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Technology Foresight and Industrial Strategy in Developing Countries *

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Abstract

When Technology Foresight (TF) began to be adopted in industrial countries, it tended to be still somewhat a marginal activity in developing countries. It was then believed that TF and its prediction of the future was a matter that only highly industrialised countries could endeavour to achieve, being more engaged and interested in frontier and "new to the world" innovation.

Today globalisation, increased complexity, competition and fast technical change, have radically transformed the range of economic activities that developing countries can perform. Production is internationally fragmented and organised along global value chains. Dense flows of knowledge and technology are available, but need to be fully exploited and employed within coherent industrial strategies. A specialisation by technology and learning has become the dominant paradigm and developing countries must detect opportunities for future technological and productive specialisation in order to catch up and forge ahead. Yet, often TF exercises do not go hand in hand with the design of a concrete policy strategy to promote emerging countries' productive development and catching up.

This paper analyses how and to what extent TF programmes are needed in developing countries given the new prevailing global context. It argues that the link between TF and broader industrial development strategy needs to be taken seriously in light of its role to shape technological change and economic growth, and that TF and industrial development strategy need to be coherently designed and implemented. We provide preliminary support to this argument by discussing the theoretical foundations of TF and industrial strategy and their justification, and then reviewing some relevant examples from Brazil, Chile and South Korea.

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Key words: Technological Change, Science Technology and Innovation Policy, Industrial Policy, Technology Foresight, Catch-up, Global Value Chains, Innovation Councils, Brazil, Chile, South Korea.

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Introduction

Technology Foresight (TF hereafter) represents a systematic exercise aimed at looking into the longer-term future of science technology and innovation (S&T) in order to make better informed policy decisions (Irvine and Martin, 1984). Since its early inception, pioneered in Japan, TF has tried to help societies and economies to define strategic areas where the future of science and technology would lead.

During the last few decades the practice of TF diffused through a wide range of developed countries as well as regions, large companies and other organisations. A growing number of developing countries have undertaken TF exercises too. But to what extent does TF really reflect their different condition of countries trying to catch up with more advanced countries? In what ways can TF contribute to the creation of a joint vision of the future where the institutional framework of the innovation system is often lacking and immature?

Given their scarcity of resources and their lower levels of technological development, developing countries are facing remarkable constraints to catch up with developed countries. Industrial and technology strategies are of crucial importance to this aim, and they need to be consistent with and help strengthen the National Innovation System (NIS). Consistently, TF needs to go beyond a pure speculation of where the future will lead and instead foster large-scale efforts involving all relevant stakeholders and induce the alignment of their interests towards the common agreed vision of the future.

This paper addresses this central question and analyses to what extent TF exercises are coherent and essential parts of wider industrial strategies in developing countries. In order to explore this issue we first review and discuss the theory and then analyse three examples from three countries. First we analyse the case of a now-developed country, South Korea, where clever industrial policies combined with a "foresighted" national vision clearly contributed to achieve a well-defined and unprecedentedly fast economic growth. In the second, we analyse the case of a developing economy, Brazil, where the link between industrial strategies and TF exercises though being less pronounced than in Korea, is demonstrating the country's ability to fully understand the new dynamics of Global Value Chains (GVC) and their implications for industrial development strategy. The example we analyse comes from the electronics sector, where the Brazilian government led a successful negotiation with a leading microelectronic contract manufacturer (Foxconn) that established some of its subsidiaries in Brazil in exchange for the Government requirement of investing 4% of all future sales in local R&D. Finally we study a specific experience of institutional development in Chile that set up a framework that would appear to favour the coherence and close connection between industrial strategy and TF. The creation of the National Council for Innovation and Competitiveness (CNIC) helps to bridge industrial and innovation strategies with a long-term perspective and as such has the potential to act as a key foresight actor within the Chilean NIS and remedy the time inconsistency that typically emerges with these policies.

1. What is Technology Foresight?

An essential fact characterising today's economic development is the speed of technological change which brought about unprecedented levels of productivity growth (Baumol, 1986). Such speed rose quite remarkably since the beginning of the nineteenth century throughout the three industrial revolutions, where the key technologies involved were machinery steam power, electricity and ICT, respectively. As a consequence, industrial and trade structures are continuously being reshaped towards more complex sets of activities, that more recently often follow a logic of vertical and horizontal fragmentation within global value chains (GVCs), with room for outsourcing by multinational companies (MNCs) and foreign buyers that drive the process and ensure its internal coherence (Baldwin, 2011, Cattaneo et al., 2013, Gereffi, 1999). Inter-firm competition is thereby increased, and a specialisation by technology is becoming a dominant paradigm within this new international organisation of production (Lall, 2004).

This opens up a new window of opportunities in terms of strategic investments and public policies that countries may follow to move closer to the technological frontier. Yet governments come to terms with the fact that in order to dominate a specific market segment, to reduce uncertainty and to cope with complexity, a multiple-actors/sectors perspective is of critical importance.

TF represents the concrete effort to overcome this emerging complexity since it systematically embodies a set of programmes to study innovation plans and priorities to foresee, shape and direct potential future orientation of technological change (Martin, 1995). Its essential feature stems from the active involvement of a variety of actors such as government, science, industry and civil society that gather together in order to define a joint vision of the future (Miles, 2010). The rationale behind these “exercises” is to generate positive sum games whose outcomes are expected to be more effective in terms of technological advancement, but also more sustainable in terms of socio-economic benefit than those of isolated initiatives taken by each actor.

Relevant literature refers to TF as to an exercise encompassing a wide range of activities, including: anticipation, forecasting, systematic looking ahead, forward looking activities, strategic intelligence, futures research and prognostic among others (Miles, 2010). The pioneering country in TF was Japan that in the 1970s used to call its national technology planning studies “forecast activity” despite the fact that what it was actually performing was “technology foresight” and perhaps in one of the most refined manners (Miles, 2010). It was later in middle ‘80s thanks to Irvine and Martin (1984) seminal work, inspired by the long Japanese tradition in S&T and TF,[1] that we now call these “forecasting” activities “foresight”. The difference is not trivial. On the one hand, forecasting activities, which are typically performed by closed-circles of experts, provide a mere prediction of future contingencies founded on deterministic precision. Their outcome reflects a specific vision of the world, with a single point of view. On the other hand, TF embraces a broader view of the world that is synergistically integrated with policy strategy. Its outcome sketches insights for forward looking S&T policies. The two distinctive characteristics of foresight as opposed to forecasting are: the importance of learning processes (van Dijk, 1991) and the dialogue among different disciplines and actors (Elzinga, 1983). In this way future is not merely “predicted” but rather “shaped and created” throughout a joint vision (Miles, 2010).

Irvine and Martin’s (1984) seminal work did not only provide the definition and understanding of TF as we conceive it today, but also led to a proliferation of TF exercises

[1] TF in Japan has taken place every 5 years since 1971. It ultimately eased the country’s transition from being a technology imitator to a technology leader (Irvine and Martin, 1984).

around the world. More specifically, right after Japan, France started to perform foresight exercises during the 1980s, followed, later that decade, by Sweden, Australia and Canada (UNIDO, 2005). However, it was during the 1990s that TF gained momentum, expanding also within the UK, the US, the Netherlands and Germany: if one country engaged in foresight activity, others decided to pursue the same exercises too in order to remain competitive (UNIDO, 2005). TF in fact was appreciated as a valuable tool to provide fast, market-oriented and forward-looking innovation policies agreed by the government and the private sector. Recently, foresight has also spread to developing countries. The narrow association that cutting edge technology productions are only a concern to industrialised countries has gradually been surpassed, and the literature has often used the language of "leap-frogging" (Perez, 1983). In developing countries TF has been envisaged as a strategic tool to narrow down their competitive gap with developed countries (DC) (see section 3).

From our perspective the most distinctive features of TF are the following:

1) In its attempt to predict the future, TF has the potential to influence technology direction and hence to "make the future happen" (Miles, 2010). In fact, by fostering a participatory approach and boasting a strong legitimacy which helps building consensus, TF increases awareness, accountability, transparency, predictability and the sense of ownership of future technological developments (Elzinga, 1983);
2) By incentivising the active participation of new actors in the strategic debate on S&T policies, it can expand the range of possible strategies beyond the narrow interests of single individuals. For instance TF can significantly facilitate the strategic decision faced by stakeholders to "make or buy" new technologies considering the local knowledge endowments and organisation (Lall, 2004); moreover it can also ensure consensus and balanced representation of stakeholders' interests.
3) TF can be pursued at various levels: organisational, local, regional, national or supranational.[2] All these levels of foresight aim to manage both demographic and socio-economic heterogeneity faced by actors involved in the analysis.
4) For its effort to try to link and reorient science and innovation on a national and regional scale, TF is inherently linked with the NIS and the related literature. TF, in fact, seeks to foster economic impact by "wiring up" the network between industries, university, governmental bodies as well as the society at large (*e.g.* ageing societies, education and training) (Martin and Johnston, 1999, Andersen and Andersen, 2014).

A number of obstacles may rise during the implementation of S&T policies, and these are usually targeted throughout the TF exercise. These obstacles are frequently related to

[2] Examples may include:

- At the organisational/business level, British Petroleum during the 1990s carried out technology road mapping activities used to devise R&D strategy to direct the core business are of the company;
- At the local level, the Competence foresight in local government services in Finland that aims at developing and piloting in regional networks a competence foresight framework that can be used at a municipal and regional level from 2011 to 2014;
- At the regional level, the Analysis of Application Areas and Technologies, in Lombardy (Italy) implemented during late 2000s which was designed in order to strengthen public procurement for regional innovation;
- At the national level, the five-year S&T Foresight in Japan started in 2010, promoted by the National Institute for Science and Technology Policy (NISTEP); and
- At the supranational level, the OECD International Futures Program and the five-round Delphi exercise in Latin America based on the 2005–07 Latin American and Caribbean Action Plan for the Information Society.

"failures" intrinsic to innovation activities as well as to the direct consequence of globalisation. These include:

- Coordination failures among NIS stakeholders that often have different views on the importance of S&T. The balancing of such interests is crucial to wipe out rent-seeking behaviours and bounded rationality. From a policy perspective it directs and manages vertical and horizontal S&T policies (Schlosstein and Park, 2006);
- Communication failures, especially when different actors from distinct disciplines (*i.e*. specialised in different subject-languages and forms of communication) put forward diverging interests and are convened together in order to define a common strategy. Even within the same disciplines introspective analytical capacity can be compromised by the lack of communication skills;
- Market failures, since usually S&T programmes require a long-term investment that should be weighed against the possibility of temporary short-term losses. Understanding emerging generic technologies (that are the main content of TF exercises) in a more complex and competitive setting requires both tangible and intangible investments that often the private sector cannot afford; and
- Political failures since governments too should adopt a long-term perspective on innovation which might not coincide with the political perspective of maximising consensus in the short-term for the upcoming election. A short-term view is in fact often exacerbated by the discrepancy between the short-run political interests and long-term socio-economic payoff of innovative processes (also called "time inconsistency").

1.2. How is TF carried out?

The first important step to carry out a TF exercise is to define its *scoping*, *i.e.* the definition of the *strategic bet* that the TF activity aims to target, the actors that should be involved, the most suitable methodologies. "Where are we now and what do we want to reach? How do we plan to do it?" are typical questions asked during this initial phase. For this purpose it is necessary to gather relevant background information. The definition of a common goal is often performed by key experts, prospective sponsors and foresight leader consultants. The outcome of the scoping is then spread either publicly or among a set of key stakeholders or sponsors. National level foresight exercises usually take place in science ministries or academies of science and their financing comes from both public and private sectors (UNIDO, 2005). Their time horizon varies from 5 to more than 20 years (Miles, 2010).

Typically TF takes place through a wide range of methodologies whose scope is to find a good approximation of the future in relation to a particular field.[3] Such methodologies can be grouped into three categories, namely:

1. **Qualitative** methods which include processes of creative thinking that are difficult to be represented by indicators, like:
    - ***Expert panel*** that is commonly used and tries to elicit experts' knowledge about the future of a given topic; it provides an ideal platform to foster a creative approach through in-depth discussion.

[3] Ciarli et al., 2013 for a comprehensive review.

- ***Strengths, weaknesses, opportunities and threats analysis (SWOT)*** which is useful for identifying emerging issues by representing experts' view throughout the development of a strategic plan. Possible strategies should be gauged in a way that can maximise their strengths and opportunities while minimising their threats and weaknesses.

2. **Quantitative** methods which are based on numerical representation and indicators of possible developments such as:

   - ***Modelling and simulations*** are extrapolative approaches used to stylise a complex system in order to understand the relations and feedback underlying a given result.
   - ***Webometrics***, which use the information available on the web as an indicator of future technological development and as such it is extrapolative.
   - **Google correlate** that allows examining the correlation between different queries, or between real data and queries (*i.e.* sales of Apple computers with the search of apple in the queries) which is also extrapolative by nature.
   - ***Prediction markets***, a technique using price mechanism in order to signal how likely a future event is to happen.

3. **Semi-quantitative** methods that apply quantitative tools to systematise experts' opinions and can include:

   - ***Delphi method*** is a popular explorative technique involving the active communication and interrelation among different stakeholders. It is adopted to explore new scenarios and to forecast performance of given variables within the system. The final aim is to obtain a consensus of opinions of a group of experts by various rounds of questionnaires. After each round an anonymous summary of experts' opinion is provided. Round after round the range of possible answers will diminish and the group will eventually extrapolate the "correct" answer. This technique can be combined with quantitative methods such as prediction markets.
   - ***Scenarios*** embody a vision of the future state(s). They can be carried out through a number of techniques like for example workshops and simulations.
   - ***Technology road-mapping*** are used to prioritise by matching short-term with long-term goals with specific technology solutions that should help to meet those goals.

Each TF exercise can blend one or more of these categories reflecting its multifaceted nature.

2. How Is Technology Foresight Related to Industrial Strategy?

Nowadays globalisation, increased complexity of manufacturing and services, stronger competition and faster technical change, have radically transformed the range of economic activities that developing countries can perform. Production is internationally fragmented and organised along GVCs. Dense flows of knowledge and technology are available, but need to be fully exploited and employed within coherent industrial strategies. A specialisation by technology and learning is becoming the dominant paradigm and developing countries need to detect opportunities for future technological and productive specialisation in order to catch up and forge ahead.

Therefore individual isolated responses cannot be sufficient to address these complexities and guarantee that countries develop and catch-up. The complexities and interdependencies impose to devise and follow an appropriate "strategy" to orchestrate responses from the Government as well as from the private sector and from research organisations (Lall, 2004). However, often TF exercises do not go hand in hand with the concrete identification and design of a policy strategy to promote catch up.

The central argument we develop in this paper is that TF exercises need to be consistent with the broader industrial development strategy. In the following section we briefly describe how the concept of industrial strategy has evolved over time, and how it needs to take into account the more recent changes to the international organisation of industry, the emergence of GVCs and the role of innovation.

2.1. Different Conceptions on Industrial Policies

Industrial policies have been the object of vivid debates expressing radically diverging views both in the literature and political arena. Nowadays however there are signs that a more shared pragmatic approach to the issue is arising (Crespi *et al.*, 2014).

Traditionally, the neoliberal approach maintains that the best policy for all countries and in all situations is to liberalise as free markets dynamics will let countries realise their comparative advantage. This will ultimately be conducive to the best use of available resources. The underlying assumption behind this rationale is that products' markets provide the correct signals for investments and actors respond to these signals accordingly. Under this framework, governments' principal and only duty would be to provide a stable macro-economic environment with clear rules of the game and the provision of essential public goods. Any further intervention is not required and would distort the already optimal allocation of resources, and would ensure the best conditions for economic growth. The weakest aspect of this approach is that it largely overlooks the existence of widespread market failures (Stiglitz, 1989), that are especially pronounced in the field of knowledge and innovation, and that in turn have a central influence on the long-term growth of productivity and income (Hall and Jones, 1999, Griliches, 1979).

In stark contrast, the literature on technological capabilities maintains that technological change is central to emerging countries' economic development, has a fundamental micro-economic dimension, but it is powerfully hindered by market failures.[4] According to this approach, countries' industrial success is largely due to their capacity to adopt and master existing technologies, even if not being themselves at the technological frontier (Nelson and Winter, 1982). Not only knowledge creation, but also the knowledge adoption process is not straightforward and it is often characterised by market failures. Technology is not freely available and cannot be absorbed without costs or risks. Conscious and purposive efforts to invest in learning and building technological capabilities are essential for firms (Lall, 1992, Pietrobelli and Battisti, 2000), and the learning process varies depending on the technology (Lall, 2004:12).

[4] Bell and Pavitt, 1993, Katz, 1984, Lall, 1992, 1996, 2001, Westphal, 2002.

The technological capability framework offers government a platform that indeed justifies policy action in a functional and selective manner. Selectivity is important, since the cost of offering uniform support to all industrial sectors would be too high and probably not effective since the learning processes differ by technology (Lall, 2004). Some activities require minimal protection and support if the learning period is relatively brief and the information is easily accessible. Conversely, in more complex activities characterised by high entry costs and complex externalities, newcomers might never enter unless specific policies are implemented to foster entry.

However, the existence of market failures does not alone establish a case for intervention: interventions are costly and risky and a careful assessment of costs and benefits and long-term impacts is required. Moreover the institutions needed to support their market functioning and remedy market failures, particularly in developing countries, tend to be weak and often affected by failures (Lall, 2004). In spite of these weaknesses however governments and public institutions can learn and improve their capacity to design and implement effective policies (Morris 2010), and governments should strive to adopt policies that best match capabilities and institutions, rather than best policies in abstract (Crespi et al., 2014).

In this policy learning and capacity development process a public and private collaboration is strongly required. In fact, effective policies necessitate partnerships and relational independence between government and the private sector and an institutionalised learning process between these two (Rodrik 2007; Morris 2010). Industrial policy is a discovery as well as a strategic collaboration process permeated with interaction between government and firms involving mutual learning and experimentation (Rodrik, 2004, Kaplinsky and Morris, 2008, Sabel and Zeitlin, 2011).

In the next section we briefly review how industrial policies worked in the extraordinary success of some East Asian economies to foster unprecedented growth rates together with structural change and diversification, and how these policies are changing in light of the emergence of GVCs.

2.1. Lessons from the East-Asian "Tigers"

The experience of the East-Asian "Tigers" (i.e. Hong Kong, Singapore, Taiwan and South Korea) offers a solid example of how an active industrial strategy promoted fast industrialisation and technological development.[5] Even though the Asian Tigers are far from having followed the same development model, some major common features of their industrial policies can be identified (Lall, 1996).

First of all, their industrial strategy has been both horizontal and selective, with the exception of Hong Kong: selective and horizontal policies have been used interchangeably and simultaneously in each country. For example all countries have been investing to create

[5] The neoclassical initial interpretation of the unprecedented fast development of East Asiatic tigers suggested that free trade dynamics and intense factor accumulation were the key determinants of growth (World Bank, 1993). This argument was then subjected to strong criticism by authors such as Amsden (1989), Lall (1992), Pack and Westphal (1986) and Westphal (1982 and 1990) who argued that the most successful Asian industrialisers had been radically interventionists in FDI, trade, technology transfer, and identified a clear causal relationship between the excellent economic performance and the national policies implemented in these countries (Lall, 2004).

advanced human technical skills, whilst also selectively supporting some sectors with innovation and export subsidies and protection of the domestic market from imports and FDI. Secondly, the capability development that they pursued actively took place within a long time frame. For example South Korea deliberately chose not to allow FDI inflows unless they became necessary to access a new technology. Thirdly, industrial policies proved to enhance technological deepening, when both South Korea and Taiwan favoured indigenous companies over foreign ones in order to increase the generation of local capabilities.

Importantly, FDI has been used differently by each country. The countries wanting to promote local capabilities development restricted foreign entry and directed their activities to exploit spillover effects (South Korea and Taiwan). Conversely, those countries relying on MNCs to promote technology development targeted foreign investors to persuade them to engage in more complex and technology-intensive functions (Hong Kong and Singapore).

The success of these policies may be explained by some significant principles guiding their implementation. Thus, East Asian tigers have been constantly selecting and targeting those activities offering better opportunities for learning, technological benefits and linkages. The importance attributed to fostering learning (Lall, 1987, Lall and Pietrobelli, 2002) implied massive investment in skill creation through education and infrastructures. Learning also extended to strategy formulation and implementation in order to discover the lessons from past mistakes and improve upon them (Amsden, 1989). Such policy learning and flexibility in the strategic decision-making also persistently foresaw the involvement of the private sector (Lall and Teubal, 1998).

Finally, the lead role of private enterprises has been systematically endorsed, but also using public institutions to fill in gaps in unusually risky areas. Exports have been constantly used as a discipline to force early entry in the world markets.

2.2. The Role of Industrial Policies is Changing with the Emergence of GVCs

During the last twenty years, the twin forces of technology and globalisation have drastically reshaped the competitive setting where many firms can find it more convenient to delocalise parts of their production in different places in order to pursue the most efficient production strategy. This geographic fragmentation of industries, where value is added in multiple countries, has come together with vast improvements in the functional integration of these activities, creating what is currently known as Global Value Chains (GVCs). Today it is difficult to imagine a production that is entirely carried out in just one country (Gereffi and Sturgeon, 2013, Milberg and Winkler, 2013).[6]

These developments pose remarkable challenges as well as opportunities for developing countries' firms and governments. A large body of evidence indicates that despite the potential presence of certain barriers in some markets and value chains, the interaction between global actors and local suppliers can be a conduit of knowledge and learning experiences that foster processes of learning and capability acquisition, and spill over to other firms not engaged in the same value chain. This, however, does not suggest that an initial contact between a local supplier and a global buyer is enough. For instance, a

[6] In 2009 world export of intermediate goods surpassed that of the combined export values of capital and final goods (WTO and IDE-JETRO, 2011:81).

minimum of previous accumulation of skills is typically required for a supplier to engage in contract manufacturing with a global buyer (Humphrey, 2004; Morrison, et al., 2008) and there are certainly cases in which existing contracts were terminated because the supplier was not capable to increase its capabilities to what was initially expected. Moreover, the learning and upgrading *via* integration in GVCs is remarkably influenced by the characteristics and effectiveness of the local innovation and business support system (Pietrobelli and Rabellotti, 2011). Therefore various countries have developed different programmes targeted at local firms to support their efforts to become suppliers of global firms. Within this new setting the case for industrial policy got elevated to a great prominence (Gereffi and Sturgeon, 2013; Pietrobelli and Staritz, 2013). The point is not only to find the country's competitive advantage, but also to tailor it to the requirements of these GVCs.

In the effort to define policies and programmes coherent with GVC organisation and requirements, careful consideration of the systemic nature of GVCs is needed. The challenge is remarkable and requires significant capabilities to design and coordinate policies that belong to different but complementary domains. In this regard, an explicit account of the local innovation system (IS) and its interaction with GVCs is necessary (Morrison et al. 2008; Pietrobelli and Rabellotti 2011, 2012). Indeed, the relationship between IS and GVCs is clearly two-way, as GVCs and in particular lead firms may support firm learning and innovation as well as improve local IS (Morrison *et al*. 2008) but may also block them, and the IS also crucially influences the capabilities of local firms and thereby the performance and functions of local firms in GVCs. Technological efforts and absorption capabilities of local firms and public support may in turn raise the interest of lead firms to support upgrading processes, locate higher value activities and source higher value products locally (Pietrobelli and Rabellotti, 2011).[7]

What is the economic rationale for value chain-related policies? The debate on public policies in the context of GVCs is part of the broader debate on the role of states and markets in the development process, and the existence of market and coordination failures. These issues are particularly problematic in the area of technology, innovation and learning where the contribution of internationalisation through integration into GVCs may be most fruitful.

Whilst market and coordination failures are powerful justifications for interventions in all areas of public policies, the following policy justifications are especially frequent and relevant in the context of GVCs. First of all, externalities on other firms are likely to emerge, once one firm signals the potential and the means required to integrate in a GVC. Secondly, with coordination failures suppliers would not invest to upgrade their processes and organisation, and lead firms would not support such upgrading processes; in the absence of long-term contracts and coordination firms may engage in learning and upgrading activities to a lesser extent than would be socially desirable. This is true both for lead-firms and for suppliers. Thirdly, the distribution of rents along GVCs is affected by substantial market failures and entry barriers in specific segments (e.g. branding and product conception). If market structures were less asymmetric and markets worked more efficiently, value chains

[7] This implies that it is obviously untrue that entering GVCs - by itself - will lead to innovation and better industrial performance. This is not a mechanistic and riskless process, local firms need to invest in learning and building capabilities and the governance of the GVC needs to be conducive.

would also work more efficiently, and resources would be better allocated (Pietrobelli and Staritz, 2013).

In sum, the existence of GVCs is raising and reshaping the need for cleverly-designed industrial policies and for their coherence with TF and long-term planning exercises.

3. Why Does a Clear and Planned Coherence Between TF and Industrial Strategy Matter More for Developing Countries?

Whilst the coherence between TF and industrial strategy is always desirable, it appears to be especially needed in developing countries for the following reasons.

First of all developing countries are often characterised by widespread market failures, poor institutional development (Rodrik, 2000), and a scarce coordination of public policies, society and science that results in a missing sense of common purpose (Tavares and Wacziarg, 1996). As a consequence, it is unlikely to expect that in such context each actor would naturally and easily align with the vision outlined by the TF. Information would probably not flow smoothly and be marked by substantial asymmetries, the rules of the games are likely not to be as solid and enforceable as it would be needed, and inter-firm and inter-organisation coordination will be poor and occasional. In this context often prevailing in developing countries, the effect of signalling future S&T developments, and the vision shared by experts and by multiple stakeholders that is offered by TF exercises, would not easily induce individuals, firms and organisations to behave consistently with the long-term objectives set in the TF.

In contrast, more developed countries are generally characterised by better-aligned NIS and actors within it that are more likely to quickly respond to the incentives launched by the market or by government policies. The simple 'signalling' effect of a TF exercise is often sufficient to determine behaviours consistent with the long-term objective outlined in the TF.

Secondly, as most developing countries are seldom frontier innovators but rather users of technologies developed abroad that need to be adopted and adapted to local contexts and conditions, their TF exercises need to be of a different nature. Provided that their final aim is to promote a catching up process, TF should help searching for existing technologies that could be more appropriate to their needs and level of NIS development, and should be closely related to their industrial strategy to promote the adoption, adaptation, improvement of technologies conducive to productive development.

Thirdly, a major issue identified in the literature inherent to developing countries' technological development is the forecast of the timing of *technology realisation.* Developing economies are generally lagging behind in technology development, and the adoption of a new technology, either through domestic firms' efforts or through technology transfer, might be retarded by several constraints which can delay the time of the technology realisation. These constraints can be identified in the lack of appropriate regulation and policy standards, human and financial resources, or research infrastructure (Chan and Daim, 2012). TF exercises should help understanding whether, given certain local conditions and needs, it is more appropriate to propose policies with a timing in line with world technology frontier as opposed to local.

Fourthly, TF carried out in close coordination with industrial strategy design and implementation can help limit the extent of the time inconsistency typically stronger in developing countries. The urgency to achieve positive results in the short-run prompts the tendency to overlook the benefits of long-term investments in favour of short-term (Ascher, 2009). This short-sightedness – or time-inconsistency between what would benefit the country in the long-run and what is required to gain support (and win an election) in the short-run - can be mitigated and possibly solved through a shared private and public vision for the future and by turning common commitment into actions as it occurs with TF and industrial strategy (Martin and Johnston, 1999). While investing in key strategic sectors of the future, TF together with industrial strategy should create, nurture and strengthen the institutional and physical infrastructure that leads to innovation. This latter type of investments are important as they can guarantee a country enough flexibility to reorient its policies in the case of failures and mistakes.

In sum, TF exercises systematically conducted in coherence and interaction with the industrial strategy setting can help overcome the time inconsistency of political choices.

3.1. How to Achieve a Strong Link and Coherence Between TF and Industrial Strategy?

A careful review of the literature points to some recurrent characteristics of successful coherence between TF exercises and industrial strategy setting. First of all, private sector involvement is an essential element to achieve the coherence between TF and industrial strategy, and needs to occur through participatory approaches. Private sector participation is not only useful to raise the relevance of these exercises and help define the content that public policies should have – the "missing public inputs" – (Hausmann et al., 2008, Hausmann and Rodrik, 2006) that are is often unknown a-priori from Government, but also to ensure that the necessary sense of ownership, responsibility and accountability is developed in the process.

Secondly, it is by now acknowledged by most scholars and practitioners that well-organised, competent and effective institutions are the backbone of innovation and industrial policies (Crespi et al., 2014). Participation of entities like the Ministries of Industry, Planning, Education, S&T should encourage actors to adopt behaviours that are consistent with the long-term benefits of TF programmes. "Innovation councils" for instance can support long-term strategies whose duration exceeds that of the government, and help mitigate Governments' tendency to overlook the benefits of long-term investments in favour of short-term gains (box 1).

A third important condition for success is a thorough understanding of GVCs logic and their underlying power relationships. With GVCs countries can target specific specialisation niches, but need to develop the necessary skills and technologies, and how to deal with powerful large chain leaders and drivers. This is all the more true insofar as outsourcing decisions are not anymore mainly based on cost considerations, but also on countries' technological capabilities and productive knowledge. In turn now GVCs represent one of the main sources of information and technology (as well as market access) for developing countries.

In the next section we examine three cases of coherence between TF and industrial policies that help us to strengthen our argument.

4. Review of Examples: The Link between Foresight Exercises and Industrial Policies in Developing Countries

This section shows examples of explicit coherence between TF activities and industrial strategies in South Korea, Brazil and Chile.

4.1. South Korea: Technology Foresight and its Overlap with Development Policies

The most striking aspect of South Korea's industrial development is the radical shift of its economy from low- to high-tech value-added sectors in only a few decades. This was made possible because, over time, TF and industrial policies have become deeply intertwined *via* complex and at time overlapping measures (Chung, 2007). Their main aim has been to respond to the technological challenges raised by global competition.

South Korea's initial development followed an inward-looking model of technology imports until the 1970s when the economy specialised in traditional low value-added, labour-intensive light industries (e.g. textiles). This specialisation soon suffered competition from low cost productions from other developing countries, and prompted South Korea's commitment to search an alternative development trajectory (Shin and Kim, 1994). This new trajectory shifted the economy towards high-value/capital intensive heavy and chemical industries and high-tech home-grown technologies such as electronics (e.g. semiconductors, mobile phones, displays and mobile internet) (Kim and Dahlman, 1992). The presence of large *chaebols*[8] like Samsung, Lucky-Goldstar (LG) and Hyundai represented a key factor in contributing to this radical change in the economic specialisation.

The industrial policies implemented by the Korean Government were inherently interventionist, pervasive and sought to promote indigenous technology whilst improving local technological capabilities (Lall, 2004). Vertical policies targeting high-tech niches coexisted with horizontal ones aimed at developing endogenous capabilities, improving local infrastructure and implementing R&D investments across a variety of sectors (Chung, 2007). This unprecedented economic growth would not have been possible without government interventions through the six National Development Plans that were designed and implemented between 1962 and 1991. From a careful analysis of these plans some key features of government intervention in the economy emerge.

The first aspect is the single-minded objective to pursue economic growth, which has been the foremost goal for all South Korean governments, even at the expense of others, like equity or poverty reduction. This goal-oriented attitude turned out to be essential in directing and forging Korean mentality and it was supported by a concomitant institutional rejuvenation that occurred through the displacement of traditional institutions, leaders and values (e.g. aristocrats, landlords) that were deemed counterproductive to the national objective of economic growth (Chung, 2007).

The second aspect was that trade policies were complementary to industrial policies and geared towards structural transformation of the economy's specialisation. They were oriented to promote capital goods imports (rather than consumer-ones), and FDI was kept out of the picture for many years unless it was deemed essential for accessing new technologies (Lall, 2004). These policies were constantly accompanied by stringent

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[8] *Chaebols* were South Korean private business owned by single powerful families ant they comprised several smaller members and units, which all maintained a close connection with the government (Chung, 2007).

performance requirements and were gradually phased out as companies demonstrated the ability to compete.

The third aspect was the governmental capacity to engage the private sector in the development process within both TF exercises and development plans. Private sector trust in government action was based on the deep-rooted legitimation of the state and on "collectivism".[9]

Korean foresight exercises date back to the 1990s, after the national development plans had taken off in the 1960s.[10] Foresight activities tended to have a strong technological connotation and the earlier national development plans in South Korea played similar functions to those of TF, and despite the different terminology in fact they did the same job. Thus national development plans foresaw the future by identifying the strategic sectors in which to invest, and they did so by combining both long and short-term perspectives.

Since the 1990s, TF exercises in South Korea have typically resulted in 5 year-plans targeted to problem solving and to understanding which general-purpose technology was worth investing in. TF results are incorporated in the wider S&T Plans which are usually longer-term (5 to 30 years).[11] The rationale is to better connect targeted on-spot technologies selected during TF exercises with the overall NIS long-term plan and projections.[12]

The conceptual and practical link between South Korean TF exercises and ensuing industrial development makes it a suitable example to follow for other emerging economies (Kim and Dahlman, 1992). During the implementation of TF investment in technology has been visibly supported by the Korean government and became integral part of the 2013-17 S&T Plan where particular emphasis was paid to renewable energies (Yim, 2010). However, the adoption of TF as a strategic tool for policy making did not come without difficulties, and the government repeatedly went through a trial-error process.

The first national R&D plan, which started in 1982, stressed the need to create indigenous capabilities in semiconductors, steel, automobiles and shipbuilding (Hwang, *et al*. 2011). During 1982-1992 a total of 2400 projects received massive government investments (US$ 207 million and more than two/thirds directed to R&D). Many research departments in firms were created (Shin and Kim, 1994) and the private sector R&D investment also increased from about US$ 297 million in 1982 to about US$ 3044 million in 1990. However, in spite of these efforts, R&D projects' commercial performance was rather unsatisfactory. Only about 4% of the 469 R&D projects funded by the government, and only about 30% of the 589 projects jointly financed by the government and the private industry, were successfully commercialised (Shin and Kim, 1994). The lack of expertise in R&D management of Government officials was deemed responsible for this poor performance. This, in turn, motivated the establishment of R&D budgets under the supervision of entrusted-specialised organisations for each line ministry (Task Force for Government-Sponsored Research Institutes Evaluations, 1991, Lee *et al*. 1995).

Recent Developments on Technology Foresight Practice in South Korea

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[9] Confucianism, the role of the family and the respect of the common good are all shared features that distinguish South-Koreans as "very optimists" and "hard-workers" and well-educated (Chung, 2007:28).

[10] TF took place in 1994, 1999, 2005 and 2008 respectively.

[11] Incorporating TF results into wider S&T plans is well-established practice that started in Japan already since the 1970.

[12] For a complete review refer to Yim, 2010 and Shin and Kim, 1994.

The last TF exercise in South Korea was conducted in 2012 and put strong emphasis on the "social needs" of the Korean society in which S&T changes will occur.

The novelty of the exercise lied not only on the new typology of selected sectors,[13] but also on the methodology adopted to detect changes in the R&D environment. The New and Emerging Signals of Trends (NEST) developed by the Korea Institute of Science and Technology Information (KISTI) firstly developed eight years ago is one of them. By combining quantitative and qualitative methods, NEST seeks to formalise the identification of weak signals[14] and emerging technology trend searches based on massive analysis, inference techniques, and Delphi studies from worldwide expert networks in order to assists researchers to better perform their research activities. NEST acts as a sort of "unsupervised bottom-up approach" since crucial decisions taken during the process are made by information technology and data mining algorithms. Human expertise is foreseen only during the assessment and the end of the process (Kim *et al.* 2013:72). This is particularly noteworthy if we consider that the Korean approach to innovation and technological development has been traditionally top-down especially during the fast catching-up period, and participatory and social dimension of the TF dynamics begin to be stressed (Hwang *et al*., 2011).[15]

5.2. Brazil's Experience with TF and a Value-Chain Approach to Industrial Strategy

One of Brazil's many historical challenges has been the diversification of its production beyond natural resources, to raise the technological content of its exports *via* new and higher-productivity industries. Within this context, Brazil has been recently reconsidering its approach to industrial strategy to exploit the potential offered by GVCs.

Technology Foresight in Brazil

In Brazil, the proliferation of TF exercises began systematically at a national level in the late 1990s with "Brazil 2020". However, national commitment to S&T policy started much earlier through S&T plans (the first Science and Technology Development Plan took place already in 1973-74) and business-level TF exercises.[16] During this initial phase, TF exercises were implemented by large banks and companies such as BNDES and PETROBRAS. TF took the form of prospective and extrapolative studies (Porto *et al*., 2010). Nevertheless, largely because of the tumultuous period of political and economic oil gas crisis, as well as the Brazilian transition out of the military government, these techniques led to mis-specified predictions which motivated the inclusion of additional foresight techniques imported from Western countries such as *scenarios* (Porto *et al*., 2010).

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[13] Selected emerging technologies include: protecting health with personalised medicine and treatment, model for forecasting health conditions, electric home appliances for future energy saving, development of bio-printing technology, global warming in the Korean peninsula, disappearing cash, new web business through removing copy protection, business models in the Web 2.0 era, popular applications of security technology, personal bio bank (Kim *et al*.:72).

[14] Weak signals are events, accidents or rare occurrences that are thought to trigger future changes (Kim *et al*.:52).

[15] The Korean NEST exercise drew from 138,000 pieces of environmental scanning data that have been gathered over 16 years and archived in the Global Trend Briefing website (GTB). Subsequent to NEST signal-detection process, 57 new-emerging technologies trends were chosen to be discussed in the Delphi study that ultimately selected 10 emerging technology trends (Kim et al. 2013)

[16] For a complete review see Popper and Medina 2008, and Chan et al. 2012.

The newly adopted techniques allowed TF exercises to strengthen stakeholders' coordination. They took place every 2 or 3 years and their main goals included:

- The identification of the strategic sectors where to invest as for example with the 2002 Brazilian TF Programme, that targeted civil construction, textile and garments plastics, wood and furniture; and
- The strengthening of investment in key infrastructures in order to be able to accommodate and take advantage of technological change, as with "Project Brazil 3 Times" (Mojica, 2010).

Nowadays, the principal institution in TF definition is the Centre for Strategic Studies and Management (*Centro de Gestão e Estudos Estratégicos* – CGEE). In 2005 CGEE together with FINEP (*Financiadora de Estudos e Projetos,* Research and Projects Financing Corporation) defined the "Brazil 3 Times" project, a strategic study that examined scenarios to characterise the country's future in 2007, 2015, and 2022 respectively. The use of scenarios contributed to raise awareness of the vast amount of local assets and of the huge Brazilian market (Gouvea and Kassicieh, 2005). By acknowledging Brazil's goal to catch up with foreign competition in international markets, this project highlighted the relevance of GVCs for the country's technology policy (CGEE website).

Foresight and GVC-oriented Industrial Policies in Consumer Electronics in Brazil[17]

An instructive case of how GVCs intersect with national industrial policies inspired by TF can be found in Brazil's recent efforts to leverage its large and growing internal market to build domestic capabilities in the consumer electronics sector.

Brazil's overall trade performance in the consumer electronics sector recently turned negative, with a decline in exports and a very rapid increase in imports to fulfil the rising demand of the local middle class. These rapid market shifts brought a new set of players to the fore, namely Apple and the many makers of Android-based smart phone handsets, and the contract manufacturers that produce the bulk of these products such as Flextronics (USA and Singapore) and Foxconn (Taiwan). Market growth and access to Mercosur is providing Brazil with the leverage to demand local production and content from consumer electronics and communications GVC lead firms, who in turn have put pressure on their key global suppliers to make investments in Brazil. To do this Brazil is bringing to bear a range of old and new policies aimed at spurring local production in the electronics sector. The key laws and programmes to stimulate local production are listed and described in Table 2.

Brazil's current industrial policies may appear similar to the old-style import-substitution policies, but they are remarkably different in several aspects. As GVCs bring new actors and industry structures to the fore, the challenges, opportunities, and outcomes related to these policies are different. Reliance on global sourcing implies openness to knowledge and technology from abroad, and this is very different from the past. Moreover old-style protection policies also importantly stifled competition, whilst the global battle to provide global suppliers represents a constant inducement to improve efficiency. Working with global suppliers also implies specialisation in fine segments of the value chain, reflecting comparative advantage as much as possible.

[17] An essential source for this section is Gereffi and Sturgeon, 2013.

For example, a centrepiece of Brazil's strategy to increase local production of consumer electronics has been to attract global contract manufacturers, known in the industry as electronic manufacturing services (EMS) providers. As electronics lead firms such as Apple and Hewlett Packard continue to outsource manufacturing, contract manufacturers have become increasingly important players in the component purchasing, assembly, test, and after-sale service functions of electronics GVCs. Seven of the 12 largest contract manufacturers are based in Taiwan, and they all suffer from low profit margins (just 2.4% in 2011) due to intense competition. Contract manufacturers fill an increasingly complex role in the electronics GVC; they must not only work closely with lead firms to develop products and meet tight production schedules, but also with a worldwide network of component manufacturers and distributors to ensure that they meet demand and keep their lines operating at, or near, full capacity. They perform an important role of coordination of local suppliers, reducing uncertainty of their final demand by presenting market opportunities and setting and showing the standards to fulfil markets requirements, and making investments with large minimum scale requirements possible.

Thanks to Brazil's industrial policies and direct pressure on the company from policy-makers, Foxconn has begun to assemble iPhones, iPads and most recently iPad minis for Apple in Brazil. While Foxconn currently imports 90-95% of its components, the company is likely to begin to manufacture components, including displays, in Brazil.[18]

The story of Hewlett Packard (HP) also offers interesting insights. HP uses three global contract manufacturers to produce in Brazil (Foxconn, Flextronics and Jabil Circuit). But hardware production is only part of the picture. In meeting the requirements for local R&D spending (4% of sales), HP Brazil employs 400 engineers and researchers in its lab in Southern Brazil and has contracts with another 1,000 collaborators from universities and research centres in the country. It also has four software centres working on local customer-specific applications, while contract manufacturers are being used to help meet the R&D spending requirement. Two of HP's research centres have been set up in collaboration with the Flextronics Institute of Technology's (FIT): the RFID Center of Excellence, which has worked on over 100 RFID-related projects with HP; and the newer Sinctronics IT Innovation Center, which focuses on environmental compliance and product recycling. R&D capacity just as like the manufacturing capacity of contract manufacturers can serve multiple lead firms. FIT performs R&D on behalf of competitors like Foxconn and Compal, which do not have the R&D facilities in Brazil needed to spend their R&D quota internally. In other words, Flextronics has been able to develop economies of scale in R&D, and these investments have remarkable externalities on other firms and sectors.

The presence of global contract manufacturers in Brazil creates a number of immediate advantages. It creates new jobs – Foxconn currently employs 6,000 in Brazil and could add 10,000 more jobs by 2016. Moreover, because contract manufacturers serve multiple customers, their manufacturing capabilities can satisfy local content requirements for multiple brands as production is flexible enough and capacity can be switched toward different product categories and firms.

[18] Recent negotiations for a fifth Foxconn factory in Brazil suggest that once production is at 100% (projected to be 2016), Foxconn will be manufacturing components including cables, cameras, touch-sensor glass, LED products, and printed-circuit boards (*Taipei Times*, 2012).

In sum, the focus of Brazil's industrial policy to attract investments from contract manufacturers, as well as GVC lead firms, signals a sophisticated understanding of the dynamics of the electronics GVCs by policy-makers. Contract manufacturers provide a leading edge, flexible, and scalable platform for local production and R&D. Furthermore, the Brazilian case emphasises that learning within GVCs is possible if induced by appropriate policies. With contract manufacturers like Foxconn the Government not only does attract foreign investment, but also set the premises to foster effective technology transfer and learning to benefit local industry. Arguably, the government understood that TF needs to be fully inserted into a modern industrial policy approach to strengthen the country's innovation capacity.

Table 2. Brazil's Electronics-related Industrial Policies

Policy mechanism	Details
Informatics Law:	The Informatics Law of 1991 initially sought to foster local production of electronics and R&D through the use of Basic Production Processes (PPBs) and R&D investment quotas.
Local content incentives:	Firms are encouraged to manufacture in Brazil through product-specific PPBs – "the minimum group of operations, within the industrial plan, which characterises real industrialisation of a certain product". PPBs reduce industrial product taxes (IPI) on final products, raw materials, intermediate products and packaging goods associated with the promoted product from 15% to nearly zero. Reduction in ICMS (state VAT) also applies in many states. PPBs are product, not company specific; only those products meeting the PPB's criteria receive benefits. They are defined and monitored by the Ministry of Science, Technology and Innovation (MCTI) and Ministry of Development, Industry and Foreign Trade (MDIC). PPBs set 'nationalisation indices' that define how much of the promoted product must be local in content in order to retain the incentives offered. For example, the PPB for computer tablets in 2012 set the nationalisation index at 30% and targets to raise it gradually over time.
***R&D spending requirements*:**	Firms must invest 4% of gross revenue from promoted products in local R&D. The key stipulation is that R&D must involve the discovery of a new technology or the development of new workforce capabilities, and not simply extend an existing, mature technology.
Incentives for the semiconductor industry:	The Brazilian Microelectronics Programme, launched by the MCTI in 2002, sought to support segments of IC manufacturing by offsetting exorbitant capital requirements involved in building a foundry with the latest technological capabilities. This focus on microelectronics continued through the '*Política industrial, Tecnológica e de Comércio Exterior'* (PITCE) enacted by President Lula in March, 2004. PITCE focused on developing outward-oriented software and integrated circuit industries, among various others. In 2007, the government enacted PADIS, a subset of the broader industrial policy '*Plano Brasil Maior*' to develop local semiconductor and display industries by targeting companies investing in R&D and manufacturing capabilities in Brazil.
Plano Tecnologia da Informação TI Maior:	Software is the fastest growing IT market segment in Brazil (16% annual growth rate during 2011-15, Business Monitor International 2012). Brazil has long had a viable cluster of software SMEs. *Plano TI Maior* is the most recent attempt to scale these firms up, the majority of which remain small and unable to compete outside Brazil. The most important component of *Plano TI Maior* is CTENIC, an equivalent of the PPB for software. This certification is currently under development and will define what constitutes 'Brazilian software'. Explicit efforts to bolster software development in Brazil are important, as software development costs are considerably higher in Brazil than in China and India.

Source: adapted from Gereffi and Sturgeon, 2013.

5.3. TF in Chile. CNIC's Efforts to Foster Innovation and Address Time-Inconsistencies

The Chilean innovation system has been suffering from several bottlenecks. The most difficult to address has been the poor institutional coordination which is reflected in the reduced trust that private sector has towards public/private business relations. Nevertheless, the Chilean political will has recently become more supportive of innovation *via* various reforms encouraging firm's R&D investments (OECD, 2013). TF programmes were launched only recently (beginning of 2000) on a national basis and they were adopting Delphi methods to select the key economic activities to promote (Popper and Medina, 2008).

A recent concrete institutional effort towards the strengthening of the NIS, which is key to TF exercises, has been made through the establishment of the National Innovation Council for Competitiveness (CNIC) in 2005, the most important institutional innovation in the last 30 years (Zahler, *et al.* 2014). CNIC embodies a permanent private-public partnership advising the Chilean government on long-term strategies related to innovation and competitiveness.[19]

Inspired by the Finnish experience and hence based on a coordination model (Box 1), CNIC serves as a platform for agreeing on policy priorities with a clear and consistent consensus. Its guidelines are part of the White Paper ("Towards a National Strategy" in 2007 and 2008). Every 4 years CNIC provides an evaluation of the accomplishments achieved, as well as an evaluation of CORFO (the Chilean Industrial Development Agency) and the National Council on Science and Technology (CONICYT). For its inherent nature, CNIC can be associated to a foresight-oriented organisation since it is entrusted directly by the government to define the direction of national innovation strategy.

Along with CNIC, the government also established the Innovation for Competitiveness Fund (FIC) that finances CNIC's decision once they obtain governmental approval. FIC's resources draw from a levy on mining introduced with the mining law (Zahler *et al.*, 2014). The CNIC actively engages with its counterpart in the Government, the Ministerial Commission for Innovation (*Comité*

Box 1 Institutional Set Up of Organizations Fostering TF

One of the major challenges of TF exercises is to align and coordinate various groups of interests toward a joint vision. This problem is additionally charged by the tendency to pursue short-term immediate benefits from temporary high gains in low added value investments (*i.e*. raw natural resources) rather than long run benefits derived by investment in higher added value productions (*i.e.* processing of mere raw materials). The outcome of this interplay of interests often results in a time inconsistency which drastically reduces development outcomes.

One valid support to overcome this time inconsistency is sometimes achieved through the establishment of a more permanent S&T policy body, able to overcome the political and economic cycles with a foresighted vision. The international experience of such S&T councils varies from country to country. Councils should be seen as a source of strategic intelligence for the innovation policy agenda. According to the extent of their influence on government policy planning, three types of councils can be identified:

A *joint planning* model: which draws from the Japanese experience, where councils serve the government as horizontal ministries of innovation by bringing together different actors from different disciplines to pursue joint projects;

A *coordination model*: based on the Finnish experience, in which the council's main goal is to advice the government by communicating across ministries to direct and align innovation policy. Such advice though is not always necessarily binding, like for the Chilean CNIC.

An *advice model*: as the Canadian case, where the government proactively seeks the council's advice though it does not intend to be restricted from it.

Source: adapted from OECD (2009)

[19] CNIC directly responds to the President of the Republic and in fact it should serve as the interface between the President and various Ministries (Finance, Education, Planning, and others).

de Ministros para la Innovación – CMI)[20] funded in 2007, an implementation body of innovation policies.

CNIC's operative mandate is based on three pillars, namely:

- Fostering a high-quality lifelong learning to increase the quality of human capital;
- Supporting scientific communication and dissemination aimed at applying knowledge to concrete productive and social needs; and
- Enhancing private sector involvement in the design and implementation of foresight exercises and concomitantly fostering internal R&D (Crawford *et al*., 2010).

One of CNIC flagship programmes was the "Cluster Programme", a vertical policy inaugurated in 2007 (and now discontinued) which witnesses the Council's capacity to introduce more selectivity within innovation policies (Zahler, *et al*. 2014). Sectors' selection was pursued through a foresight-forward looking activity.[21]

CNIC Evaluations and Critiques

The international experience of national innovation councils hints by and large to a continuous trial and error process before they set to work efficiently. The Chilean case is not an exception in this regard. The history of the council is rather recent and the council had to deal with a number of structural problems (i.e. the change of government in 2009 discontinued some already initiated programmes).

A certain degree of experimentation has been crucial in order for CCNIC to adapt to the context in which it operates. The OECD (2009) identified some major bottlenecks that needed to be addressed to promote a successful NIS policy. This report proposes that the role of the Council should be set clearer so to guarantee its neutrality as an advisory body. The council should also improve the communication among different government bodies and agencies so as to generate an efficient and transparent social networking.

Moreover, the legitimacy of the Council should be founded on clear basis in the parliamentary legislation (and not on a presidential decree).[22] This point is particularly important for TF policies since a clearer legitimacy can foster the council's capacity to solve time inconsistency issues.

All these recommendations have to deal with a more sophisticated level of institutional set up required for the CNIC to operate more effectively. They also highlight the fact that technological and economic change need to be sustained by appropriate institutions able to overcome the political time inconsistency that prevents the NIS to flourish.[23] CNIC's

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[20] CMI directly manages the Innovation for Competitiveness Fund (FIC) that achieved had USD169 million in 2008. Furthermore, it is in charge of coordinating the different public agencies that form the National System of Innovation for Competitiveness (*Sistema Nacional de Innovación para la Competitividad*, SNIC).

[21] In order to avoid the risk of political capture CNIC chose external consultants to carry out a top down sector selection. Both traditional and new sectors were targeted such as for example aquaculture and tourism and offshoring and financial services.

[22] In the UK the council is defined on a parliamentary basis, and a simple ministerial decision is effective in signaling an intention so to align actors towards it.

[23] According to the OECD (2013) one solution to reorient long-term strategic planning and to reduce institutional fragmentation could be to establish a unique Ministry of Innovation to help solving coordination issues while maintaining

institutional answer to foresight policies requires a considerable commitment in many respects. According to the OECD (2009) the CNIC should actively engage to align ministries and agencies towards a common vision. Ministries in turn have to give up part of their autonomy in favour of a national innovation policy. Ultimately, the challenge for CNIC is to establish itself as a credible advisor of the government and help systematise competitiveness and innovation policies.

Moreover, a participatory approach should be constantly encouraged. CNIC aims at becoming an arena where critical inputs/information on the Chilean NIS can be discussed, and where a collective and strategic intelligence can be pursued by gathering together different actors with different interests (OECD, 2009). The participatory approach aims at ensuring that different policies can take place concomitantly and that objectives of competitiveness and innovation can be jointly pursued.

In sum, despite significant investments and a favourable macro-economic environment, Chile has not yet succeeded in becoming an innovation-based diversified economy (OECD, 2013). However, institutions like the CNIC can help tackle and solve Chile's NIS inherently highly fragmented nature. A certain degree of experimentation is still needed to improve its role and functioning, but the efforts to learn from past initiatives have been a central and very appropriate feature of its experience.

Two important outcomes are that CNIC initiated a process to establish an innovation culture in the country with a stronger interaction between the public and private sectors, and that this institutional set up promises to help the country address the typical time inconsistency and distance between TF and an appropriate industrial strategy.

5. Conclusions

In this paper we have argued that the link between TF and broader industrial development strategy needs to be taken seriously in light of its role to shape technological change and economic growth, and they need to be coherently designed and implemented. When Technology Foresight began to be adopted in industrial countries, it tended to be still somewhat a marginal activity in developing countries. It was then believed that TF and its prediction of the future was a matter that only highly industrialised countries could endeavour, being more engaged and interested in frontier and "new to the world" innovation.

Today globalisation, increased complexity, competition and fast technical change radically transformed the range of economic activities that developing countries can perform. Production is internationally fragmented and organised along global value chains. Dense flows of knowledge and technology are available, but need to be fully exploited and employed within coherent industrial strategies. A specialisation by technology and learning has become the dominant paradigm and developing countries need to devise an appropriate industrial strategy to address these complexities and interdependencies.

Yet, often TF exercises do not go hand in hand with the design of a concrete policy strategy. In addition to providing insights about critical technological areas, TF can prove a valuable

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the autonomous role of CNIC (OECD, 2013). Recently other Latin American countries such as Brazil, Argentina and Costa Rica also engaged in such large-scale institutional changes with mixed results (OECD, 2013).

instrument to add coherence to S&T policy in developing countries but needs to be designed and implemented in coherence with the country's industrial strategy. The experiences we explore from Brazil, Chile and South Korea, where this coherence has been sought successfully, provide preliminary support to our argument

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