The challenge of alignment and barriers for the design and implementation of science, technology and innovation policies for innovation systems in developing countries

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INTRODUCTION

In the last few years, a growing number of developing countries have officially adopted the innovation system (IS) approach to formulate their science, technology and innovation (STI) policies (Padilla-Pérez, 2013; ECLAC/OCDE, 2012). This is the case even for some low-income countries such as Ghana, Honduras, Mauritania and Nicaragua (UNCTAD, 2010, 2011a, 2011b, 2012).

In general, policies targeting the IS as a whole seem to be more appropriate for developing countries than pure science or technology policies since they encompass not only science and technology, but all public actions influencing competence building and learning, like education and training, social policies underpinning social capital and labour market dynamics (Lundvall et al., 2009, p. 6).

But they are also more challenging. In order to be effective, STI policies from an IS perspective (IS policies now onwards) require an explicit alignment of policies with the specific development challenges that the country is facing. The problem is

that more often than not, the STI policies deployed in developing countries more reflect a process of imitation of objectives and instruments than actually a strategy to address the specific problems that the country has. It is also often the case that there is a lack of alignment between objectives, instruments and specific problems (Chaminade et al., 2012). Moreover, STI policies frequently are neither at the centre of the economic development agenda nor aligned with a national development strategy (Padilla-Pérez and Gaudin, 2014; Padilla-Pérez, 2013).

The existing literature has paid lip service to the analysis of the adoption of the IS approach for STI polices in developing countries and to the specific barriers of its implementation. This chapter aims at fulfilling this gap. Although more theoretical in nature, it presents examples of STI policy design and implementation in Asian and Latin American countries to illustrate the arguments deployed in the paper.[1]

This chapter is structured as follows. First, in the second section, STI policies as policies targeting the IS are conceptualized. In the third section, the main barriers for designing and implementing STI policies are examined. The fourth section is devoted to the issue of vertical and horizontal alignment in STI policies in developing countries. The fifth section concludes.

CONCEPTUAL FRAMEWORK: STI POLICIES AS IS POLICIES

The systems of innovation concept (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 1997) has been gradually adopted as the focus of STI policies in both

[1] This chapter is based on recent works by the authors which discuss the importance of innovation system policies for developing countries (Chaminade et al., 2009) and the barriers that developing countries face to design and implement STI policies (Padilla Pérez and Gaudin, 2014), and examine issues of alignment between objectives and instruments (Intarakumnerd and Chaminade, 2007; Padilla-Pérez and Martínez-Piva, 2009; Stezano and Padilla-Pérez, 2013) and between instruments and systemic problems (Chaminade et al., 2012).

developed and developing countries. However, their effective implementation has been far from easy and only a handful of countries have been able to upgrade their innovation capabilities throughout time. One of the possible explanations for this is the difficulties of aligning objectives, policies and instruments with context-specific problems that the ISs of these countries face.

STI policies from an IS perspective are defined here as actions by public organizations that influence the functioning of the IS and aim at solving problems in the systems of innovation (Borrás et al., 2009). And these problems are fundamentally different in a developing context as the composition and functioning of the system of innovation also differs from that of a developed country (Lundvall et al., 2006, 2009).

One could argue that science policies, technology policies and innovation policies target different elements of the system (Lundvall and Borrás, 2004). Science policies aim at ensuring that there are sufficient resources for science. The main actors targeted are those conforming to the 'research subsystem', that is, universities, research institutions, technological institutes and research and development (R&D) laboratories. The main instruments are usually financial incentives (in the form of direct subsidies, R&D grants, etc.) to reduce the high costs of research. Technology policies, on the other hand, refer to policies that focus on specific technologies and sectors that are considered strategic for the country. They target similar actors in the IS but pay more attention to the links between university and industry and to applied more than to basic research. Finally, Lundvall and Borrás (2004) define innovation policies as a more holistic type of policy, which pays particular attention to the linkages in the system of innovation while putting more emphasis on the institutions and organizations than pure science and technology policies do. Innovation policies are often considered to focus on the outcome, that is, on new products and services

and, as such, they are criticized for an excessive focus on the firm as the main actor transforming ideas into new products and services.

While in theoretical terms it is useful to identify the main features of science policies as compared to technology policies and innovation policies, in practice, the boundaries between the three are not so clear. They all target the system of innovation and, as such, they need to be combined in order to achieve the desired effects in terms of increasing technological capabilities and well-functioning ISs.

We understand ISs in a broad sense, that is, as 'an open, evolving and complex system that encompasses relationships within and between organizations, *institutions and socio-economic structures* which determine the rate and direction of innovation and *competence building* emanating from processes of *science-based and experience-based learning*' (Lundvall et al., 2009:6, italics by the authors).

This definition has important consequences in terms of how we conceptualize STI policies in developing countries. First, this definition emphasizes competence building, thus pointing out the importance of building absorptive capacity, and absorbing technology rather than only creating it. Second, as it embraces both processes of science-based and experience-based learning, innovation policies cannot be disentangled from science and technology policies, as they are both sides of the same coin. Third, there is an explicit focus on institutions and socio-economic structures. The extensive literature on systems of innovation has largely emphasized the role of institutions in shaping capability building and interactive learning. Formal and informal institutions such as rules, norms, routines or informal social patterns of behaviour shape the interactions of the different organizations in the system of innovation (Nooteboom, 2000; North, 1990). And those institutions are highly

context-specific and highly path-dependent. Adopting such a holistic policy is very challenging particularly in a developing country context as we will discuss next.

BARRIERS FOR THE IMPLEMENTATION OF STI POLICIES IN DEVELOPING COUNTRIES[2]

There is increasing recognition among policymakers in developing countries of the crucial role of STI for inclusive and sustainable economic growth. Yet developing countries commonly face significant barriers to design and implement STI policies. Empirical studies highlight the following barriers (Padilla-Pérez and Gaudin, 2014; Chaminade et al., 2012; Nurse, 2007):

First, the increasing recognition of STI as a central driver of economic growth has rarely been accompanied by a significant increase of financial resources. Public financial support for STI activities is scant and even nonexistent in some developing countries. Therefore, governments in those countries usually have a limited budget to implement national plans of STI (Lall and Pietrobelli, 2005; World Bank, 2010). In addition, public bodies in charge of STI policies (national councils, secretariats, vice ministries and ministries) do not have enough leverage to push their own agendas across all ministries. Usually, national STI plans are not fully implemented due to insufficient funds when executing programmes and policies. Exiguous finance normally goes hand in hand with smaller staffs. Actually, lean finance just mirrors a major political obstacle: STI policies have not yet attained the status of pillars of economic and social policies. Low public sector revenues are a significant barrier to increasing public investment in STI, since governments in developing countries face

[2] This subsection is based on Padilla-Pérez and Gaudin (2014).

overwhelming demands to tackle basic needs such as health care, shelter, education and security.

Second, both long-term planning and continuous implementation of STI policies are absent (Wamae, 2006; Nurse, 2007; Altenburg, 2009; World Bank, 2010). The implementation of these policies suffers frequent institutional changes, sometimes to strengthen them in the political agenda, other times to undermine them. Their place within the economic agenda commonly depends on the priorities and strategies followed by each government. National councils or vice ministries of science and technology often fall under different ministries, such as economy, industry and trade, or education. Likewise, STI programmes and policies do not always survive the entrance of new governments. Their place in the economic agenda frequently depends on the priorities and strategies being followed by each government. Tangible results of STI activities usually take a longer time than a political period. Therefore, it is likely that incoming governments that execute STI policies will hardly see concrete outcomes by the end of their administrations.

Third, there are neither financial resources nor the institutional culture to monitor and evaluate programmes and policies (Hadjimanolis and Dickson, 2001; Lall and Pietrobelli, 2005; Aubert, 2010; World Bank, 2010). Such deficiencies appear as barriers to strengthening the impact of STI policies. Public programmes are underfunded and do not allot resources to conduct evaluations. Sometimes STI indicators are not collected periodically and systematically, a flaw which hinders policy evaluation exercises.

Fourth, governments must deal with a reduced commitment from all the components of the national IS with STI activities. R&D investment by the private sector is scant and in general private enterprises do not demand more active public

support in this area (Lall and Pietrobelli, 2005; Altenburg, 2009). Universities are mainly focused on teaching or carrying out basic science research, but are weakly linked to private enterprises (Brundenius et al., 2009).

Fifth, although the degree of institutional development varies among developing countries, most of them have built a basic set of institutions such as public bodies to promote STI activities and to protect intellectual property rights and promote competition, as well as national plans for STI. However, public funds and the commitment to implement plans and enforce intellectual property rights and competition are usually limited (Aubert, 2010; Chen and Puttitanun, 2005; Nurse, 2007; Altenburg, 2009).

Sixth, the education system at all levels does not generate enough human resources in terms of both quality and quantity (Aubert, 2010; Segarra-Blasco et al., 2008; World Bank, 2010). STI activities demand highly qualified human resources, particularly in engineering and hard sciences. Universities are oriented to social sciences and administrative programmes, and offer few postgraduate programmes. Primary and secondary education does not obey a clear-cut strategy to strengthen the role of mathematics and basic science. Creativity and innovation are barely included in taught programmes.

Seventh, financial systems in developing countries are not akin to support innovation. New entrepreneurs and existing firms hardly find access to the formal financial sector to finance innovation activities (Segarra-Blasco et al., 2008; Gorodnichenko and Schnitzer, 2011). And a vicious circle takes place: on the one hand, the risk-averse financial sector avoids offering long-term credit for risky innovation projects due to scant incentives to finance a minimally or non-profitable segment (in comparison to more profitable segments such as mortgages and

consumption). On the other, credit demand in this area is minimal because those firms engaged in innovation activities are few. Small- and medium-sized enterprises also find it arduous to meet the financial guarantees that would give them access to long-term credit.

Eight, policymakers must implement STI policies in a socio-economic environment frequently characterized by poverty, health issues, severe income disparities and insecurity. Limited access to health services, education and housing undermines the impact of STI policies. In addition, income and wealth inequality have a negative impact on trust between individuals and organizations, which is a key factor to fostering interactions.

Finally, the coordination among public organizations in designing and implementing STI policies is weak (Hadjimanolis and Dickson, 2001; Aubert, 2010; Lall and Pietrobelli, 2005; Nurse, 2007). Sometimes they even compete among themselves for access to public funds. Ministries and other public agencies tend to elaborate their own strategies, which frequently are not fully integrated and coordinated. This is a barrier to improving the impact of STI policies and fostering an efficient use of scant public resources. Furthermore, there is often a mismatch between the objectives and instruments used for policy (which reflects the underlying rationale) and the specific problems that the system has. The lack of vertical and horizontal coordination is a very critical one. Even when resources are highly scarce, as highlighted in the previous seven points, STI policies can render much better results if they are aligned with other policies to address the specific problems of the system of innovation. The next section will be dedicated to the issue of alignment.

THE CHALLENGE OF DESIGNING STI POLICIES FOR ISS IN DEVELOPING COUNTRIES: AN ISSUE OF ALIGNMENT

Designing and implementing STI policies for ISs in developing countries is fundamentally an issue of alignment as discussed before. On the one hand, policy objectives and instruments need to be tailored to the specific characteristics and needs of the particular IS, including the socio-economic and political environment in which the system is embedded. We call this vertical alignment. On the other hand, different policies need to be coordinated to achieve the desired objectives in terms of capability building and innovation. We call this horizontal alignment. Figure 1 depicts both forms of alignment.

INCLUDE FIGURE 1 ABOUT HERE: "**Figure 1. Horizontal and vertical alignment**"

Vertical alignment: Fine-tuning policies to specific problems of the system[3]

The first form of alignment is that between rationales, objectives, instruments and specific problems of the system.

The first challenge is to align the rationales with the objectives and instruments. Following an IS approach implies the adoption of new rationales that might collide with former rationales. The result is often that policymakers might adopt the SI

[3] This section is substantially based on Chaminade, C., P. Intarakumnerd and K. Sapprasert (2012), 'Measuring systemic problems in National Innovation Systems. An application to Thailand', *Research Policy*, **41** (8): 1476–1488.

approach in their discourse while still using 'market failure' arguments for allocating resources for innovation (Chaminade and Edquist, 2010; Intarakumnerd and Chaminade, 2007). As a result, the most widespread instruments for STI policy are those aiming at reducing the cost of R&D to encourage the exploitation of technological opportunities, while maintaining the same level of capabilities (Metcalfe and Georghiou, 1997). Designing STI policies targeting the IS requires adopting a systemic perspective, tackling the system as a whole, not specific components, and paying special attention to competence building and the linkages that facilitate interactive learning, both STI and DUI (Doing, Using, Interacting) forms of interactive learning (Jensen et al., 2007).

The second grand challenge is to align STI policies (objectives and instruments) with the problems of the IS. In the context previously outlined, it is clear that STI policies need to be very selective. A critical challenge is to decide where to invest the limited resources so as to have the larger impact, giving the socio-economic and political context of a particular developing country. From a theoretical perspective, policymakers should intervene in the IS when there is a problem or a 'failure of the system' (Woolthuis et al., 2005; Chaminade and Edquist, 2006, 2010). The difficulty is that in developing countries, more often than not, ISs are plagued with systemic failures or problems.

So, as we have argued elsewhere (Chaminade et al., 2009) the critical question is not whether the elements and relationships within the system are weak but, taking a dynamic perspective, to investigate which elements are critical for the emergence and development of an IS into a fully-fledged IS over time. Following the World Bank

(2010), it is possible to distinguish between three main ideal types of ISs in developing countries, attending at the general level of technological capabilities:[4]

- Emergent IS, characterized by low levels of technological capabilities
- Fragmented or dual IS, characterized by medium levels of technological capabilities and some pockets of innovation
- Mature ISs, portraying high levels of technological capabilities and competitiveness at the international level

Table 1 summarizes the main characteristics of ISs at different stages of development, particularly highlighting the most common problems as well as STI policies at different stages of development.

INCLUDE TABLE 1 ABOUT HERE: "**Table 1. Contextualizing STI policies to developing countries according to ideal types of ISs**"

Countries with **emerging or nascent ISs** are highly dependent on technology developed abroad. A critical objective for STI policies for emerging ISs is to facilitate the adoption of technology developed abroad and the development of research and technological capabilities. Both critical capabilities and linkages needed at this stage of development are highly related to adopting technology and building competences. Governments in developing countries, but particularly in emergent ISs, suffer from

[4] It is important to highlight that these are *ideal* types which try to describe the common features of a group of developing countries but each country has its own characteristics and idiosyncrasies and, as a consequence, STI policies need to be country specific and based on the detail analysis of their IS. Furthermore, any scheme of this sort can be misleading if it is interpreted in a linear way, as a sequential model with one unique ideal development path. Far from that, adopting an evolutionary perspective implies that each innovation system is unique and there is no single ideal innovation systems type that all countries need to strive for nor one single path of development.

acute financial problems. Effective policies could consist in micro-level reforms such as small-scale programs or projects involving some key actors in the SI (see the example of university-industry linkages in Tanzania in Chaminade et al., 2011; Szogs, 2008), micro-credits and partial reforms of the financial system or other aspects of the business environment (World Bank, 2010). The key aspect here is starting with small-scale projects and prioritizing capability building through education, on-the-job training, vocational training and university training of engineers. Without a certain level of capabilities, all other STI-focused policies are likely to have very limited results (see more examples in the section on horizontal policy coordination). In this respect, international organizations, such as the United Nations Commission for Trade and Development (UNCTAD)or the World Bank, base their STI policy reviews on the identification of one or two critical industries which have a certain potential to leverage technological capabilities like health, agriculture and agroindustry in the Dominican Republic (UNCTAD, 2012), agro processing in El Salvador (UNCTAD, 2011a), traditional herbal and medicine sector in Ghana (UNCTAD, 2011b) or oil and mining in Mauritania (UNCTAD, 2010).

A large proportion of developing countries, usually the large ones, have **fragmented and dual ISs** characterized by two speeds, with some clusters or industries that are highly innovative and capable of technology creation side-by-side with underdeveloped clusters, regions and industries with very low technological capabilities and capable, at most, at technology adaptation. Some of the indigenous firms are born-globals firms that have evolved into large emerging multinationals or large business groups (Gammeltoft, 2008; Santiso, 2008)**.** This makes STI policies very challenging, since general policies targeting capability building or the attraction of technology-related foreign direct investment (FDI) need to be combined with

policies targeted to the specific needs of the most advanced sectors and regions. Policymakers in these countries often suffer from policy fatigue (World Bank, 2010). Both technology adaptation and technology creation are the objective of STI policies in fragmented ISs. Coordination of policies is paramount in all ISs as we will discuss next, but particularly in these fragmented or dual ISs. Effective STI policies in these systems may be cluster and value chain policies, since there is a certain level of technological and scientific capabilities. One of the capability problems that these ISs face is limited soft skills (leadership, management, problem solving) to complement the already existing technical skills. In terms of linkages, one of the most important challenges for STI policies is to establish linkages between the pockets of dynamism and the rest of the system. Relevant linkages are university-industry training and research linkages, clusters and value chains and linkages with international and local users. In fact, user-producer interaction with local users has proved to be a very effective source of innovations[5] (Prahalad, 2005). Furthermore, south-south cooperation between users and producers is more likely to lead to industry innovation than north-north (Harirchi and Chaminade, 2014, forthcoming), probably due to the similar level of technological capabilities of both users and producers, which facilitates interactive learning.

Emerging and fragmented ISs may gradually evolve into **mature ISs**. Mature ISs are usually found in developed countries or embedded in otherwise fragmented ISs, as discussed before. Former developing countries that have well-functioning ISs are the Asian tigers: Hong Kong, Singapore, South Korea and Taiwan. Strictly speaking, these countries can no longer be considered as developing countries but

[5] Well known examples are the low cost electrocardiogram developed by General Electric initially to cater the rural population in India (Immelt et al., 2009), the nano-car developed by Tata (Ray and Ray, 2011) or the nanocomputer.

they were developing countries not so long ago and thus, their experience in upgrading capabilities and developing their ISs into fully-fledged ISs is very valuable here. The main challenge for these SIs is renewal, finding new growth paths and sustaining their technological competitiveness over time. In mature ISs, organizations' interactions are intense and take diverse forms, from sourcing of technology through market mechanisms to research collaboration through formal and informal networks. While in emerging and fragmented ISs the international linkages are predominant in innovation, in mature systems we can observe a more intense use of regional and national linkages, which simply reflects the higher level of technological competences of the organizations in the country and region (Plechero and Chaminade, forthcoming)

It is important to highlight that these are only general and ideal types of ISs. Each system of innovation has particular characteristics and, as a consequence, STI policies need to be based on a specific analysis of the IS and need to be the result of experimentation with different instruments and approaches. What works in a specific country may completely fail in another. STI policies should be designed and implemented ad hoc, taking into account the specificities of the country.

A first attempt in the direction of empirically identifying systemic problems in developing countries was recently made by one of the authors in collaboration with researchers in Thailand (Chaminade et al., 2012). The point of departure was firm-based data collected through the Thai Innovation Survey. The Thai innovation survey follows the definitions and methodologies used by the OECD (1997, 2002). In that respect, the survey is similar to other innovation surveys in Asia (i.e. Singapore, Malaysia, Japan, Taiwan and Korea) and Latin America (Brazil, Mexico, and Argentina, among others). But it also has some distinctive questions on the quality of

the business environment which helps in the identification of some institutional problems.

Due to the cross-sectional nature of the data, it is not possible to identify if there are transition or lock-in problems. The analysis, which is described in detail in Chaminade et al. (2012),[6] identified four problems in the ISs related to institutions, science and technology (S&T) infrastructure, networks and one which was not considered in the existing literature on systemic problems, 'support services'. Capabilities didn't emerge as a critical problem in the Thai IS.

Once that the specific problems have been identified, it is possible to design STI policies that targeted those bottlenecks. An analysis of the STI policies in Thailand revealed a lack of alignment between policies and problems. Most of the problems identified in the SI were at most partially tackled with the existing policy portfolio of instruments. At the same time, a number of policies were aimed at augmenting the S&T capabilities, when that was not considered a problem anymore in the IS by the surveyed firms. Box 1 illustrates the problems of vertical alignment for the Thai case.

Box 1. Vertical alignment of policies in Thailand

Like the four Asian Tigers (Korea, Taiwan, Singapore and Hong Kong), Thailand has gradually moved from an agriculture-based economic structure to one in which the industrial (manufacturing in particular) and service sectors have distinctive significance, while attempting to modify the export structure. However, unlike the Asian NIEs, Thailand has a low performance in terms of research and innovation.

One of the reasons for the relatively low innovative performance of Thailand – compared to the Asian NIEs – is the lack of adequate policies that target the specific weaknesses of its IS (Arnold et al., 2000; Bell, 2002; Intarakumnerd et al., 2002; Intarakumnerd, 2005). For decades, the emphasis was on developing S&T capabilities in the public sector, ignoring almost completely the firms.

[6] Using hierarchical factor analysis on a selection of questions in the survey, systemic problems suggested by prior studies are grouped into four components: institution, network, science and technology infrastructure and other support services. These system components were then linked to a qualitative description of the real situation in Thailand in the discussion of whether there is a mismatch between Thai innovation policy instruments and the systemic problems captured.

This narrow scope of S&T was highly based on the linear model of innovation that put research at the core of the innovation process. Private firms were almost absent from the policy (Bell, 2002) and were regarded at most as 'users' of S&T knowledge mainly produced by government agencies and universities (Arnold, et al., 2000).

In 2001, there was a major shift in the orientation of STI policy. The ten-year Science and Technology Strategic Plan for 2004 to 2013 placed the concepts of a national IS and industrial clusters at its heart (NSTDA, 2004).

Nonetheless, as Intarakumnerd and Chaminade (2007) point out, the innovation policy instruments that were actually put in place more reflected the old STI policy paradigm, since they placed considerable emphasis on research-based activities and much less on innovation in a broader sense, involving capability building and DUI as well as STI forms of interactive learning. The main difference between the new plan and the previous plans is that the latter explicitly targets firms.

The empirical analysis of the innovation survey data (Chaminade et al., 2012) revealed that for non-research-based firms, the main systemic problems relate to the institutional conditions for innovation (including capabilities, hard and soft institutions, networking and support services). However, the current instruments are barely tackling the identified problems.

Source: Chaminade et al., 2012; Intarakumnerd and Chaminade, 2007

In sum, vertical alignment implies tailoring STI policies to specific needs and characteristics of the IS. This implies taking into consideration the stage of development of the system, as discussed in the third section of this chapter, as well as start the policy design from the analysis of the problems in the specific system of innovation. For that, developing countries need to develop a proper system of STI indicators that capture the systemic aspects. While some countries have made an effort in that direction and have (more or less) regular R&D and innovation surveys, others lack even the most basic information like R&D investments or number of researchers (UNCTAD, 2010).[7]

Designing effective STI policies when there is a lack of information of the system is problematic and more efforts should be made in the design of innovation surveys that capture the complexity of innovation in developing countries and that, for

[7] It is important to bear in mind that innovation surveys are potentially good sources of information, but they are limited, since they only target firms.

example, collect information on innovation in agriculture or innovation in the informal sector.

Horizontal alignment

This section discusses the challenges faced by developing countries when coordinating STI policies among different ministries and other public organizations, and among diverse government levels. It also discusses the need to coordinate STI with national development agendas.

First, although there is an increasing recognition among developing countries of the crucial role of STI for long-term economic and social development, quite often national development agendas do not include STI as a central pillar, that is, STI is neither embraced by nor coordinated with other development areas. For instance, although all Central American countries (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama) have elaborated national development plans which include STI policies, only in Costa Rica is STI a key component of the plan and specific strategic lines are comprised (Padilla-Pérez and Gaudin, 2014).

Adopting an IS approach to STI policies implies bringing together a variety of policies that have traditionally been separated (education policy, industrial policy, trade policy, etc.). In this sense, innovation policy can be seen as a policy system itself, integrating traditionally individual and independent policies into a new systemic policy with new rationales, new instruments and new governance bodies (Intarakumnerd, 2007). However, coordination among public organizations for designing and implementing STI policies in developing countries is frequently poor. There is even some competition among them for gaining access to public funds and

international aid. National councils or ministries for STI, ministries of economy and education, as well as ministries that conduct and coordinate STI in specific areas (energy, health, etc.), have their own agendas and budgets. New types of public organizations such as cross-sector and interdisciplinary councils on innovation (Borrás and Lundvall, 2004), cross-ministerial agencies (Dutta et al., 2015) or new and stronger mandates for existing organizations are needed.

As a result of this poor coordination and integration, STI policies are frequently fragmented. Science and technology councils mainly support research on universities and public research centres and offer scholarships for postgraduate studies; ministries of education focus on technical and university-degree education; ministries of economy provide technical assistance and financing for firm-level innovations. These policies are not coordinated and it is common to end up with diverse programmes pursuing similar objectives and targeting the same population. A detailed study of public policies to support small and medium-sized enterprises in Latin America, including diverse programmes for strengthening their technological capabilities, found that there is poor coordination among national public agencies (for instance, ministry of economy, competitiveness councils or institutes, ministries or councils for science and technology, etc.). This results in a lack of synergies and inefficient use of public funds, hindering the impact of such programmes (Ferraro and Stumpo, 2010).

A second challenge comes from the centralization or decentralization of STI policies in, large countries and countries with different government levels. On the one hand, centralizing STI policies (federal or national government) may result in economies of scale and internalization of positive externalities. On the other, centralized policies, that is, policies designed and implemented by federal or national governments, may often reduce the ability to meet local needs, respect diverse

regional (subnational) preferences and adapt to local circumstances (Padilla-Pérez, 2013).

Developing countries, characterized by large income and technological-capability gaps among their subnational regions, face an enormous challenge to foster capability building in technologically backward regions and reduce heterogeneity. The case of Mexico illustrates this challenge. Mexico is a federation with three government levels: federal, state and municipal. State governments collect a limited amount of taxes and most of their revenues come from direct transfers from the federal government, including funds to support STI activities. Federal funds are matched by state financial resources (through a bidding scheme), therefore the states which possess higher capabilities and resources frequently receive more funding for STI activities. This process widens technology gaps between states (Stezano and Padilla-Pérez, 2013).

Third, the economic model and theoretical assumptions behind policymaking significantly shapes the scope and approach of STI policies. For instance, STI policies in Latin America have been characterized by a persistent linearity for the last six decades. During the import substitution phase (from the 1950s to the 1980s) a linear supply model of technology policy prevailed. The public sector played a major role in identifying priorities and directly conducting S&T activities. S&T policies were mainly oriented to the creation of basic infrastructure and to the promotion of human capital formation, based on government priorities (Cimoli et al., 2005). Reduced attention was paid to innovation policies.

The theoretical background of the supply model derived from the assumption that knowledge was a public good and that government and public agencies were natural knowledge providers. Knowledge was supposed to ‘naturally flow’ and

circulate among economic agents once it had been inserted in the economic system by public institutions (Cimoli et al., 2005).

In contrast, STI policies in the 1990s and 2000s were dominated by a linear demand model. It emphasized the role of markets incentives and of demand side in priority setting. The rationale for STI policies was based on correcting market failures. For instance, R&D subsidies did not discriminate among sectors or activities, and were aimed at addressing failures resulting from externalities and public goods. The assumption behind these policies was that knowledge and innovation were the same as information accessibility. The reliance on market mechanisms resulted in neutral and horizontal policies planned to minimize state interference with market behaviour (Cimoli et al., 2005).

This misalignment of objectives, assumptions and instruments is illustrated by the relationship (or lack thereof) between international trade and FDI, on the one hand, and technical change on the other, in Latin America in the past three decades.

One of the common policies pursued by some developing countries in the past three decades has been to open the economy to international trade, in order to facilitate the access to foreign technology and increase local competition. Following a neoclassical, demand-led approach, opening up an economy to international trade creates the demand conditions necessary, and in the most extreme forms of the theory also sufficient, to develop local technological capabilities (Balassa, 1991; World Bank, 1991; Krueger, 1993). This is based on the alleged positive effects that opening up to international trade has on technological capabilities through exports of goods, imports of intermediate and capital goods and FDI. The main assumption is that technology is a free and fully codified good that can be easily diffused and absorbed among countries. According to this approach, exports of goods give access to new and

bigger markets, generating economic incentives for increasing innovative efforts. Additionally, foreign buyers are an important source of new technologies, and exposure to international markets keeps exporters informed of new products (Padilla-Pérez and Martínez-Piva, 2009).

In terms of imports and in order to compete successfully in the domestic and international markets, local firms demand foreign capital goods and intermediate components, which are a source of technical change. FDI also has important positive effects on local capabilities through technology spillovers, which are understood as the positive unintended effects from transnational enterprises to the host economy arising from forward and backward linkages, migration of trained workers, informal collaboration agreements and dissemination of information on foreign markets (Grossman and Helpman, 1991; Blomström and Kokko, 1998).

However, these alleged effects are seldom achieved without active policies aiming at building absorptive capacity in firms, universities and other organizations of the system, as Box 2 illustrates for Latin American countries. Without investments in absorptive capacity, trade and investment policies aiming at introducing competition and facilitating foreign investment and the access to technologies developed abroad are likely to fail to leverage local technological capabilities (Padilla-Pérez and Martínez-Piva, 2009).

Box 2. Horizontal alignment: Technological upgrading through trade liberalization in Latin America

Championed by the Washington Consensus, Latin American countries, in general, implemented far-reaching economic reforms in the 1980s and 1990s. They conducted unilateral trade liberalization processes through international trade tariff reduction; signed bilateral and multilateral free trade agreements, including those under the World Trade Organization (the Multilateral Agreements on Trade in Goods, GATT; the General Agreement on Trade in Services, GATS; the Agreement on Trade-

Related Aspects of Intellectual Property Rights, TRIPS; the Agreement on Trade-Related Investment Measures, TRIM); lifted restrictions on FDI; and simplified import barriers (permits and quotas).
After three decades of economic reforms the results have been satisfactory in terms of export growth, but quite modest in terms of technological capability building. Latin American countries performed well in the last two decades in terms of export growth and FDI attraction, but technological capabilities indicators (both output- and effort-oriented) have not improved.
In the 1980s, 1990s and 2000s, STI policies and industrial policies in general were characterized by a horizontal and passive approach. For instance, R&D tax incentives and public funding of research in universities and research centres were neither focused on specific sectors or technologies nor coordinated with other policies, such as development of endogenous capabilities through FDI attraction. More attention was given to generating a stable macroeconomic framework and simplifying regulations to establish and operate private enterprises.
Therefore, FDI and international trade were seen as substitutes and not as complements of indigenous efforts to develop technological capabilities. Given the weaknesses of domestic local capabilities, foreign sources of technology are crucial. However, demand-led policies did not consider that stronger local efforts must be carried out to develop local capabilities. Since technological learning is a cumulative, dynamic and costly process, foreign technologies cannot be successfully exploited without a local knowledge base.

Source: Padilla-Pérez and Martínez-Piva, 2009

CONCLUSIONS

The concept of IS has been widely disseminated among policymakers of both developed and developing countries. This concept has been a useful and comprehensive tool to identify current weaknesses and strengths to adopt, modify and generate technological knowledge and to design systemic STI policies. Yet, quite frequently in developing countries STI policies have not reached the desired results for diverse reasons: scarce resources allocated to STI policies, limited policy competences, short-term vision, weak commitment from the actors in the system, weak financial and institutional systems, and a lack of policy coordination, among others.

The analysis of STI policies as IS policies in developing countries suggests that developing countries need policies that are comprehensive, evidence based, long term and aligned. The policies need to be comprehensive in the sense that they need to tackle all elements in the system of innovation (actors, linkages and institutional frameworks). Actions in just one of these pillars is often not enough and upgrading is possible only when the three elements are addressed. Policies need to be evidence based, that is, based on the specific needs of the country. This requires efforts in data gathering at the country level but also through international comparisons; –the Global Innovation Index (Dutta et al., 2015) is a good example. To be effective, STI policies require a long-term commitment. Finally, STI policies need to be aligned both horizontally (with broader development goals, with other policies) as well as vertically.

This chapter has discussed how the lack of vertical and horizontal alignment can lead to ineffective STI policies in developing countries, particularly in emergent or fragmented ISs.

STI policies in developing countries have often not been properly aligned with the national development agenda and other economic development policies such as industrial, trade and education policies. If STI policies are not properly aligned and coordinated, the results in terms of capability building are usually poor, as shown in the previous sections of this chapter. Developing countries devote scant resources to STI and misalignment reduces their impact in terms of long-term economic growth.

Vertical alignment means tailoring STI policies to the specific needs and characteristics of the IS. It implies the alignment of objectives, instruments and specific problems of the system. In turn, horizontal alignment implies the coordination of STI policies among different ministries and other public agencies, as

well as their coordination with the overall development agenda. The stage-based approach illustrates the importance of adapting STI policies to the current capabilities and needs of each IS. But it shows also a close association between active and aligned STI policies and the stage of development of ISs. New quantitative and qualitative methodologies to examine the dynamics of technological change, such as those presented in this paper, are offering new inputs for enhancing ISs policies and their impact on economic and social development.

STI policies in developing countries need to be the result of continuous policy experimentation (World Bank, 2010; Chaminade et al., 2009). Since not one single IS is equal to another, STI policies that have worked in one country may completely fail in another. Although robust public organizations are needed for long-term planning and implementation of STI policies, experimenting with new policy instruments, new constellations of actors and new technologies can lead to very successful STI policies which stimulate both science-based and experience-based learning.

REFERENCES

Altenburg, T. (2009), 'Building inclusive innovation systems in developing countries', in B.A. Lundvall, C. Chaminade and J. Vang (eds.), *Handbook of Innovation Systems and Developing Countries*, Cheltenham, UK: Edward Elgar Publishing, pp. 57–96.

Altenburg, T., H. Schmitz and A. Stamm (2008), 'Breakthrough? China's and India's Transition from Production to Innovation', *World Development*, **36** (2), 325-344.

Arnold, E., Bell, M., Bessant, J., & Brimble, P. (2000), *Enhancing Policy and Institutional Support for Industrial Technology Development in Thailand*, Washington: World Bank.

Arora, A. and A. Gambardella (2005), *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland, and Israel,* Oxford: Oxford University Press.

Arora, A. Badge, S. (2006), 'The Indian Software Industry: the Human Capital Story', Paper presented in DRUID, June 18-20 2006, Copenhagen.

Aubert, J. E. (2010), *Promoting innovation in development countries: a conceptual framework*, Washington D.C.: World Bank Institute.

Balaguer, A., Y.-L. Luo, M.-H. Tsai, M.-Y.H. Wu and K. Wang (2008), 'The rise and growth of a policy-driven economy: Taiwan', in C. Edquist and L. Hommen (eds.), *Small Country Innovation Systems: Globalization, Change and Policy in Asia and Europe*, Cheltenham, UK: Edward Elgar Publishing, p. 31.

Balassa, B. (1991), *Economic Policies in the Pacific Area Developing Countries*, New York: New York University Press.

Barnard, H. (2006), Investment from less to more developed countries as a mechanism for capability upgrading in developing country firms, PhD thesis, New Jersey-Newark: Rutgers University.

Barnard, H. (2010), 'Overcoming the liability of foreignness without strong firm capabilities—the value of market-based resources', *Journal of International Management*, **16** (2), 165–176.

Barnard, H. (2011), 'Emerging multinationals benefiting from subsidiaries located in more developed countries: drivers for the sharing of capabilities', *Innovation and Development*, **1** (2), 187–203.

Basant, R. and P. Chandra (2007), 'Role of Educational and R&D Institutions in City Clusters: An Exploratory Study of Bangalore and Pune Regions in India', *World Development*, **35** (6), 1037–1055.

Bell, M. (2002), "Knowledge Resources, Innovation Capabilities and Sustained Competitiveness in Thailand: Transforming Policy Processes", in *Report of the Project Thailand: National Science and Technology Policy Capacity*, Brighton: SPRU Sussex University.

Binz, C., B. Truffer and L. Coenen (2013), 'Systematic anchoring of global innovation processes and new industry formation–the emergence of on-site water recycling in China', Lund University, CIRCLE-Center for Innovation, Research and Competences in the Learning Economy.

Blomström, M. and A. Kokko (1998), "Multinational corporations and spillovers", *Journal of Economic Surveys*, **12** (3), 247-277.

Borrás, S., C. Chaminade and C. Edquist (2009),"The challenges of globalisation: Strategic choices for systems of innovation", in G. Marklund N. Vorontas and C. Wessner (eds.), *The innovation imperative – globalization and national competitiveness,*, Chentelham: Edward Elgar, pp. 7-23.

Brundenius, C., B.-Å. Lundvall and J. Sutz (2009), 'The role of universities in innovation systems in developing countries: developmental university systems–empirical, analytical and normative perspectives', in Lundvall, BA., Joseph, KJ., Chaminade, C., Vang, J. (eds.), *Handbook of innovation systems and developing countries: building domestic capabilities in a global setting*, Chentelhalm: Edward Elgar, pp. 311-335.

Chaminade, C., Lundvall, B.Å., Vang, J., Joseph, K. (2009), "Designing innovation policies for development: towards a systemic experimentation-based approach", in: Lundvall, B.Å., Joseph, K.J., Chaminade, C., Vang, J. (eds.), *Handbook of innovation systems and developing countries: building domestic capabilities in a global setting*, Edward Elgar, p. 360.

Chaminade, C., A. Cunning and A. Szogs (2011), 'Building systems of innovation in less developed countries. The case of Tanzania and El Salvador', *Innovation and Development,*, **1** (2), 283–302.

Chaminade, C. and C. Edquist (2006), 'From theory to practice. The use of the systems of innovation approach in innovation policy', in J. Hage and de Meeus (eds.), *Innovation, Learning and Institutions*, Oxford University Press. 141-160

Chaminade, C. and C. Edquist (2010), 'Rationales for public policy intervention in the innovation process: A systems of innovation approach', in S. Kulhman, P.

Shapira and R. Smits (eds.), *The theory and practice of innovation policy: an international handbook*, Cheltenham, UK: Edward Elgar Publishing, 95-114

Chaminade, C., P. Intarakumnerd and K. Sapprasert (2012), 'Measuring systemic problems in National Innovation Systems. An application to Thailand', *Research Policy*, **41** (8), 1476–1488.

Chaminade, C. and J. Vang (2008a), 'Globalisation of knowledge production and regional innovation policy: Supporting specialized hubs in the Bangalore software industry', *Research Policy*, **37** (10), 1684–1696.

Chaminade, C. and J. Vang (2008b), 'Upgrading in Asian clusters: Rethinking the importance of interactive-learning ', *Science, Technology and Society*, **13** (1), 61–94.

Chen, Y. and T. Puttitanun (2005), "Intellectual property rights and innovation in developing countries", *Journal of Development Economics*, **78**, 474–493.

Cimoli, M., Ferraz, J.C., Primi, A. (2005),"Science and Technology Policies in Open Economies: The Case of Latin America and the Caribbean", *Productive Development Series*, 165, ECLAC, Santiago de Chile: United Nations.

Crescenzi, R., A. Rodríguez-Pose and M. Storper (2012), 'The territorial dynamics of innovation in China and India', *Journal of Economic Geography*, **12** (5): 1055–1085.

D'costa, A.P. (2006), 'Exports, University-Industry Linkages, and Innovation Challenges in Bangalore, India', *World Bank Policy Research Working Paper 3887, April 2006*.

Dutta, S., Lanvin, B. and Wunsch-Vincent, S. (eds.) (2015), *The Global Innovation Index 2015. Effective innovation policies for development*, Fontainebleau, Ithaca and Geneva: WIPO.

Economic Commission for Latin America and the Caribbean and Organization for Economic Co-operation and Development (ECLAC/OECD) (2012), *Latin American Economic Outlook. Transforming the State for Development*, Santiago de Chile/Paris.

Edquist, C. (ed.) (1997), *Systems of innovation: Technologies, institutions and organizations*, London: Pinter.

Edquist, C. and L. Hommen (2008), *Small Country Innovation Systems Globalization, Change and Policy in Asia and Europe*, Cheltenham, UK: Edward Elgar Publishing.

Ferraro, Carlo and Giovanni Stumpo (2010), *Políticas de apoyo a las pymes en América Latina*, ECLAC, Santiago de Chile: United Nations.

Freeman, C. (1987), *Technology policy and economic performance: Lessons from Japan*, London: Pinter.

Immelt, Jeffrey R., Govindarajan, Vijay, & Trimble, Chris. (2009), "How GE is disrupting itself", *Harvard Business Review*, 87(10), 56-65.

Intarakumnerd, P. (2005), 'Government Mediation and Transformation of Thailand's National Innovation System', *Science, Technology & Society*, **10** (1).

Intarakumnerd, P., P. Chairatana and T. Tangchitpiboon (2002), 'National innovation system in less successful developing countries: the case of Thailand', *Research Policy*, **31** (8-9): 1445-1457.

Lundvall, B.-A. (ed.) (1992), *National systems of innovation. Towards a theory of innovation and interactive learning*, London: Pinter.

Gammeltoft, P. (2008), 'Emerging multinationals: outward FDI from the BRICS countries', *International Journal of Technology and Globalisation*, **4** (1), 5-22..

Grossman, G.M. and E. Helpman (1991), *Innovation and Growth in the Global Economy*, Cambridge: The MIT Press.

Gorodnichenko, Y. and M.,Schnitzer (2011), "Financial constraints and innovation: Why poor countries don't catch up", *NBER Working paper*, National Bureau of Economic Research: United States.

Hadjimanolis, A. and K. Dickson (2001), "Development of national innovation policy in small developing countries: the case of Cyprus", *Research Policy*, **30**, 805-817.

Harirchi, G. and C. Chaminade (2014), 'User-producer interaction and the degree of novelty of inovations: a global perspective', *World Development*, **57**: 19–31.

Harirchi, G. and C. Chaminade (forthcoming), 'User-producer interaction and the degree of novelty of inovations: a global perspective', *World Development*.

Intarakumnerd, P. and C. Chaminade (2007), 'Strategy versus Practice in Innovation Systems Policy: the Case of Thailand', *Asian Journal of Technology Innovation*, **15** (2), (PAGES).

Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.A., 2007. "Forms of knowledge and modes of innovation". *Research Policy* 36, 680-693.

Kapur, D. (2002), 'The Causes and Consequences of India's IT Boom', *India Review*, **1** (2), 91–110.

Krueger, A. (1993), "East Asia: Lessons for growth theory", Paper presented at the Fourth Annual East Asian Seminar on Economics, National Bureau of Economic Research: United States.

Lall, S. and C., Pietrobelli (2005). "National technology systems in Sub-Saharan Africa", *International Journal of Technology and Globalisation*, **1**, 311-342.

Lim, C. (2008), 'Towards knowledge generation with bipolarized NSI: Korea', in C. Edquist and L. Hommen (eds.), *Edquist, C.; Hommen, L. Small Country Innovation Systems*, Cheltenham, UK: Edward Elgar Publishing, pp. 113–155.

Lundvall, B.-A. and S. Borrás (2004) "Science, technology and innovation policy", in J. Fagerberg, D. Mowery and R. Nelson eds., *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, pp. 599-631.

Lundvall, B.-A., P. Intarakumnerd and J. Vang (2006), *Asian innovation systems in transition*, Cheltenham, UK: Edward Elgar Publishing.

Lundvall, Bengt-Åke, K. J. Joseph and Cristina Chaminade (2009), *Handbook of innovation systems and developing countries: building domestic capabilities in a global setting*, Cheltenham, UK: Edward Elgar Publishing.

Mcmahon, D. and H. Thorsteinsdóttir (2013), 'Pursuing endogenous high-tech innovation in developing countries: A look at regenerative medicine innovation in Brazil, China and India', *Research Policy*, **42** (4), 965–974.

Metcalfe, J.S. and L. Georghiou (1997), *Equilibrium and evolutionary foundations of technology policy*, Manchester, UK: University of Manchester, Centre for Research on Innovation and Competition.

National Science and Technology Policy Committee (2004) (NSTDA), *Science and Technology Strategic Plan 2004-2013*, Bangkok: National Science and Technology Development Agency (NSTDA).

Nelson, R. ed. (1993), *National innovation systems. A comparative analysis*, New York: Oxford University Press.

Nooteboom, B. (2000), "Learning by interaction: Absorptive capacity, cognitive distance and governance", *Journal of Management and Governance*, **4**, 69-92.

North, D.C. (1990), *Institutions, institutional change and economic performance*, Cambridge: Cambridge University Press.

Nurse, K (2007), "Science, Technology and Innovation in the Caribbean", UNCTAD, presented at Technology Policy and Development in Latin America ECLAC, Santiago, Chile, December.

OECD (1997), 'Oslo Manual (Second edition)', OECD: Paris, p. 91.

OECD (2002), 'OSLO Manual. The measurement of scientific and technological activities. Proposed guidelines for collecting and interpreting technological innovation data', OECD: Paris.

Padilla-Pérez, R. and J.M. Martínez-Piva (2009), 'Export growth, foreign direct investment and technological capability building under the maquila model: winding roads, few intersections', *Science and Public Policy*, **36** (4), 301–315.

Padilla-Pérez, R. ed. (2013), *Sistemas de innovación en Centroamérica. Fortalecimiento a través de la integración regional*, Libro de la CEPAL, no. 118, Santiago de Chile: CEPAL, United Nations.

Padilla-Pérez, R. and Y. Gaudin (2014), "Science, technology and innovation policies in small and developing economies: the case of Central America", *Research Policy*, **43**, 749-759.

Parthasarathy, B. and Y. Aoyama (2006), 'From software services to R&D services: Local entrepreneurship in the software industry in Bangalore, India', *Environment and Planning A*, **38**, 1269–1285.

Plechero, M., Chaminade, C. (Forthcoming) 'The role of regional sectoral specialization on the geography of innovation networks: a comparison between firms located in regions in developed and emerging economies', *International Journal of Technological Learning, Innovation and Development.*

Prahalad, C. (2005), *The fortune at the bottom of the pyramid: Erradicating poverty through profits: enabling dignity and choice through markets*, Upper Saddle River, NJ: Wharton School Publishing.

Ray, S., & Ray, P. K. (2011), 'Product innovation for the people's car in an emerging economy'. *Technovation*, **31** (5–6), 216–227.

Santiso, J. (2008), 'The emergence of Latin multinationals' , Munich Personal Repec archive, MPRA Paper No. 12904, Online at http://mpra.ub.uni-muenchen.de/12904/

Saxenian, A.L. (2001), 'Bangalore: The Silicon Valley of Asia?', *Working Paper*, Center for Research on Economic Development and Policy Reform, Tanford, 32.

Segarra-Blasco, A., J. García-Quevedo, M. Teruel-Carrizosa (2008), "Barriers to innovation and public policy in Catalonia", *International Entrepreneurship and Management Journal*, **4**, 431-451.

Sharif, N. and E. Baark (2008), 'From trade hub to innovation hub: Hong Kong', in C. Edquist and L. Hommen (eds.), *Small Country Innovation Systems: Globalization, Change and Policy in Asia and Europe*, Cheltenham: Edward Elgar, p. 194.

Stezano, F. and R. Padilla-Pérez (2013), "Governance and coordination between federal and state-level innovation and competitiveness policies in Mexico, Inter-American Development Bank (IADB), Technical Note 512, Washington.

Szogs, A. (2008), 'The role of mediator organisations in the making of innovation systems in least developed countries: evidence from Tanzania', *International Journal of Technology and Globalisation*, **4** (3), 223–237.

UNCTAD (2006), 'A Case Study of the Salmon Industry in Chile', UNCTAD Series on Transfer of Technology for Successful Integration into the Global Economy. New York and Geneva: United Nations

UNCTAD (2010), *Science, Technology and Innovation Policy Review - Mauritania*, New York and Geneva: United Nations.

UNCTAD (2011a), *Science, Technology and Innovation Policy Review - El Salvador*, New York and Geneva: United Nations.

UNCTAD (2011b), *Science, Technology and Innovation Policy Review - Ghana*, New York and Geneva: United Nations.

UNCTAD (2012), *Science, Technology and Innovation Policy Review - Dominican Republic*, New York and Geneva: United Nations.

Wamae, W. (2006), *A Survey of Innovation Policies in Developing Countries: Lessons and Case Studies*, Canada: IDRC.

World Bank (2010), *Innovation Policy, A Guide for Developing Countries*, Washington D.C., United States.

Wong, P.K. and A. Singh (2008), 'From technology adopter to innovator: Singapore', in C. Edquist and L. Hommen (eds.), *Small Country Innovation Systems: Globalization, Change and Policy in Asia and Europe*, Cheltenham: Edward Elgar Publishing, pp. 71–112.

Woolthuis, R.K., M. Lankhuizen and V. Gilsing (2005), 'A system failure framework for innovation policy design', *Technovation*, **25**: 609–619.

World Bank (1991), *World Development Report 1991*, New York.