SMEs (called Mittelstand) is the backbone of the economy with the highest rate of in-house innovation in the world, based mainly on highly qualified staff and labour (Som, 2015).

12 See for instance https://industrie4.0.gtai.de/INDUSTRIE40/Navigation/EN/industrie-4-0

3.1.1 The industrialisation era

Many aspects of Germany's innovation system have their institutional and economic roots in the 19th and 20th centuries. Meyer-Stamer and Wältring (2000) give a detailed overview of this history. During this period, sectoral roots were laid down with a strong focus on disciplines such as machine building, automotive, chemistry and related supply sectors.

Many of the present institutional arrangements date back to the 1880s and the introduction of **"Ordnungspolitik".** This term refers to the legal and organisational means governments can use to influence the institutional framework of the economy. Within this framework, the economic actors were free to pursue their own goals.[13] It is a German phenomenon and addressed the means which the government could use to influence the institutional framework of the economy. Unlike the *laissez-faire* approach, it provided a more emphatic development role for all the relevant stakeholders including the state. Corporate structures were implemented to consider policies and to promote a more cooperative as opposed to competitive style of governance (Audretsch & Lehmann, 2016). Germany has a long track record of corporate structures in which not only the public and private sector but also the labour unions take a greater responsibility in organising themselves and certain governance processes (Abelshauser, 2004). Especially with the rise of new industries in the 19th century, such as machine building, electronics and chemical products, infrastructure development, foreign trade promotion and qualification policies (including the dual vocational training system and support for R&D and university support) became more important. Meso level support and regulatory institutions such as the national metrology and standardization institute (the PTB), founded in 1887, as well as well-organised private sector associations and unions emerged during the industrialisation phase and contributed to the development of technological capabilities.

In addition to the emergence of corporate structures, strong decentralised structures and economic responsibilities beyond the federal state played an important role in promoting certain sectors in the regions as well as the development of, and knowledge exchange between, regional support institutions. Germany's regional structures have always had a relatively strong autonomy with authority and resources clearly delegated to the subnational levels. In the 19th century and the first half of the 20th century, cities and districts were managing the most relevant sectors (public utilities) such as electricity and water and the local banking systems ("Sparkassen"). They played an important role in the development of these institutions and always had a strong regional orientation. After World War II the design of the regional government structures (the so-called Länder) gained even more political autonomy, based on the foundations for local and regional innovation structures that were laid out earlier in the century.

13 According to Kirstein (2000) „Ordnungspolitik" is a term that can roughly be translated as "institutional policy" or as "constitutional political economics".

3.1.2 The era following World War II

In the post-war era it became clear that the recovery of the German economy as well as further growth of industries required certain new rules, national policies and institutional coordination structures (Abelshauser, 2004). Around the 1950s, new organisations were created that provided the basis for what we could now call the narrow understanding of a German national innovation system. It was based on national government´s efforts to increase basic research and applied science-oriented institutions related to the development of new products and new knowledge. Well-known basic research organisations that were and still are promoted by the Federal Government include the Max Planck Institute (founded in 1948), the Leibniz Institutes and the Helmholtz Centres.[14] With more than 160 institutes and more than 40 000 employees they provide continuous basic research into relevant topics.

The other part of the research infrastructure promoted in the 1950s was more application-driven. One of the strongest and most visible institutions established in this era was the Fraunhofer Gesellschaft (1949). It currently has 47 institutes carrying out applied research covering a diverse range of competences. Significantly, it is estimated that 70% of applied research carried out by Fraunhofer is paid for by the private sector. The institutes are created in partnership with universities (typically they are hosted by an academic department, with many staff being common to the institute and the academic department) and with close ties to industry. They play an important role in knowledge transfer. At the same time, these institutions have the explicit mandate to create new knowledge and technology that are of direct interest and value to industry.

The Steinbeis Foundation's structure is similar to that of Fraunhofer, but unlike Fraunhofer, it is privately run and can been seen as a knowledge intermediator especially between the universities of applied science and SMEs. It was only founded in 1971. A Steinbeis centre is typically hosted by an academic or group of academics, and makes knowledge and capabilities available to SMEs in the form of technical services from a university. The Steinbeis Foundation provides the Steinbeis centres with a range of support and management backstopping services.

The German Research Foundation (DFG), founded 1951, is a major national self-governing organisation promoting basic and applied science and research activities in Germany. Its main tasks are to finance support for research projects, provide support for research cooperation, and promote junior researchers. Moreover, it is an important advisor the German government on science policy-making matters.

3.1.3 Structural change in the 1980s and1990s

Since the 1970s and 1980s, traditional sectors such as coal, steel, textiles and many others have been in decline in many regions. Changes in the economy required structural changes to promote new business potentials, as markets for and stocks of traditional commodities such as steel and coal declined. It was in response to this crisis that more proactive technology and innovation policies were developed by the Ministries of Economy and Education at national and regional level. This can also be interpreted as the adjustment of social and political structures (or technologies) according to the declining relevance of former physical technologies and the need

14 The Helmholz Centres and Leibnitz Community of Institutes were founded at a later stage, but many of their individual institutes have a long history, even going back to the 19th century.

to (re-)design new business models. Before the 1970s, Germany's competitiveness was built more on mechanical and technical engineering qualifications as well as on science-based qualifications. The dual vocational training qualification system for blue and white-collar workers was in operation. With regard to STI, support policies up to the 1970s rather tended to be based on the support of basic and applied research institutions as well as Universities.

From the early 1980s, Germany embarked on more aggressive regional economic development promotion. Before that, economic development support at the regional and local level mainly focused on attracting new investors through tax incentives and the establishment of industrial estates and industrial parks. With this change in tasks, it was relevant to create new knowledge requirements and new forms of actor networks.

While in the 1970s and 1980s the support provided was still focused on individual enterprises and special research institutions, in the late 1980s and 1990s more network-driven efforts at local economic development became more prevalent and mainstream. This trend was reinforced by an awareness that the different public funding mechanisms were relatively isolated and fragmented. This led to a stronger focus on promoting synergies between existing enterprises, new start-ups and potential new investors at local and regional level. The identification of sector priorities as well as innovation-enriching institutions let to the promotion of networks of enterprises and clusters. SME networks and clusters at local and regional level became the target group and more coordinated efforts were made to identify sectors and support mechanisms for key technologies.

At the same time local and regional economic development agencies and technology centres with stronger links to local universities were promoted at the municipal and regional government level. This process occurred mainly because of the strengthened autonomy and leadership of decision makers such as heads of universities and R&D institutes, sector labour unions, business associations, business leaders and city administrations. More autonomy and a proximity to the effects of the economic decline in many traditional economic sectors pressured these local representatives to take on a greater responsibility and to change their attitude towards working together. The crisis created the pressure and opened up the opportunity to discover new ways of doing things. The outcome was more public-private communication and cooperation, a greater variety of locally and regionally relevant sector interventions, and greater efforts to increase competences, align expectations and strengthen coordination. These structural dynamics demonstrate that even in Germany certain elements of cooperation are relatively new and based on a change in responsibility that was largely brought about by a crises and a shift in economic activity. The shift towards more bottom-up responsiveness to local economic challenges and opportunities was only possible through a change in the understanding of the actors' role of each, the requirement for the development of new organisational functions and the emergence of innovation strategies in many regions.

3.1.4 Shaping the future through Industry 4.0

The fourth industrial revolution was driven by the German government and its high-tech strategy (see Section 3.2). However, the term "Industry 4.0" became a buzzword for the current trend of automation and data exchange in manufacturing technologies (also referred to as digital manufacturing). It is based on the logic of interoperability and the ability of machines, devices, sensors and people to connect and communicate with each other via the Internet (also popularly referred to as the Internet of Things and People). It concerns high-tech production solutions that will lay the foundation for future state-of-the-art technology and knowledge transfer.

The term "Industry 4.0" arose in Germany because of an awareness that the future economic development challenges of the country were related to the increase of ICT solutions and their integration into manufacturing technologies. It can also be interpreted as a renewed attempt at more radical innovation for future competitiveness, while at the same time rethinking how resources are used. To make this step forward possible requires additional technical capabilities in the German innovation system as well as increasing absorptive capacity in many competitive businesses.

Germany has been strong in specialising in relatively complex products and after-sales service in most engineering and process-oriented industries (machine tools, engineering elements, engines, materials processing, etc.). However, according to Casper and Van Waarden (2005:3), Germany does not perform well in many of the newer, more radically innovative technologies, such as biotechnology, telecommunications or information technology. This trend is mirrored in the relatively low increase in new enterprises in the service and ICT sector.[15] Thus the Industry 4.0 approach seeks to address weaknesses in the innovation system by integrating new ICT solutions and developing innovative processes and products in industry. The German government and especially the BMBF is currently intensively promoting research and application in these future technologies. The Industry 4.0 strategy was developed in close cooperation with a range of public and private sector stakeholders throughout the German economy.

In summary, the different phases of innovation system promotion in Germany have provided an insight into the evolutionary process of the system. To increase technological capabilities, a constant process of increasing relations between key stakeholders, additional institutions and policies is required.

Chapter 5 discusses how the German Development Cooperation can develop additional and effective promotion of STI and innovation systems.

15 According to the most recent GEM (2015) Global Report, Germany is less successful than its peer countries in the promotion of start-ups. In 2012 it was estimated that 4.7% of Germany's working age population were actively trying to start a business or were owners or managers of firms that were no more than 31/2 years old. Germany ranks 15 out of 189 economies.

Some areas that can be pointed out here are:

- The long history of trial and error in establishing innovation and decentralised policies and experimentation with support programmes to strengthen networking between enterprises and to support institutions and policy representatives. An exchange of these experiences with other policy representatives from less developed countries can provide new insights into the running of policy approaches.
- The experience of involving the private sector and unions in corporate structures based on clear development and competitiveness principles.
- The establishment of a dual education system with a strong role for the private sector in the management of quality aspects. Despite the dual model being difficult to copy, its key principles can still provide insights into the prerequisites for successful private-public cooperation in skills development.[16]
- The more than 100 years of experience in adjusting and innovating technology-intensive manufacturing products also provided a solid knowledge of different levels of technology of products. This is also a valuable source of knowledge transfer which is adjusted to the technological capabilities of partners in ODCs and LDCs.

3.2 Salient features of the German innovation system

As pointed out in Chapter 2, technological capabilities require not only individual skills but a system that continuously ensures new knowledge generation and diffusion. In the following sections the main visible characteristics of the German innovation system beyond those discussed Section 1 are documented. The systemic competitiveness framework is a good structure to provides an overview of the different levels that constitute this system.[17]

3.2.1 Meta level

At the **meta-level**, there are several elements that create a favourable framework. Germany has a long history of industrial development, engineering and production, which also includes a strong production, engineering and service culture. The social status of entrepreneurs is relatively high, and entrepreneurial success is an important means of ascending to higher social stratum.[18]
The driving sectors are export-driven and competition is accepted as a thriving dynamic factor to improve products and skills as well as innovation. The relationships between worker unions, enterprise associations and the government follow a culture of consensus and communication rather than a power struggle orientation. Additionally, society, private and public representatives and institutions believe in the subsidiarity principle. This principle emphasises that social, economic and political issues should be dealt with at the most immediate (or local) level that is consistent with their resolution. This applies to governments and also to business associations,

16 Elements of the dual education systems have already been introduced to many developing countries including South Africa

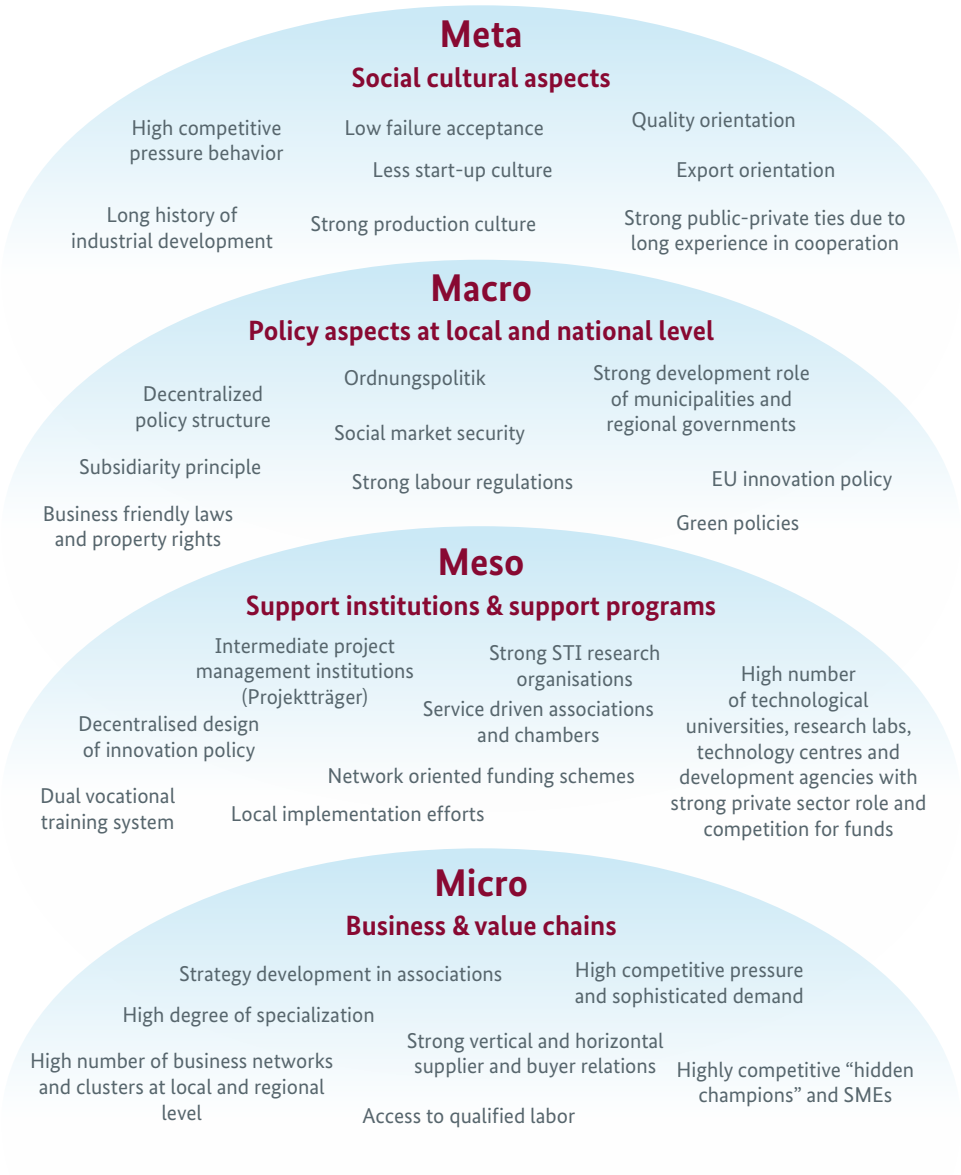
17 For further information on the systemic competitiveness framework see Esser, Hillebrand, Messner and Meyer-Stamer (1995)

18 It is soften argued that in comparison with for example the USA, the social status of entrepreneurs in Germany is low. But it has also to been emphasised that USA plays an outstanding role in regard to entrepreneurial culture.

support organisations and R&D relevant institutions. The national government's involvement is to promote generic policies, while the regional governments and stakeholders develop their territories through coordinated and cooperative efforts. This reduces unreasonable expectations from the public and private sector, and creates more opportunity for the development of trusting decentralised relations. Finally, an important relevant sociocultural aspect is that the private sector plays an important role in the design of the educational and dual system supported by civil society and government.

Figure 3-1:

The systemic competitiveness of Germany



3.2.2 Macro level

At the **macro-level**, economic conditions are generally business friendly. This is embedded in a politico-economic context creating a very stable macro-economic framework and a business-friendly environment, while at the same time alleviating the negative social impact of industrialisation, i.e. a social market economy as opposed to a free market economy. It is a widely shared view that the basic organisation of the German economy in this respect differs from the Anglo-Saxon variety of contemporary capitalism (Meyer-Stamer & Wältring, 2000).

The strongly decentralised political structures in Germany, supported by a development role played by the federal states (Länder) and the municipalities have created a wide range of network governance opportunities in which the private and public sector have cooperated in the development of institutions, policies and networks. This process also includes EU integration. Many guidelines for innovation and technology policies and promotion frameworks are defined at the EU and regional level, but the federal states and networks of actors in the regions are the ones who design and implement them. For example, the EU also determines trade policy aspects and limitations to directly subsidise enterprises in different ways. This has also contributed to more network-driven promotion activities since the 1980s rather than isolated and individual enterprise support.

3.2.3 Meso level targeted interventions

The **meso-level** is the level where the "ecology of organisations" (Kraemer-Mbula, 2011) or the supporting organisations and support programmes act with the objective of strengthening the innovation orientation and capacities of the private sector. In Germany there is a highly differentiated and decentralised system of organisations that even compete for clients, enabled by policies which create favourable conditions for innovation in general and SMEs in particular. They demonstrate the complexity of the system, as well as a certain fragmentation and rivalry of roles and functions. At the same time, they demonstrate the many ways in which businesses are supported in their innovation efforts The highly developed institutional infrastructure takes over network facilitation activities between institutions and businesses, which to a certain extent reduces the necessity and importance of direct cooperation between businesses. It means that Germany's institutional arrangements reduce the costs of finding other businesses to cooperate with. In fact, in our opinion, businesses are under pressure to engage at the meso level instead, otherwise they risk being left behind by their competitors.

Meso level aspects at the federal level

The multitude of research, training and quality infrastructure institutions, and especially their interrelations with the private sector form the backbone of the German innovation system. Strong labour regulations and unions have in the past put pressure on the private and public sector to increase the knowledge intensity of employees and products. The decentralised policy structure enabled the emergence of organisations, institutions and networks that were related to certain regional sector and competitive advantages. The following extract emphasises some key aspects of this institutional knowledge and innovation infrastructure as well as relevant support programmes promoted at the federal level:

The *dual vocational system* dates back to the 19th century and even earlier. It was based on struggles between associations, unions, chambers and government bodies to react to skills demanded in the respective development stages. The system has become famous worldwide. The education system and vocational education training programmes in Germany have even been recognised as the main cultural and political drivers of Germany's innovation (Allen, 2009:383). In 2015 alone more than 500 000 young people received training based on apprenticeship standards in 330 vocational education fields. This is not only a significant contribution to individual and societal knowledge generation, but is seen as one of the main reasons behind the relatively low rate of youth unemployment, which is estimated to be 7% (BMBF, 2015). The German model of high-quality production is highly dependent on this system because young apprentices are learning through practical and theoretical training ("dual system") and contribute to the value-added production and additional knowledge generation.

Another key federal support mechanism for the German innovation system is the support of the key **R&D bodies** with their institutional network, namely the Helmholtz centres, the Max Planck and Fraunhofer institutes and the DFG. Although supported from the federal level, their offices are highly decentralised and normally linked to regional and local universities and technology centres.

During the 1970s to the 1990s intermediate project management organisations *("Projektträger")* were also established to manage the increasing number of support programmes on behalf of public authorities, especially for national and regional ministries and the EU (especially the Ministries of Education and Innovation (such as the BMBF and federal state ministries). Examples are the Jülich project management authority, the VDI/VDE-IT and the DLR. They still play an important role today as professional managers of support programmes and promoters of network-driven innovation projects. They often advise local stakeholders, regional government and various networks, and also provide policy advice to the Federal Government.

Although the Federal Government is in general not involved in the design of national sector strategies, the national *Hightech Strategy 2020* is an exception (German Federal Government, 2014). It aims to adjust Germany's innovation system to meet competitive pressures in order to ensure the continued strength of the system (Allen, 2009). It was first defined in 2006 and has since been continuously updated. It identifies the priority areas of German research policy through the definition of goals for seventeen technology fields that are likely to be important in terms of both jobs and prosperity in the future. For each of these fields, a number of initiatives are promoted. Through the high-tech strategy of "excellence universities", it supports graduation schools, regional clusters and an outstanding potential SME sector. The objective is to promote outstanding businesses, academia and networks that have the potential to gain national and international importance for driving innovation. The excellence universities with their excellence clusters is driving the process, often cooperating with Fraunhofer institutes and other basic research programmes. In high-performance clusters, the drivers are often more strongly aligned with the needs and involvement of the private sector, with a clear orientation towards directly improving the competitiveness of businesses in the respective areas.

Meso level aspects at regional government (*Länder*) level

The "Länder" level is the main level where *innovation strategies* are defined, often supported by European Union or other higher-level funding mechanisms. It is at this level where cluster strategies, SME network funds as well as regional competence fields are defined and supported. Many overlapping funding mechanisms exist that can be accessed to support joint R&D between SMEs, with R&D institutions and within SME or supplier-buyer networks.

A large number of *higher education institutions* (universities and "*Fachhochschulen*") are promoted at the Länder level. They are strongly linked with the private sector through university research, dissertations and internships. After completing their studies, many of the students take over highly relevant management, product, process and service development functions. In 2015, 2.75 million students were enrolled in 427 universities in Germany, of which nearly 50% are universities of applied science with close ties to the private sector.[19]

Meso-level aspects at the city government and provincial level

A wide range of additional institutions are supported by municipal governments, which are providing the key institutional setting for the local and regional innovation systems in Germany. There are economic development agencies at different decentralised levels (e.g. city development agencies, district economic development agencies) and local banks (city, region, federal state) that all have a public duty to contribute to the economic development of the territory.

Additionally, a wide network of decentralised support instruments that contribute to knowledge and innovation flows can also be found. They try to group together the interests of enterprises and include incubators, technology centres in every larger city, business parks, clusters and business networks, co-working spaces or start-up promotion activities. To foreigners and even locals, this system seems fragmented and overwhelming. Wältring and Meyer-Stamer (2000), Dornberger and Wältring (2014) and Allen (2009) provide a more detailed overview of these different instruments and how responsive they are to the needs of SMEs.

Especially since the beginning of the 1990s, network support programmes at the local and provincial government level have become a more critical element in overcoming isolated and individually oriented subsidies to strengthen SMEs to overcome their disadvantages in size and economies of scale.

Meso level aspects brought in from the private sector

Not only the public meso support structure plays an important role in supporting R&D and innovation networks. There are also private sector research foundations, private business associations as well as cluster initiatives that provide a variety of innovation services. Additionally, the private sector plays an important role in funding meso level support programmes through paid services.

19 See some statistics in: http://de.statista.com/statistik/daten/studie/1264/umfrage/anzahl-der-studenten-nach-hochschulart/ and http://de.statista.com/statistik/daten/studie/247238/umfrage/hochschulen-in-deutschland-nach-hochschulart/

In general, public funding support at the meso level requires a large *financial contribution* by the private sector. It often involves a sliding scale cost increase of cost sharing by the private sector. For example, support for the facilitation of a cluster by private businesses is 30% in the first year, in the second year 50% and in the third year 80%, with the shortfall met by public funding. In contrast to many other funding programmes where funds are given unconditionally, this approach entails to a certain extent the design of a sustainable funding strategy, which also ensures an increasing financial responsibility on the part of the target group.

Germany´s R&D spending benefits from the *industry research contribution.* Around 70% of the contributions for R&D come from industry. The strength of Germany's industry in terms of R&D is primarily due to R&D-intensive sectors within the manufacturing and automotive industries. 55% of R&D activity is concentrated in the vehicle manufacturing, computing/electronics and mechanical engineering sectors (Zimmerman, 2015). Although Germany is challenged when it comes to diversifying its R&D basis, the high contribution of the private sector to application-driven research is an important indicator for public-private partnership in the promotion of national innovation.

The *self-organisation of the private sector* into sector associations, economic lobby organisations and chambers has a long history in Germany. Although they started to emerge in the late 19th century as lobby groups against free trade or as employer organisations against the growing organisation of unions, at a later stage many of them also became service providers for their clients, which involved a professional management structure. Business associations now play an important role in this respect in promoting networking, cluster projects and using funding for the skills development activities of their members. Especially during the last two decades traditional associations came increasingly under pressure from cluster initiatives as groups of businesses that can be linked to one sector but can also be organised around a competence field or include several sub-sectors (e.g. mechatronic cluster) or cross-cutting aspects (e.g. ICT). New emerging sectors such as ICT, biotechnology, etc. often no longer fitted into the traditional sector structure and started to open their own associations or cluster networks with professional cluster managers in place. Their key role is to promote networking, knowledge exchange and the creation of innovation synergies between businesses and knowledge and R&D providers. Traditional organisations such as the chamber of commerce and industry and crafts are the key organisations that define the curricula for the apprenticeship programmes and test the quality of the dual vocational system and recognise training and qualification degrees. In many developing countries, chambers are more like representatives of large businesses, whereas in Germany they represent all business groups due to mandatory membership. For example, they are heavily involved in offering start-up information services for new businesses. Although often criticised for their bureaucratic and inflexible organisational approach, the chambers, along with many other associations, play a key role in promoting inter-entrepreneurial dialogue as well as private-public communication channels. Although their role is often underestimated, they have been able to greatly reduce market and coordination failures.

In addition to the wide network of more than 800 publicly funded research institutions and development and technology centres in Germany, there are a large number of *German private non-profit organisations* or foundations which play an important role in promoting innovation in Germany. The Association of German Foundations lists more than 20 000 foundations that are active in various fields, e.g. education, culture, science and social disciplines. Especially important is the Stifterverband für die Deutsche Wissenschaft, or "Association of Foundations for

German Science Promotion". It was founded in 1920 as a joint initiative started by companies and foundations entirely devoted to consulting, networking and promoting improvements in the fields of education, science and innovation. It engages more than 3 000 members including DAX companies, SMEs, associations and private individuals. Additional key German private sector foundations with strong private sector roots and an explicit focus on science, innovation and labour issues are the Volkswagen foundation (annual funding of projects of 150 million Euros), the Robert Bosch-Stiftung (around 80 000 Euros annually), the Bertelsmann Foundation (around 75 000 Euros annually), and the Hans Böckler Foundation (around 70 000 Euros).

The amount of research and applied science funding that comes from these private foundations makes up at least 6% of the third-party funding at higher education institutions.[20]
At the same time it demonstrates the strong commitment by many large companies in Germany to promote the German innovation system as the basis of their competitive advantage.

In summary, looking at this wide range private and public sector support organisations and support at the national and local level, it can be seen that they play a key role in overcoming market and coordination failures between businesses and contribute greatly to innovation and skills development in the business sector.

3.2.4 Micro level

At the **micro-level**, German SMEs are directing 75% of their exports to other EU countries and they are highly competitive. The phrase "small is beautiful" based on the book by economist E.F. Schumacher in 1973 was often used in developing countries to justify the promotion and subsidisation of rather weak SMEs and even survival businesses as opposed to large enterprises. In Germany this phrase fits well because the SME sector plays a significant role in the education of young people, in employment absorption and in value addition. In 2013, it was estimated that 99.6% of German enterprises belonged to the SME sector, which in Germany is defined as businesses with up to 500 employees. They created 35.5% of the overall turnover in the German economy, employed 59.2% of the working population, provided 82.2% of all apprenticeship programmes and contributed 18% of the national export turnover (without considering the supplier products that went into exported products).[21]

The degree of specialisation in the SME sector is very high, with strong vertical disintegration and differentiation within technologies being high. This means that risk is spread out over the system. Competition in the EU is fierce, being based as it is on high-quality products, technologically advanced production processes, high quality and regulatory standards and high qualifications of entrepreneurs and workers.

One can distinguish between vertical and horizontal relations between firms. German industry is characterised by strong vertical supplier relations in which densely vertically integrated production clusters can be found in different regions in Germany. As mentioned previously, the cluster approach has in the last two decades demonstrated the efforts to encourage horizontal relations between enterprises, between enterprises and research and innovation promotion organisations,

20 See number of foundations in www.research-in-germany.org

21 See http://www.ifm-bonn.org/statistiken/mittelstand-im-ueberblick

and between competence fields. In this respect, SMEs in Germany play an important role as knowledge carriers in which highly educated people are working in many different sectors and contributing to value addition and knowledge creation at the company as well as the cluster or industry level.

In summary, the systemic competitiveness of Germany with its four levels provides a good overview of its national and regional innovation system structure (see Figure 3–1). Developing countries and countries in transition generally have serious shortcomings at all four levels (see Chapter 4). At the same time, the German system also faces criticism in certain areas. It is, as in all countries and territories, a continuous process to strengthen and promote the interrelations and knowledge flows between the levels, stakeholders, businesses, institutions and policy representatives at national and local levels.

Finally, it is not so much about what exists in each of these layers of systemic competitiveness that matters, but the interaction, feedback loops and dynamics that exist between the layers and the activities in each.

3.3 Inconspicuous or not readily visible characteristics

There are key dynamic elements in an innovation system that can really only be sensed when engaging with the system and its stakeholders. This section is based on impressions gained by the authors of this study in their role as brokers between German and developing country STI organisations, as organisers of study tours over the last 15 years and as participants in technology transfer projects. Many of the issues raised in the following sections are based on the insight that study tour participants typically find the most surprising or the hardest to come to grips with – the belief of the authors that these inconspicuous characteristics must be considered as undercurrents beneath the salient features discussed in Section 3.2.

3.3.1 Competitive and cooperative undercurrents

Although Section 3.2 often mentioned the innovation and cooperation-oriented network characteristics of the German innovation system, it is important to raise the point that not only is there high competition between businesses in improving their quality, products and processes, but also between supporting institutions and policy representatives in accessing funds and networks as well as achieving policy success. This mixture of cooperation and competition (co-opetition) is an important underlying current that shapes many of the features of the German innovation system.

In Germany as well as in the EU a large number *of support programmes to promote innovation are contest-based.* The lack of transparency is often criticised by the stakeholders and has reached the point that service providers specialise in providing consultancy on transparency and application requirements. Duplication of funds is one result of the fragmentation of efforts.

Although the existing multitude of structures has been criticised to a large extent, the positive aspect is that they are contest-based and that they require certain partner networks as pre-conditions:

- The criteria for selection include cooperation requirements. For example, businesses have to apply jointly for business network funds, research organisations have to involve businesses in research applications, and cluster projects have to demonstrate the involvement of businesses, universities, other research organisations and public agencies.
- The applications for funds are benchmarked against other applications on a contest basis. The idea is that the application with the best proposal and with the most motivated stakeholders receives the funding. This also puts supporting institutions at the meso level under pressure to perform as promised and to create positive-scale externalities. This leads to fiercely competitive relationships between local organisations to improve project concepts or conjure up "better sellable" projects.
- At the same time many organisations also apply jointly and collaborate on many bids to demonstrate synergies as well as to fulfil network criteria. At least this demands of the meso level institutions a proactive attitude instead of a publicly financed, supply-driven approach to economic development.
- To be ready for a future funding application, all the actors have the incentive to continuously work together, build their networks, and foster their ideas so that their proposals can be generated fast when bidding opens.

This approach encourages a demand-oriented approach. Instead of providing subsidies and funds to groups who have not searched or even asked for support in any way, it creates incentives for those who are already in the process of organising themselves to promote certain changes.

3.3.2 The explorative aspect: Encouraging discovery with STI and DUI and neutral spaces for collaboration

In Chapter 2 we explained the *different innovation modes* that are focused on scientific and technology-based innovation (STI) and the modes based on learning-by-doing, by-using and by-interacting (DUI). These two modes are often separated from each other. One of the key strengths of Germany is that its innovation system has succeeded in combining the STI and DUI approaches to innovation.

The highly decentralised structure of universities and technology centres that are linked to the university campus often involves key R&D system institutions such as one of the Fraunhofer or Max Planck institutes and other university-driven research centres and laboratories. In this respect, it is difficult to set clear boundaries between national, sectoral and local innovation systems. The SME capabilities that are accumulated through productive experience and vocational training as well as engineering performance contribute to incremental innovation through learning-by-doing, by using and by interacting with the direct clients, buyers and larger enterprises. The role of local and regional economic development agencies, local authorities, universities, R&D facilities and vocational schools, together with strong competitive pressure for businesses, supports a relatively pronounced innovation orientation on the part of SMEs.

In addition, strong export performance requires an increase in R&D performance. Still, the so-called "hidden champions" in Germany are the companies, which tend to be medium sized and world leaders in their markets. They often combine a DUI as well as an STI work approach based on their own development experience.

The large number of innovation network projects promoted in the German system has led to exploration spaces and laboratories where the DUI mode is strongly promoted. In this respect the funds provide an opportunity to test innovative ways of doing and applying ideas and insights to combine different interdisciplinary teams of experts and to create a neutral space for elaborating on concepts and ideas. This explorative method of funding is often not offered in many developing countries, but provides the basis for lateral thinking and innovation in Schumpeter's sense of combining existing modules in new ways.

Explorative space is needed in the approaches of many donors and developing countries, especially when it comes to addressing local constraints and opportunities through a process of continuously combining and recombining old and new ideas in novel ways, while at the same time having the space and resources to reduce risk and encourage experimentation. It is hard to develop new ideas when there is a strong determination to create very specific kinds of solutions, businesses or technologies.

3.3.3 Horizontal and vertical coordination and cross-fertilisation

One process that went hand-in-hand with the structural change processes in many sectors and locations since the end of the 1970s in Germany was a shared realisation that a *stronger horizontal and vertical coordination* effort by the different stakeholders would be necessary to manage the changes in the global and regional economies. Development agencies and politicians in larger cities, often even in cooperation with the unions, started to identify certain cluster groups with growth and future employment potentials. Universities, supported by the regional governments and the municipalities, started to set up new faculties with a particular orientation towards local demand. Cities and their stakeholder networks started to develop locational marketing strategies based on the increasing awareness that regions and cities were no longer competing for less qualified labour in mass production but, for highly educated labour in specialised fields. Textbox 3-2 gives two examples of local initiatives that were scaled up to become national flagship projects.

Textbox 3-2:

Scaling up local successes to national flagship projects

One of the flagship instruments of the German high-tech strategy as basic national innovation and industrial policy during the last six years was the support of regional high-performance clusters. During the last two decades many municipalities and regional governments started to promote business clusters in certain economic areas as one of the dominant SME support instruments. This was, for instance, the case in Dortmund and Paderborn. Dortmund, located in the Ruhr Valley, went through an intensive structural change process in the 1980s, in which three key sectors, steel, beer and coal, went into a steep decline. Today it is the centre of the regional high-performance cluster in logistics. Something similar occurred in the region around Paderborn. Within its region of East Westphalia, the regional high-performance cluster of "intelligent systems" emerged that was based on a long history of machine building.

Both high-performance clusters were supported by the national high-tech strategy as clusters of national importance. However, they actually emerged due to a strong commitment by the self-organised businesses at the local level and the support of the respective city economic development agencies. The latter in Dortmund and Paderborn started to support the networking between companies and local R&D institutions, suppliers and skills development institutions. So both regional clusters started as small city clusters in the early 2000s and increased their visibility, outreach and influence. Thus the success of the two highly visible regional initiatives were due to the efforts made at the local level to increase cooperation and coordination. Local networks grew into regional networks with national importance. Although the clusters have increased their outreach, local agencies, R&D institutions, business associations and leading Mittelstand companies are still members of the clusters. This synergy can be observed in most of the high-performance clusters in Germany which started as small initiatives with strong support from local groups of leading entrepreneurs and development agencies..

The examples in Textbox 3-2 demonstrate how local, regional and national innovation policies complement each other[22].

The Federal government´s "High Tech Strategy 2020" (BMWi, 2015) is an example of an intelligent top-down strategy which is coordinated at the highest level of government in support of bottom-up initiatives. What might instead sound like a centralistic innovation and industrial policy has an enabling bottom-up character. Local initiatives are supported by a wide range of ministries and departments. This can be seen as comprising complementary efforts to consolidate outstanding strengths and potentials beyond the regional level, to increase national and international profiles of certain innovation clusters as well as to encourage exchange between regional bottom-up initiatives, programmes and innovation stakeholders.

22 For more information on the two examples visit http://www.its-owl.de/downloads/informationsmaterial/ and http://www.effizienzcluster.de/en/index.php

3.3.4 Professionalisation of management competences in public institutions

During the 1980s and 1990s several policy functions of the public sector were handed over to external management authorities or units with a more professional and more business-oriented approach. Some examples are regional and local innovation centres, development agencies and technology centres, but also regional landscape and economic development institutions.

Municipalities have started to outsource their economic development offices to dedicated management organisations. The latter become agencies with increasing independence and less bureaucratic constraints, but they also have a greater responsibility for finding and accessing additional funding (e.g. from the EU, from cooperation agreements, for own services, etc.). Municipalities thus also became stronger development drivers headed by more professional agencies. Actually the structural change process in many cities in the 1980s put city administrations under pressure to take on a more proactive role to counteract rising unemployment and the potential declining attractiveness and well-being of their locations. This happened in many places in cooperation with other local institutions such as local banks, associations, business networks and university and training bodies.

Many technically oriented universities started to establish *externally managed technology centres* to link the education of students and research fields, and so promote start-ups and develop new services that provide opportunities for more knowledge-oriented business growth.

Furthermore, at the regional level, new interdisciplinary management units for regional structural change projects were inaugurated to ensure an innovative and interdisciplinary process of implementation. The instrument which was used in many regions to initiate new future orientations and to create new images was the "International Exhibition model" (Internationale Bauausstellung, or IBA). In this approach, regional ministries supported a programme for a specific district or economic region that was in decline due to the dominance of a certain industry that was losing its reason for existence. For example, this was done in the coal mining and steel-producing area of North Rhine-Westphalia, the Ruhr valley and the lignite mining area of Lusatia in the federal state of Brandenburg. For a period of 10 years the ministries of the federal states supported the structural change process in these regions with coordinated funding streams. The strategy for the process was designed outside the political structure by a management agency that involved highly creative and professional experts from different disciplines such as urban planning, economic development and social change. The IBA offices, with local stakeholders and through international architecture and idea exhibitions, developed a large number of lighthouse projects and smaller projects that were intended to change the image and the economic foundation of the region.

Even for Germany these programmes were a novelty: they encouraged innovative thinking from different disciplines, they were based on coordination between the different ministries in the federal states (e.g. the Ministries of Construction, Innovation, Economics, etc.). The administration handed over the baton for the design of the future programme to a creative and self-managed project unit that employed many different professional and creative people. Finally, the large number of change initiatives that emerged from this process were based on a participatory approach, where the projects were developed in cooperation with local stakeholders and knowledge institutions, but ensuring that additional innovative ideas were coming in from the outside and from international experiences.

Some federal states such as North Rhine-Westphalia copied the IBA model and applied it on a smaller scale in smaller regions. The so-called "Regionale", or regional, instrument follows the same logic, runs for six years and is also based on the promotion of innovations from different fields of work[23].

23 See www.regionalen.nrw.de for more information on the "Regionale" instrument.

Chapter 4.

Strengthening innovation systems in developing countries

This chapter starts by considering some of the generic features of innovation systems in developing countries. The term "developing countries", similar to the term "industrialised countries", covers countries with very different development stages and contexts. This heterogeneity is also often expressed in UN classifications such as Least Developed Countries (LDCs). We use the term LDC to refer to least developed countries and ODC to refer to other developing countries characterised by a certain positive development dynamic. Although there are many differences within groups of developing countries, there still are some generic principles that LDCs and ODCs have in common.

The weaknesses of innovation systems in developing countries have been addressed by a broad range of scholars in many publications and at many events, for instance at the annual Globelics[24] conference. The topic of how to promote innovation systems in developing countries is dealt with extensively by Lundvall *et al*. (2009). One of the authors of this discussion paper has also written on the topic of how to lay the foundations in developing countries (Cunningham, 2012). We will not repeat all the issues here.

In the following sections we provide tables of comparisons between aspects of innovation systems in Germany and in many different developing countries. These aspects are informed by our experience and the broader experience of the German Development Cooperation in brokering relations between stakeholders in developing countries and Germany. We again emphasise that each driving or hindering development factor in developing countries has to be considered within its context, its historical path and the systemic perspective where many factors interact in a complex way. If this is not done, recipes, ideal institutions and copying and pasting may be the result.

We thus start with an observation of the systemic prerequisites in developing countries considering a similar level structure as given in Section 3.2.

The framework highlights:

- The meta level or cultural and path dependent aspects of the development of an innovation system
- The generic or macro-economic environment
- The meso level of specific interventions, organisations and infrastructure
- The micro level of firms, networks and hierarchies
- Approaches that promote innovation systems in developing countries under the given systemic circumstances

The final section of this chapter focuses on absorptive capacity, as this is of great importance to the German Development Cooperation.

24 See http://www.globelics.org Globelics is a worldwide, open and diverse community of scholars working on innovation and competence building in the context of economic development.

4.1 Meta level

In Chapter 2 we emphasised the co-evolution aspects of technology which dictate that physical and social technologies have to go hand-in-hand in the development of business models. Table 4-1 highlights some cultural characteristics in Germany that reflect societal experience in co-operation, institution building, industrial development processes and accordingly attitudes that have influenced most of society. From the table it can be seen that the German context is very different from the that of developing countries.

Some of the differences can be attributed to the education sector and network governance arrangements (e.g. dual qualification system, technology universities with close links to the private and locally relevant sectors, etc., strong local institutional networks). Furthermore, in Germany a significant number of SMEs and employees are involved in the value addition process of products, and also in engaging with public institutions to shape the outputs (public goods) to the needs of the broader society. In contrast, many developing countries with low levels of experience in industrialisation will have a less definite attitude towards further processing, engineering and manufacturing. In agriculture-based societies only a low number of inhabitants have benefited from and are involved in learning processes related to value addition, new technology and new organisational network arrangements.

The DUI mode is dominant in many circumstances but often lacks inflow of new knowledge. The more stakeholders who are involved in such a process, the greater will be the overall cultural influence. This also means that absorptive capacities and attitudes in this area are emerging and are not already strongly developed.

Entrepreneurship might be strong in some areas (especially trade and informal services), but job opportunities in the public sector are often more attractive due to the search for employment and job security.

An often volatile business environment, a rather weak social security system and university and R&D systems strongly oriented towards the STI mode of innovation and weakly linked to the local sector challenges do less to contribute to a supportive cooperation culture. Moreover, many inhabitants and business actors still have high expectations of government. Different roles in promoting innovation and service orientation in knowledge and business institutions have not yet been clearly defined or learned.

Finally, it is only possible to influence cultural aspects that support the development of innovation systems and flow of information through new societal opportunities that aid by participating in a more industrialised development process. This requires balancing short-term poverty and social priorities with longer-term infrastructure, education and technology investments. To enhance this process, systemic changes at the macro, meso and micro levels of the innovation system are necessary.

Table 4-1: **Highlights of some differences between the meta level factors in Germany and in developing countries**

Meta level factors

Germany	Many LDCs and developing countries
Long track record of structural change, industrialisation, manufacturing and production	Low technological capabilities due to low industrialisation and manufacturing experience (from subsistence to basic production to industrialisation islands)
Strong production, service and engineering culture	Weak production and engineering culture due to low participation in the production process
High social status of entrepreneurs	High social status of working in the public sector (security, image) Successful entrepreneurs rather seen as outliers in an isolated system, critical status and rather seen as cash cows
Social market security system assures social security and enables risk taking	Lack of integrated or holistic social system that provides security encouraging entrepreneurship and risk taking
Export-driven, quality-driven and competition-driven culture	Local price-driven culture lacking sophisticated demand
Subsidiarity principle and local responsibility is anchored in the society	High expectations that central government is providing support and decision making
Corporate relationships have emerged over time between unions, private and public sector	Either strong separation or merger of political, economic and labour interests, often fragmented group and tribe belongings and interests in society

4.2 Macro level

Rules and regulations such as labour rights, property rights and control systems against unfair competition provide a foundation for a structured approach to innovation promotion. In many developing countries these structures do exist to a certain extent, but often lack enforcement und thus trust. The dominance of **top-down or centralised decision making** public planning models undermines local capacities for network solutions, as well as leading to poor opportunities for DUI approaches and local institution and knowledge creation. Some of the most common features that are different from those in Germany are summarised in Table 42.

The promotion of local, sectoral and national innovation systems require policy management capability in government. The set-up of industrial and innovation strategies and policies requires expertise in the public sector, network governance, coordination and engagement with the private sector and a certain market competence to prevent market-distorting projects from being promoted. Altenburg and Lutkenhorst (2015) describe this polarity challenge: on the one hand markets are failing due to a lack of intelligent support mechanisms, and on the other hand many developing countries lack the expertise to intervene in a non-distorting way owing to their weak state. Public decision makers need experience and accountability structures. At the same time the interface with the private sector to make decisions about resource allocation and priorities is often suppressed.

Supporting innovation depends on a range of complementary support programmes that encourage the development of demand-driven meso institutions. What often dominates in many developing countries are rather isolated subsidy mechanisms or incoherent interventions that do not complement each other but that may even have a market-distorting effect. Furthermore, not only is the private sector fragmented and unable to articulate their requirements, but the public sector itself is poorly coordinated and lacks a network and collaboration approach. Many opportunities could be identified here to combine intelligent top-down policies with empowering bottom-up networks. However, this would also involve a strengthening of innovation and network management competencies, in both the public as well as the private sector.

Finally, one of the key aspects of the success of innovation system promotion is the overall orientation of the government. Many developing countries need to simultaneously manage multiple societal priorities such as economic and social development, inclusion and competitiveness, and rural and urban development, drawing on a finite number of managers, engineers, project managers and funds. In many cases competitiveness and innovation promotion are thus not high on the agenda. From an innovation systems perspective, it is necessary to distinguish more precisely between different target groups. An innovation systems perspective would, for instance, focus on the low equilibrium that exists between productivity gains, employment and education. It would emphasise the need to strengthen the technological capabilities of the system, including educational and knowledge creation aspects and thus also strengthen the absorptive capacities of the individuals.

Table 4-2: **Highlights of some differences between the macro level factors in Germany and in developing countries**

Macro level factors

Germany	Many LDCs and developing countries
Clear orientation towards strengthening competitiveness	Often orientation rather towards poverty alleviation and social security
Decentralised policy structure	Highly centralised structure with low decision power at local level and less coordination between the different ministries and line structures
Strong economic development role of municipalities and regional governments	Centralised decision-making and planning, centralised line ministry control at local levels, compliance role of municipalities and regional public entities
Business-friendly environment: trust in policies, political structures and politicians, control bodies, property rights	Business-unfriendly environment: untransparent political structures and bureaucratic procedures, lack of efficient control bodies
Strong labour regulations	Weak labour regulations
Green policies	Lack of environmental awareness and policies
Work distribution between national, regional and local governments on subsidiary principle	National government plays a central role in planning the economy and in setting rules also for lower government levels
Strong role of private sector in educational system and in QA, etc. (see above)	Role of private sector weak in setting up systems for education, QA, infrastructure, R&D
Generic economic strategies in key areas and specialised ones at regional level	Most strategies are designed at national level and lack specialisation and bottom-up opportunities

4.3 Meso level

Table 43 highlights a range of different characteristics of the institutional support environment between Germany and developing countries. Instead of mentioning each of these issues again, it is more relevant here to point out certain systemic elements that influence the meso level in many countries. The weakness of meso or supporting institutions in providing knowledge, technology information, production-related training and capacity building in developing countries is well known. In many locations and developing economies the meso level institutional layer is non-existent, or very weak, with a few institutions providing rather generic or low-impact services. Given that this is such a widely known fact, why has so little been achieved in this area?

Multiple factors are in play that at the same time demonstrate the complexity involved in economic development. To highlight but a few:

- A lack of decentralisation and often a lack of concrete competitive pressure leads to the existence of knowledge institutions that are weak in the delivery of innovative services.
- Often publicly supported meso level organisations that are publicly funded lack business and demand orientation and are also rather designed to tell businesses what to do than to identify with them concrete market and innovation needs.
- Isolated funding streams contribute rather to ad hoc activities without a system perspective and system impact. In most developing countries, little importance is attached to meso organisations delivering services that are highly valued by the private sector. By implication, "highly valued" means that the private sector is willing to contribute significantly to the costs of these services. At the same time, the private sector must be able to leverage or utilise these technological inputs to increase their margins and access new markets, meaning that their contributions yield competitive advantages.

Although many donors and governments nowadays mention the importance of public-private partnership or dialogue, in reality it is still understood only as a general dialogue between the private and public sector. It differs from the term "networking", in which support or knowledge institutions develop initiatives and projects together with businesses to improve the competitiveness of products and procedures.

For existing meso institutions, a lack of pressure to increase client orientation and networking with other players as well as a lack of innovation culture and a weakly organised business sector makes it difficult to promote creative solutions, targeted STI research activities or innovative DUI modes of cooperation.

A lack of targeted innovation and industrial strategies and policies also does not provide clear policy guidelines for many institutions.

Table 4-3: **Highlights of some differences between the meso level factors in Germany and in developing countries**

Meso level issues

Germany	Many LDCs and developing countries
Meso space has developed from synergies between decentralised structure and institution building. Sufficient diversity and competition between organisations to drive down transaction, search and coordination costs for enterprises.	Many missing public, regulatory and supportive organisations in the meso space, high coordination, search and transaction costs
Participation of many people in the educational system with strong link to the demand (dual ystem, universities, institutes, QA, services, etc.)	Fewer people participate in the educational system beyond primary school and in technical and higher education areas with strong links to private sector demand
Practice-driven education and involvement in value addition	Theory-driven education and less involvement through jobs in industrial production
Qualified knowledge, educational and technology institutions as intermediaries and "network brokers" with a certain demand orientation	Few institutions exist, many existing ones rather less qualified and strongly supply driven
Regionally authorised universities and technical universities with strong links to private production sector	Regional universities have mostly weaker links to the private sector
Private sector is a supporting force in research through foundations, clusters and business associations with services looking for synergies beyond political interests	Professional private sector bodies mainly focus on advocacy and securing work from government, less focus on the development of careers, professional standards and knowledge. Often volunteer based and underfunded
Strong co-finance of private sector in support programmes and networks. High ability to charge fees and recover costs	Low financial contribution of private sector in support programmes – mainly subsidy-driven, hard to recover costs and charge fees
Many instruments for the promotion of new sectors such as technology institutes, etc. jointly linked and looking for synergies with universities	New instruments for promoting knowledge transfer are often set up politically without strong institutions as sustainable partners
Contest-based support programmes demand proactive behaviour from support institutions, strong incentives to cooperate and work in synergistic ways	Subsidisation of meso institutions often not performance based and rather provide isolated support with poor coordination and synergies
The many support programmes provide a lot of space for exploration	Support programmes from government and donors often do not provide space for exploration but are directly linked to defined outcomes and outputs
Effective networks due to professionality of the partners involved and clear orientation	Lack of network initiatives due to network failures, fragmented structures and a lack of real constructive cooperation

4.4 Micro level

Some general comparisons of micro level arrangements that are possible between Germany and developing countries are highlighted in Table 44.

From a micro economic perspective, it is often argued that the weaknesses of the private sector in developing countries is reinforced by a lack of competitive pressure. The description of Germany's complex innovation system demonstrates that businesses, clusters and sectors can relate back to an environment that is highly supportive, yet where competition still is encouraged. As discussed in preceding sections, this environment does not exist, or only exists sporadically in developing economies, often in the form of pockets of intense rivalry, surrounded by a vast landscape of low competition between different ideas, business models, technologies and resources. The absence of innovation-based vs. price-based competition has a strong impact on the performance of the SME sector in Germany. Localised learning and the development of technological capabilities depend on competitors being near, and the ideas and stimuli from proximate customers and suppliers that are able to clearly articulate their demands. They are recognised sources of innovation, especially if they are demanding and are able to choose between a wide range of local and international sources. In developing countries, there are often fewer competitors, and some kinds of input suppliers and customers are not available in many locations. Thus not only is the public sector fragmented, but also the private sector.

However, in developing countries, local demand that arises from the context may in many cases be far more sophisticated in terms of performance, maintenance, power and overall conditions of operation, yet this demand is often low in volume terms and is poorly articulated.

Many businesses in developing countries also lack a long upgrading trajectory in certain sectors. While German companies had to continuously upgrade in the manufactured products sector and even in traditional sectors due to high regional and international competition, this type of pressure as well as models for upgrading efforts are often lacking in developing countries. Markets are mainly local and often isolated from regional and international competition, with low exposure to international export markets and the shifting technology and performance requirements in global markets. There are always outliers that have managed to become more specialised and more innovative, but often rather despite the system instead of through the system. For instance, there are a growing number of multinational companies originating in countries such as India, China and Nigeria.

Owing to the lack of a conducive innovation environment, businesses lack access to knowledge sources for upgrading. There are many persistent market failures, and many market-enabling institutions are emergent or non-existent. The pervasiveness of these market failures increases the costs of coordination and makes investment more expensive. Public institutions at the meso level that are meant to overcome persistent market failures often do not exist, or they are not focused on addressing market failures at all (Esser *et al.*, 1995). Technology-related services and investments are particularly prone to market failures. Beyond technical and product inputs, firms in developing countries also often underinvest in building human capital, which is also a market failure. In developing countries, market failures are often visible in the form of the growth of monopolistic firms and other non-competitive organisations. Different markets are interdependent, so a failure in one market could affect the viability of many others.

Table 4-4: **Highlights of some differences between the micro level factors in Germany and in developing countries**

Micro level factors

Germany	Many LDCs and developing countries
Export-driven companies in the chain or as first tier producer	Rather locally driven companies
High specialisation in companies	Low specialisation
Highly educated employees contributing to value addition	Lower educated employees and entrepreneurs reduce opportunities in value addition and innovation
Strong competition in quality issues and good products require research efforts. Role of specialists, experts and knowledge teams are important and valued.	Strong competition on price causes vicious competition cycles and running-to-standstill activities and less research efforts. It is very expensive to specialise; knowledge and expertise are not highly valued
Especially in knowledge-intensive businesses creating and having access to specialised knowledge networks is a competitive advantage	Lack of knowledge-intensive businesses also creates less incentives to cooperate with other businesses

From a systemic perspective it can be said that the competitiveness of businesses in a region and in a country cannot be reduced only to cultural aspects. All levels influence each other and finally provide a culture that mirrors the overall system. Cooperation in networks requires pressure to learn and to improve current procedures; improvement opportunities require access to information and knowledge; and motivation to innovate requires entrepreneurship and involvement in decision making. There are many opportunities for improvement of the different characteristics of the innovation systems levels in developing countries. What is highly relevant is to consider a systemic perspective instead of simply promoting activities at one level without looking at its effects on other levels.

4.5 Approaches to promote innovation systems in the less developed world

While the priorities of promoting innovation systems in different contexts may be different in developed and developing countries, the principles remain the same. An economy is a complex adaptive system that is evolving. The past matters and shapes the options at the present moment and in the future. It is not possible to fix on or a few elements in the hope that the whole system will be changed. In fact, “fixing” on one or two issues in isolation might even make the whole system more unstable. The focus should rather be on opening up the innovation system in Germany, so that stakeholders from developing countries can reach into and draw into their own context the elements, ideas and even past technologies or concepts that are most appropriate to their own context in the present.

Economic development in more developed countries is made possible by relatively stable social-market systems and organisational and policy systems that often do not exist in developing countries. At the same time social, sectoral and business prerequisites are often very different. In the industrialised world, innovation systems have been on the development agenda for a long time (OECD, 1992).

The four layers of the systemic competitiveness framework used to structure the discussion in the preceding parts of this chapter should not be seen in isolation. These layers and the factors they contain are tightly interrelated and affect each other. The system constrains the actions (or choices) of the actors, while the collective decisions of the actors shape the overall system. I

In most developing countries there are pressing priorities to deal with. UNCTAD, in a Least Developed Countries report (2007) dedicated to knowledge, technological learning and innovation for development, argues that many LDCs hardly have innovation systems, and that it is more appropriate to concentrate on the technological systems of these countries. Other authors such as Fagerberg and Srholec (2009), Fagerberg *et al.* (2007), Fagerberg and Verspagen (2007) and Nelson (2004) have also explored the catch-up conditions of developing countries. However, several emerging countries, such as Brazil, India, China and South Africa are already working on improving their national innovation systems, especially through reforms or improvements to publicly funded institutions involved in science, technology and innovation.

Altenburg (2009) proposes that national innovation systems, especially in LDCs should be focused on solving problems facing the country, and concurs with Bell (Bell, 2007), who argues that the emphasis should not be on creating "new-to-the-world" innovations or low spill-over interventions such as science parks or incubators. Bell argues that the focus of innovation policy in developing countries should be on diffusion of existing technologies which are nevertheless new to firms in developing countries. Likewise, research and development should not be seen as the main input to innovation; instead, innovation in these countries is an engineering-centred process (Bell, 2007:28).

Altenburg further argues that developing countries should focus on protecting or addressing the interests of the poor, and that the productivity and technological gaps between developing countries and industrialised countries should be reduced. Most of the current debate around innovation systems in developing countries overemphasises the role of the state and formal R&D through non-market institutions, and underemphasises the role of markets and the private sector.

Furthermore, the need of local stakeholders to gain knowledge or understanding of technologies or even sub-elements of technology that enable local problem solving, learning and technological competencies to be built are often overlooked. While local stakeholders may not "know what they don't know", many German multinationals and development projects with their counterpart networks may be in a better position to help the German Development Cooperation to determine what the possible starting points are to build relations between German and developing country innovation systems.

4.6 The importance of diffusion of knowledge and improving absorptive capacity and learning

Central to an innovation systems approach is the accumulation, integration and diffusion of knowledge (see Chapter 2). But there are many factors that make this accumulation process more difficult in developing countries.

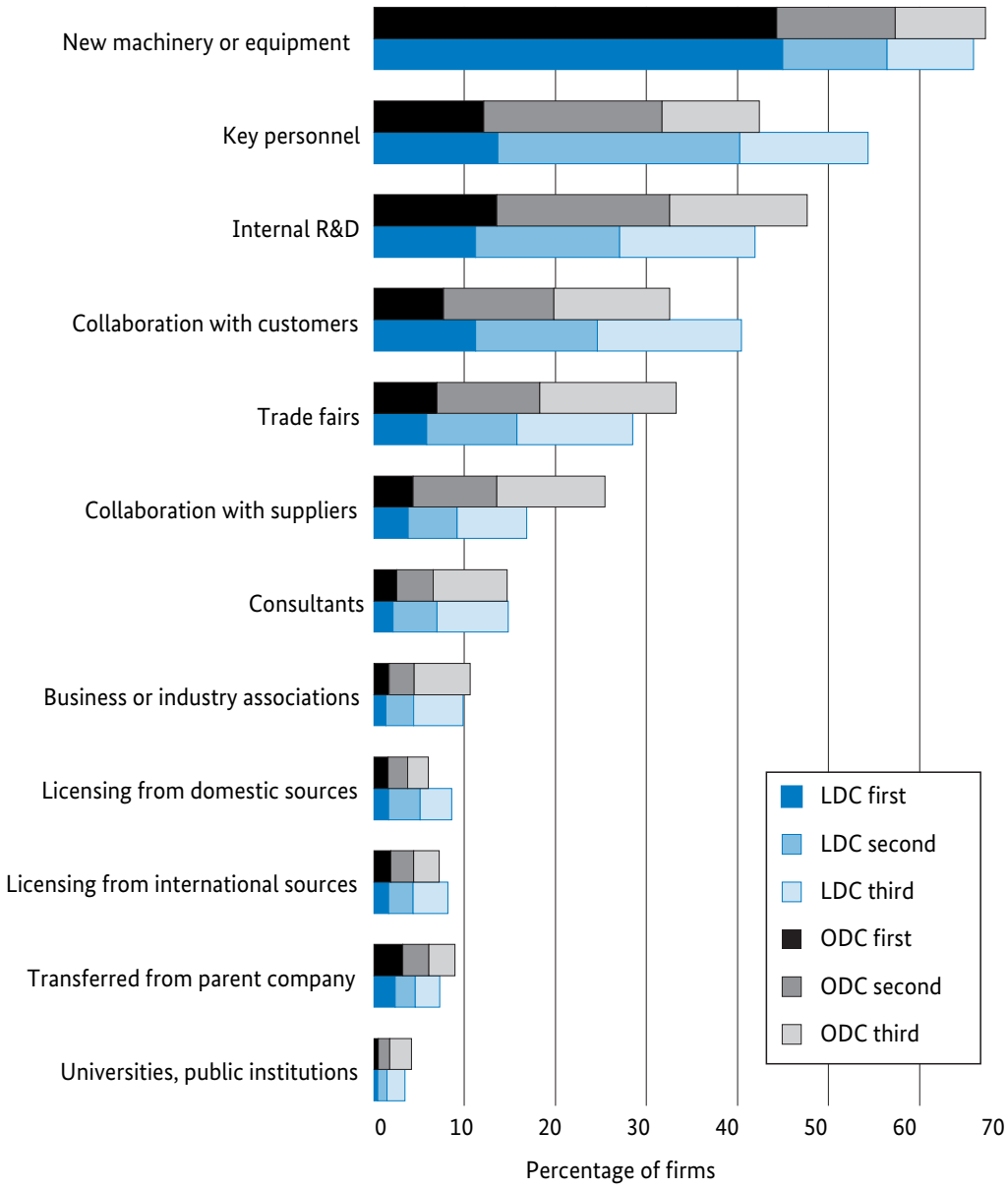
Developing countries often depend on knowledge (and capital and equipment) from outside the region and the country, making the technological catch-up of indigenous organisations more expensive and difficult. Attempts to protect the local industry from imports often simply result in new production technology and intermediary inputs costing more, further isolating the economy from the international improvement in productivity and efficiency. The importation of equipment is often affected by fluctuating currencies and high transport costs, which results in developing countries falling further behind the technology curve.

The sophistication and scale demand in local or nearby markets is an important driver of innovation. If this demand is not well articulated or is unknown, local manufacturers might not respond to it by investing in and acquiring the needed skills and resources. In poorer regions, consumers buy cheaper goods in an attempt to maximise the value of their money. The result is that producers are under pressure to cut costs, and find it hard to move up the value ladder to higher-income goods. Producers in other regions that are further down the efficiency curve may be able to undercut local enterprises, further reducing scale in the local market.

UNCTAD's 2007 Least Developed Countries Report (UNCTAD, 2007) shown graphically in Figure 4-1 highlights the importance of new equipment suppliers, followed by new employees and internal R&D as sources of knowledge. If the domestic market is too small for an international provider of equipment, then acquiring the required equipment and support will be expensive or even impossible to achieve.

Figure 4-1:

The most important sources of technological innovation in LDCs and ODCs, 2000-2005



Source: UNCTAD, 2007

Figure 4-1 highlights the importance of four non-STI-related inputs as sources of technological innovation. Yet the STI infrastructure, combined with the whole of the education sector, makes it possible for organisations to absorb technology and knowledge from abroad. The figure shows that in both LDCs and ODCs the most important conduits of technology transfer are the acquisition of new machinery and equipment, the recruitment of specialised staff, internal R&D, interaction with customers and suppliers, and trade fairs. The assumption that knowledge of how to use new technology flows from universities and public institutions is wrong.

It is also necessary to give a caution: over-dependence on external acquisition in the form of equipment might also undermine efforts to develop technological capability (perhaps from a lower base). So somehow a balance must be found, even if this is subjective and hard to do.

Developing countries often have to face the reality that specialists and knowledge workers migrate from rural areas to cities, and from secondary cities to primary cities or to more developed countries where they have higher earning and development potential. This phenomenon is called the brain drain and it has a devastating effect on many developing countries which are able to train but not retain their knowledge workers.

Lastly, procurement from the public sector is an important impetus to economic development. However, corruption, centralised procurement and preference for foreign goods may undermine efforts to develop local industries.

Chapter 5.

Germany's potential contribution towards strengthening innovation systems in developing countries

This chapter identifies potential learning and institutional structures that could be relevant for developing countries. The cooperation and competition between businesses, institutions and policies and the interplay between the private and public sector play a key role in the systemic competitiveness of Germany and its ability to upgrade technological capabilities. At the same time, the diversity, decentralisation and sometimes competing elements of the German innovation system make it harder for developing countries to engage with. This is especially important as for most Germans this system is invisible and non-obvious.

Furthermore, many German development programmes, including private sector and non-governmental organisations, are already contributing to the innovation systems in developing countries unintentionally as part of their normal operations, albeit at a sub-system or sectoral level in many cases. The fact is that this support is often poorly coordinated and piece-meal, or aimed at a narrow project or technology-related issue without considering how the system of innovation in the developing country could be fostered or strengthened.

From the literature study in the preceding chapter it is evident that technological catch-up in developing countries requires access to international knowledge and the ability to master and adopt foreign technologies. At the same time, the dynamic of the national innovation system in each country must be strengthened. It is not only about the presence of "the right institutions", but also about how they interact with each other, how they collectively respond to local constraints and how they respond to changes in the global economy and technological landscape.

The objective of this chapter is to outline some starting points for further discussion between the stakeholders involved in German Development Cooperation.

We have structured our recommendations for future discussions under five themes that emerged from the preceding chapters:

- How technology transfer can be strengthened through existing and future trade channels
- How collaboration with FDI partners from Germany can be leveraged to strengthen DC innovation systems
- How the current STI cooperation can be broadened to include more DUI mode innovation
- Improving German Development Cooperation to strengthen an innovation system approach
- The movement of people as a means to strengthen capability and absorptive capacity.

Under each of these themes we make recommendations arising from discussions in the previous chapters of this study which broadly set a direction, and initiatives or specific interventions that could be considered.

5.1 Strengthening channels of technology transfer through trade

In Chapter 2, we discussed how, according to UNCTAD and others, the major channels for technology transfer to developing countries includes the importation of capital goods, the closer integration into global value chains and licensing. These three channels are mainly about trade, where many developing countries are already tapping into the German innovation system directly or perhaps indirectly. For example, a company in a developing country can transact directly with a German supplier, who in turn is connected to a network where there is collaboration between a range of private and public experts.

It was mentioned in Chapter 3 that exports from Germany are characterised by the export structure, which consists largely of manufactured goods and process technologies. For instance, 87% of Germany's exported products are manufactured goods which embody knowledge. This knowledge can be traced back to Germany's innovation. Germany´s global export network offers large opportunities for development cooperation, and as UNCTAD (2007:12) showed, some of the most important sources of knowledge for manufacturers in LDCs were equipment suppliers.

The knowledge embodied in products mainly create spill-over effects if receiver countries are able to identify and make use of the embodied information. To enable the absorptive capacity of developing countries requires the purposeful development of their innovation systems (see Chapter 2). While manufactured products harness natural phenomena and embody knowledge, technologies traded through normal commercial transactions do not necessarily transfer tacit and contextual knowledge. As the absorptive capacity of developing countries improves, they will also be better able to identify gaps in their own knowledge capacity that can be explored or met through networks in Germany.[25]

A key question for discussion in development cooperation is how the technological capabilities and absorption capacities of developing countries can be increased through existing and future trade links with Germany.

A point of concern is that when the trade balances of LDCs and developing countries for the last 25 years are assessed, it can be seen that imports of more knowledge-intensive capital goods such as machinery and equipment have lost momentum, while it increased in many ODCs (other developing countries). This means that LDCs have lagged behind ODCs, and thus are falling behind even further. Perhaps the improvement in developing countries can be traced back to a stronger industrialisation process, especially in Asia, making use of products involving stronger technology know-how.

25 Based on our practical experience in brokering cooperation between developing countries and German companies or institutions, once it is possible to articulate what an organisation based in a developing country is struggling with or trying to master, then it becomes much easier for German-based experts to respond and provide detailed expertise.

Considerations

- Overall in international trade, much of the machinery and many parts imported by LDCs and ODCs are second-hand products or well-established technologies that are not state of the art. This underlines the fact that technology diffusion in trade from Germany to LDCs and also to many developing countries must not only consider the diffusion of state-of-the-art technology but also adopted technology that is relevant to the respective countries and related to their absorptive capacities.
- Germany's long track record in the manufacture of knowledge-intensive technologies required for productivity improvement provides a deep knowledge base (know-how and know why) that enables the adaptation of technologies to unique circumstances in LDCs and ODCs (without raising concerns about intellectual property rights or IPR). Insight into state-of-the-art technology in many German SMEs can be used to diffuse older or well-established technology[26] to LDCs and ODCs in a more intensive way, but also considering and building in the new learning. This would provide the opportunity to deliver technologies that are related to the absorptive capacity of the customers but at the same time enable the buyers of the technology to take part in learning loops related to past learning. Many German companies can benefit from market expansion by adjusting their products to the demands in developing countries and establishing consultancy and maintence services around it.

Options to explore

- There is a wide network of stakeholders in Germany such as German suppliers, developers and researchers of well-established technology that can be integrated as knowledge transmitters in developing countries. Often this does not require direct involvement of the CEOs of the companies and the leaders in research and development, but rather relies on a wide range of technical and operational experts who are (in our experience) keen to expand their experience in developing countries and to learn from the respective demands in developing country markets. Up to now it seems that this potential has not received real attention. Although organisations such as CIM and even the German Senior Expert Service draw on experts from German companies and knowledge institutions, it seems that there is much more potential. Such potential could contribute to transfering and elucidating the embodied or tacit knowledge not explicitly captured in the technologies that have already been established in the German market, increase the absorptive capacities and reduce search and evaluation costs.
- Critical consideration of how certain imported technologies emerged in Germany and a better understanding of the interplay of different contextual elements has led to the emergence of certain product designs, standards and technologies, skills requirements, specific knowledge domains, articulated or clearly visible market demand, financial and input product resources, and the interplay of policy and private sector relations and regulations. This support structure, if transferred, will provide insights that are also relevant to the set-up of demand and market-driven STI projects for certain knowledge providers and institutions in developing countries.

26 It is not so much about "older" technology than about well-established technology that is easier to maintain and manage in developing countries. Our research has shown that the latest cutting-edge equipment is not always required.

- In German Development Cooperation, public-private partnerships (PPPs) offer a mechanism for leveraging an importer´s and investor´s knowledge. However, PPPs have mainly been related to small projects with specific beneficiaries to support capacity-building initiatives. Making use of knowledge exchange in technology application aspects with private importers, research institutions and investors could make a difference in this respect.
- Value chain relations in trade between first-, second- and third-tier suppliers must be scrutinised more closely in regard to informal and formal knowledge services that are involved around the world. Many donor organisations promoted a business development service (BDS) approach at the beginning of the 2000s. They were looking for opportunities to strengthen embedded services in developing countries and in local and global value chain relations. By reconsidering embedded services and cooperating more strongly with German small and medium-sized enterprises (SMEs) and large companies in formally improving and extending such embedded services, additional opportunities of product, process and functional upgrading would be provided.
- A final option would be to determine whether there is a role for a high-level technology broker or intermediary to connect "solution owners" in Germany with "problem owners" in developing countries. The priority should be to identify German technology that can be adapted to suit operating requirements in developing countries, and through the adaptation process to strengthen the capability in the developing countries.

5.2 Areas of exchange with FDI partners from Germany

The difference between trade and FDI (foreign direct investment) is that in FDI relationships companies or subsidiaries are based in the respective country, from where it can serve the domestic, regional or even international markets. In general, FDI implies a long-term relationship between the investing company and the location of investment. From its established base in a developing country, these manufacturers must then establish supplier networks, national, regional or international market channels, and in instances where supporting technological infrastructure is lagging, it must either create its own (alone or in partnership with others), or reach back into the German innovation system.

Due to their interest in the stability and wellbeing of the countries they have invested in, German multinational companies have a different perspective on the constraints and opportunities of different countries. They can provide a detailed and context-specific insight of the technological shortcomings, underutilised capability or potential in developing countries. For instance, they can assess whether standards, metrology, quality and measurement systems are sufficient, or whether local engineering, design and management capability exists that can be further strengthened.

A question that deserves more attention is how to make use of international investments from the German private sector to link the stakeholders from the innovation systems in developing countries more to other international knowledge networks and to use the cooperation with FDI stakeholders in a more effective way. Not all German manufacturers involved in FDI are large multinationals. German medium manufacturers, and in some instances smaller manufacturers, have established operations abroad in order to be close to key customers, suppliers or even knowledge centres.

It is relatively easy to make contact with German manufactures who are actively expanding internationally into developing countries as they often establish German-developing country chambers of commerce and industry abroad, or are known to German embassies. For German Development Cooperation to foster networks of collaboration between manufacturers in developing countries and to develop synergies with direct business support structure strengthening or supply chain development, relationships would be relatively easy to establish, which has already been done in some places. Working with the German private sector based in developing countries to strengthen technological support structures that are backed by or connected with the German Innovation System will also ensure sufficient scale of technological infrastructure in developing countries which is better able to respond to domestic technological challenges and opportunities.

FDI branches and their subsidiaries often provide the opportunity for stakeholders (businesses as well as researchers and even policy representatives) to tap into networks of knowledge and technology diffusion outside their own system, even taking part in international processes of knowledge creation and diffusion. Marin & Arza (2009) emphasise that knowledge spill-overs that emerge out of FDI relations are not only beneficial for the recipient country but also for the investors themselves. The identification of new supplier and research linkages as well as market insights are still important reasons why companies invest in new markets.

Germany´s strength lies in the production of manufactured goods, especially in relatively sophisticated process technologies and equipment. There may be a special advantage in approaching specific German investors and to search for cooperation projects, or to understand their hesitation in entering certain markets or expanding in certain markets. A deeper analysis of the German FDI structure in respective partner countries would be necessary.

Consideration

- UNCTAD (2007) emphasises that FDI provides opportunities for knowledge transfer although these opportunities are in many cases overestimated. It depends on the form of the FDI. The production of more knowledge-intensive products and not mainly natural resource attraction as well as the dependence on local content and input products provide opportunities for technology and knowledge diffusion. However, this also requires proactive policies and a differentiation in FDI attraction from the policy representatives of developing countries.

Options to explore

- How can stronger collaboration and partnerships with German manufacturers with operations abroad lead to the identification of opportunities to strengthen technological infrastructure and cooperation between the German Innovation System and the actors in the developing country innovation?
- Drawing the representatives of the FDI companies and their clients in developing countries into the strategy process of designing more congruent linkages in the respective NIS. This should go beyond technological infrastructure alone and should also consider how education programmes, trade support and infrastructure issues could be addressed. This can also be done, for example by looking at local content requirements of FDIs that cannot be matched at present.

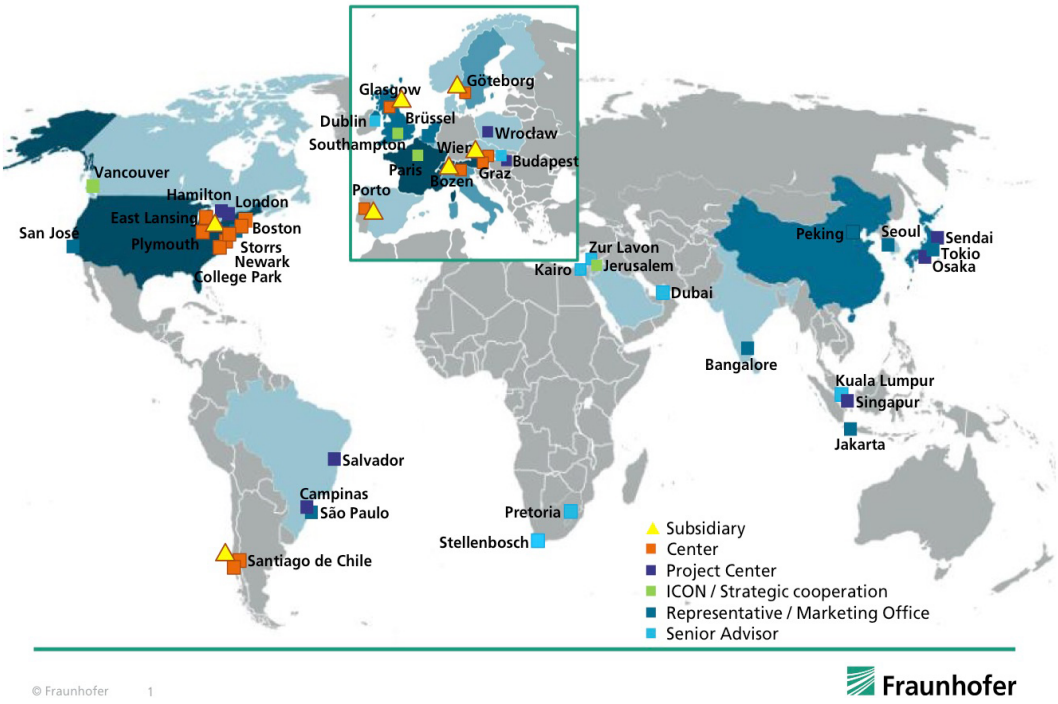
- Is it possible to design a portfolio of networking projects that encourage linkages between innovation system stakeholders which FDIs in Germany are linked to and stakeholders in the respective developing country?

5.3 Broadening current STI cooperation to include more DUI mode innovation

Beyond the interests of exporting enterprises in Germany there is a strong international orientation of research organisations and even universities. Many research organisations have created alliances with other international organisations, universities, technology transfer institutes, basic and applied science research institutions focusing on concrete research projects, scholarship provision etc. Figure 5-1 illustrates the international representation of the Fraunhofer-Gesellschaft.

Figure 5-1:

The international presence of Fraunhofer



Source: Fraunhofer (2016)

The large research institutes, such as the Fraunhofer institutes, Helmholtz and Max Planck are recognised as international transmitters, co-operators, developers and connectors of knowledge with a diverse range stakeholders and institutions (public, private and NGOs) in developing countries.

Some articles use the term "cooperation jungle" [27] to describe partnerships between universities in different countries. In the last two decades, global competition for students, third-party funding and reputation universities had to intensify its international visibility, accessibility and partnerships with other foreign universities.

Several regional offices and programmes have an established track record of promoting cooperation and research abroad, both in terms of making supply more visible and in brokering relations internationally. This includes, for instance, the German Academic Exchange Service (DAAD), the BMBF and the German Research Foundation (DFG) who are promoting collaboration and partnerships in research projects. German research and business foundations and research funding organisations maintain information centres and regional offices worldwide. Embassies are in general an information point for the distribution of additional information and contacts.[28]
In this respect there are many ongoing activities internationally and in Germany in which research representatives from DCs are already involved in joint research. In this way they exchange information between the different innovation systems and share knowledge often in globalised networks. Also the EU with research programmes such as Horizon 2020 is promoting concrete research projects that connect research organisations from the EU with each other as well as integrating many projects partners from DCs.

Lastly, there are many international postgraduate courses, including German postgraduate courses such as SEPT at the University of Leipzig. These courses are offered in developing countries, and students have the opportunity to obtain a degree which is accepted in Germany and which provides access to German teachers and knowledge material.

Considerations

- From our brief scan it seems that many of the research projects are focused more on basic research and state-of-the-art inventions and less so on applied research and adaptation and diffusion of technologies.
- Most research networks lack concrete orientation to strengthen the local knowledge systems in developing countries beyond the immediate requirements of a specific project. DUI modes of research with exploration efforts and the emphasis on developing and improving the local technological capabilities, as well as in many cases cooperation with the private sector, are rather underdeveloped. In many of the research networks, patents and traditional STI characteristics are still dominant.

27 See for example https://www.academics.de/wissenschaft/kooperationsdschungel_-_internationale_universitaetspartnerschaften_56024.html

28 For a more detailed list of regional offices and support programs for research visit http://www.research-in-germany.org/en/infoservice/ambassadors-of-german-research-abroad.html

- For many German universities cooperation with institutions in developing countries is interesting if a certain professional orientation and capacity exists, with developed research areas in place that are mutually beneficial. This means that especially in LDCs, research institutions need to develop certain organisational prerequisites before cooperation is possible, for which additional support may be required (but not necessarily supplied by the German institutions involved).
- Cooperation with German and developing country education and STI institutions are necessary to strengthen the orientation of faculties to contribute to national required knowledge for increasing technological capabilities.

Options to explore

- How can joint research projects be developed that identify applied solutions and technologies that can solve problems in developing countries while at the same time encouraging promising STI organisations, networks and researchers to participate in international research, technology development and problem-solving activities?
- How can engineering and technology education platforms in developing countries be strengthened with German medium-level researchers and education cooperation? This could, for instance, involve creating incentives for German technology institutions and MNCs to establish demonstration facilities in regions in the developing countries. The facilities must be useful for education, but must also demonstrate non-salient aspects of the technology (for instance standards, quality assurance, performance, maintenance, etc.).

5.4 Improving German Development Cooperation to strengthen an innovation systems approach

German development cooperation with institutions such as the GIZ, DEG, KfW, CIM and others present a diverse range of competence fields and product offerings that are relevant for the promotion of innovation systems in developing countries. The authors see the highest relevance for the promotion of innovation systems as being in the field of economic development and employment promotion, but skills development, environmental protection and other topics may also be relevant depending on the context. However, there are more competence fields which need to be considered and which should contribute to the systems approach. These are listed in Textbox 5-1.

Textbox 5-1:

Competence fields of German development cooperation relevant to promoting innovation systems in developing countries

- **Economic development and employment promotion.** This field of expertise includes private sector development (LED, cluster and value chain promotion and migration aspects), skills development (technological and vocational education and capacity building), finance system promotion (including innovation finance) and economic policies (e.g. quality infrastructure, innovation policies, R&D policies, etc.).
- **Governance and democracy.** These competences tackle pro-poor governance, promotion of participatory governance models, decentralisation, urban and municipal development, and public management.
- **Rural development** is involved among others with standards and food safety, agro-processing, increasingly also alternative energies, mitigation and adaptation innovation requirements, etc.
- **Environment and climate change.** These areas include expertise in the fields of sustainable tourism and resource-efficient economy.
- **Sustainable infrastructure** includes renewable energy resources, energy efficiency and sustainable urban mobility.

Source: Cunningham & Wältring (2015)

The GIZ has developed and designed a wide range of programmes for private sector development. All these programmes address aspects of the promotion of an innovation system, but have at the same time a different focus. They look less explicitly at the promotion of innovation flows between the responsible actors, although the innovation system perspective can use these competence fields to ensure that a system perspective is the leading guideline. It is also possible to explicitly combine areas where GIZ has deep knowledge, for instance in supporting developing countries to better manage urbanisation with an innovation systems perspective (Cunningham & Waeltring, 2015).

The GIZ have been working together with a number of public and private organisations on the promotion of innovation systems for a number of years[29]. An inter-agency working group was established. The cooperation of this working group culminated in an event in Dortmund in 2009 that was moderated and documented by the authors of this study (Bauer & Hartmann, 2010). The objective of that event was to highlight the topic of the promotion of innovation systems to development projects and to showcase the work of various German and European organisations in this field. Two further publication outputs of this working group are important. The first is a publication that was commissioned to look specifically into many of the different competence fields of the German Development Cooperation and the respective project and programme approaches (Kadura, Langbein & Wilde, 2011). The paper strived to create more synergies between different programme instruments of the GIZ.

29 In our understanding, the working group is currently not very active.

Their approach distinguishes between instruments that:

1. Aim at reinforcing the sub-systems of innovation systems (education and qualification sector; research institutions; companies), e.g. promoting innovation management in SMEs, incubators, etc.

2. Build bridges and links between the different sub-systems (e.g. building innovation partnerships between companies and research, providing platforms for collaboration, promoting university spin-offs)

3. Improving framework conditions, e.g. designing incentive systems and innovation policies, supporting monitoring instruments.[30]

The second important publication was a toolkit published by the same working group. It contained more detailed descriptions of projects that were directly promoting innovation systems (GIZ, 2014). However, in the authors' experience, these publications still exclude many development projects that used an innovation systems logic, and were not about innovation systems promotion per se[31].

The German Development Institute (GDI/DIE) is recognised as a leading think tank in the promotion of innovation systems in developing countries, among many other related topics. In the last twenty years, the GDI/DIE has published many research and policy papers to improve the effectiveness of German Development Cooperation as well as bilateral and multilateral relationships. Support for the design of industrial policies, innovation and technology policies, as well as innovation systems in developing and emerging countries, are some of their key competences. They also contributed to the work of the inter-agency working group that was mentioned above.

Considerations

- Innovation systems promotion cuts across not only sustainable economic development subdomains, but also involves other sectoral approaches such as infrastructure development, rural development, global trade partnerships and financial services. The German Development Cooperation needs to re-energise the ongoing consideration of ways to promote innovation systems in partner countries, based on a more congruent approach that does not mainly focus on coordination between competence fields of the German Development Cooperation, but more explicitly on the coordination with donors under the leadership of the partner countries.

- This also requires a comprehensive analysis of the state of the respective innovation systems and a congruent approach to strengthen technological capabilities hand-in-hand with the absorptive capacity of the different stakeholders.

- The selection of partners would have to be based more on the identification of stakeholders that source, provide and transfer knowledge and that are motivated to contribute toward cooperation under a banner of promoting innovation systems in a holistic way.

30 See Kraemer-Mbula 2011, p.6.

31 An example would be the GIZ Support to the South African Department of Science and Technologies Technology Stations Project, which is mainly about skills development and the strengthening of the higher education system.

- Many support activities, not only in the German Development Cooperation, but overall in donor approaches, tend rather to concentrate on small and rather short-term interventions without having the innovation system approach in mind. The reality of ODAs shows that many innovation projects run in parallel without being connected with each other. For example, in a given developing country, one project might focus on upgrading productivity and employment in selected value chains, while in a sister project the focus might be on strengthening business associations, while yet another project might be focused on strengthening the TVET (Technical and Vocational Education and Training) system. Without a joint objective and purposeful development of joint activities and knowledge exchange it leads to isolated upgrading efforts with few spill-over effects.
- Ways to strengthen the top-down and bottom-up policies in developing countries that encourage the creation of learning networks, faster feedback between policy and implementation are required, and much stronger emphasis on discovery and learning than on direct project delivery towards extremely narrow indicators.
- A clear business-centred approach to innovation and education promotion is needed in which the reference point must be businesses with growth potential and an interest in innovation, which at the same time supports technologies or networks that will directly contribute to strengthening the developing countries' ability to deal with national imperatives such as poverty reduction, environmental management or infrastructure improvement. Support for technology and educational institutions needs to be oriented towards strengthening the sectors with high development potentials.

Options to explore

- The need for the promotion of programmes and interventions under the banner of "innovation system promotion" instead of the promotion of somewhat unconnected and isolated innovation projects.
- Approaches with a flexible partnership model will have to be promoted to encourage experimentation and exploration of new networks, new adapted solutions and new learning loops in the system.

5.5 The movement of people as a means to strengthen capability and absorptive capacity

In our view, the movement of people, which has to some extent already been covered in the preceding sections, is a critical element of strengthening capability and increasing absorptive capacity in developing countries. Moving people, whether managers or decision makers or rather more technical, academic, engineering or science-focused people, not only transfers knowledge between Germany and its developing country counterparts, but is also the fastest way to reduce the search cost of developing country meso organisations trying to find resources and support in the German economy. The extent and complexity of the German Innovation System has been discussed in much detail in Chapter 2. However, there is another dimension to this. It is not only beneficial to developing countries. By incentivising German experts to engage in problem solving and discovery in developing countries (in close cooperation with hosting meso organisations of course), the German Innovation System itself will be strengthened as it becomes more aware of and responsive to the realities of developing countries. This movement is also not only in one direction. Hosting decision makers, engineers and scientists from developing countries temporarily or as part of exchange programmes is another way of facilitating the transfer of knowledge between systems. In our experience, carefully designed study tours that result in or strengthen cooperation between meso organisations in Germany and developing countries is also a powerful mechanism that strengthens longer-term knowledge exchange.

However, we acknowledge that this approach is also the most difficult to coordinate, and much depends on the institutional capability of the meso organisations in developing countries and their relations with German public and private representatives.

Options to explore

- Systematically fostering the two-way mobility of technical expertise in a small number of pilot countries where strong German private sector and public sector representation is already established. The purpose of this pilot is to bring together all the (German) stakeholders who either have a track record or an interest in exchanging expertise with the developing countries to strengthen systemic weaknesses.
- As German Development Cooperation already has a track record and institutional capability in exchanging or deploying expertise, it might be valuable to revisit these mechanisms and to record good practices with a specific focus on how these experts strengthen the innovation systems in developing countries.
- It would be interesting to engage with German multinational companies to see how they currently support technical capability development in the countries where they are expanding their presence. It might be possible for German Development Cooperation to bring together private sector actors in a particular developing country who are not cooperating yet and to develop specific instruments to support the efforts of these investors to work together with meso organisations and public programmes in developing countries.

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