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natural resource revenues:
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Financial mechanism to invest in knowledge from natural resource revenues: Experiences from Bolivia, Chile, Colombia and Peru

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UNU-MERIT¹

Abstract

In resource-rich emerging countries, management of revenues from natural resources (NR) plays a critical role in transforming their economies. In this paper, a conceptual framework is constructed for an institution to promote the economic diversification through investing in knowledge, based on the literature from management of natural resources, industrial policy and public management. Existing financial mechanisms in Bolivia, Chile, Colombia and Peru, where NR revenues are invested in knowledge to enhance productivity (natural resources for knowledge, or NR4K funds), are examined applying the framework. The analysis identified that NR4K in these countries currently fall short of achieving their intended purpose of transitioning their economies toward increased diversification. These require complementary public policies to enhance capabilities, coordinate between stakeholders and initiate experimental investments.

Keywords: Natural resources, STI policy, Natural resource fund, NR4K, Latin America, Bolivia, Chile, Colombia, Peru

JEL CODE: P48, P51, O38, O21, O54

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1 Introduction

Natural resources (NRs) have been considered a ‘curse’ for development for many years. Recent literature has questioned whether the NRs themselves were to blame while also considering factors such as the absence of good institutional capacity and sound policy interventions to manage NRs effectively for development (Andersen et al., 2015; Brunnschweiler, 2008; Collier, 2010; de Ferranti, Perry, Lederman, & Maloney, 2002; Humphreys, Sachs, & Stiglitz, 2007; Iizuka & Soete, 2013; Marin, Navas-Alemán, & Perez, 2015; Perez, 2010; Sinnott, Nash, & de la Torre, 2010; Natural Resource Charter, 2014; Ville & Wicken, 2013; Wright & Czelusta, 2004; Dietsche, 2014). Effective practices for management of NR revenues include investing in knowledge that promotes diversification of the economy; however, few studies have addressed how such processes can be effectively implemented. This article attempts to provide a framework for institutions mandated to manage revenues from NRs to invest in diversification of the economy. Based on existing literature, we develop a framework for managing funds and apply this to specific cases of natural resources for the knowledge economy (NR4K) funds in four Latin American (LA) countries to identify difficulties when such a framework is implemented in practice.

Since the 1990s, several NR-rich countries have set aside part of their earnings from NRs to establish separate financial mechanisms aimed at neutralising negative effects on macroeconomic stability resulting from fluctuations in commodity prices and exchange rates (Collier, 2010; Hamilton & Ley, 2011; Wall & Pelon, 2011; Zhang, Garcia-Quiles, & Thelen, 2015 etc.). These are referred to as Natural Resource Funds (NRFs), a type of sovereign wealth fund. NRFs have successfully shielded resource-rich countries from volatility and contributed to sound macroeconomic management (Hamilton & Ley, 2012). Nevertheless, with a growing number of countries utilising this mechanism, there is increasing evidence that it may not provide a permanent solution for countries seeking sustained economic growth. The Latin American NRFs are relatively small compared to those of oil-producing countries in the OECD (e.g. Norway, Canada) as well as in the Middle East (e.g. UAE, Kuwait, Saudi Arabia).²

NRFs are generally designed to remove the rent—the excessive profits from NRs beyond the level sufficient to attract necessary investment—from the home country’s economy through financial operations abroad (World Bank, 2011; Hamilton & Ley, 2012). Although this presents advantages for counteracting unwanted variations in the exchange rate, prior domestic investments are also necessary to overcome dependence on NRs. Indeed, Collier (2010) and Collier & Laroche (2015) argue for

² For example, reserves of Chile’s Social Economic Stabilization Funds and, Colombia’s Saving and Stabilization Funds are US\$14.7 and US\$3.5 billion, respectively, while Norway’s Government Pension Fund, UAE’s Abu Dhabi Investment Authority and the Kuwait Investment Authority in Kuwait are US\$922.1, US\$828.0, and US\$524 billion, respectively. Retrieved from <http://www.swfinstitute.org/sovereign-wealth-fund-rankings/>. Accessed Aug 2017

systemic policy interventions to promote investment in building domestic capacities (“investing in investing”) to design, manage and implement projects that maximise public returns. Investment towards diversification of economic activities based on knowledge may be a step in the right direction. However, such activities may entail higher risks and uncertainty unless there is a good ‘policy mix’ that encompasses complementary areas such as capacity development, export and investment promotion and enhancing competitiveness of industries.

The cases of resource-rich advanced countries, such as Australia, Finland and Norway, demonstrate the relevance of developing a knowledge-based productive sector to diversify the economy (Gelb, 2012; Gylfason, 2012; Ville & Wicken, 2013). The policy interventions for knowledge investment are necessary because market forces only allow suboptimal investments in knowledge (Arrow, 1962; Nelson, 1959). At the same time, there are also difficulties in articulating social benefits in the distant future. Aspiring to higher levels of knowledge and capability requires active and consistent learning and investments accompanied by policy support, perhaps extending for more than a century. Maintaining such high of investments is not an easy task, owing to the dynamic inconsistency of governments (Pietrobelli & Puppato, 2016). Even if investments in knowledge do take place, they need to be coordinated and integrated into the private sector so that productive development can occur in a dynamic manner (Crespi, Fernández-Arias, & Stein, 2014). These investments should follow both conventional and experimental initiatives, as discussed in recent industrial and technology policy debates (Steinmeuller, 2010; OECD, 2014a; Rodrik, 2004; Breznitz and Ornston, 2013, 2016).

Since the 2000s, several NR-rich LA countries have introduced policies oriented towards decreasing their dependence on commodities. The approach has diverted a certain proportion of revenue to invest in the promotion of science, technology and innovation (STI), emphasising the role of institutions (physical and legal) and importance of developing human resources (Murillo, Scartascini & Tommasi, 2008; Cimoli, Dosi, & Stiglitz, 2010; Crespi & Dutrénit, 2014; Crespi, Fernández-Arias & Stein, 2014; Navarro, Benavente, & Crespi, 2016; Perez, 2010). The introduction of these policies coincided with the *commodity super cycle*, when revenues from NR substantially increased (Sinnott, Nash & Torre, 2010). This paper first reviews the recent literature on NRs in relation to economic development, outlining key characteristics and potential. Building upon the literature on public management and industrial policies, the next section outlines the design principles for financial mechanism to promote policy initiatives toward knowledge investment, NR4K funds. We then examine cases from Bolivia, Chile, Colombia, and Peru, using the framework as a reference point. The cases illustrate the current challenges and possible pathways for transformation of natural resource-based countries in LA with investments on STI. This helps to address the central question of *how NR rich developing countries can use their resources to diversify their economy and make their economy more productive and sustainable*.

2 Theoretical considerations on natural resources and economic development

2.1 The curse of natural resources revisited

NR-based activities acquired the infamous title of being a ‘curse’ for development, mainly as a result of the volatility of commodity prices and demand creating an unstable macro-economy (Gylfason, 2012). This is partly due to appreciation of the exchange rate, which discourages growth in other export sectors (*Dutch disease*) (Corden & Neary, 1982). Moreover, over-reliance on ‘commodities’, inferior goods, causes long-term trade imbalances, as these can be replaced easily by other exporters or technology (Prebisch, 1950; Sachs & Warner, 2001; Singer, 1949). Extractive sectors tends to operate in ‘enclaves’ and creates very few forward or backward productive linkages to ensure effective employment and generate economic impacts (Hirschman, 1958). Furthermore, the NR sector has been considered as a weak source for the advancement of technology and science, because innovation is driven by the suppliers to these sectors (Pavitt, 1984). Finally, ‘access’ to resources can cause political conflicts and corruption that hamper stable development without the presence of good institutions (Auty, 1990, 1993).

These views on NRs are now being reconsidered in different streams of literature. Empirical studies from development economics present inconclusive results concerning the negative terms of trade argument via the selection of different indicators (Brunnschweiler, 2008; Cuddington, 1992; Ellsworth, 1956; Tilton, 2013), time periods covered (Cuddington, 1992; Ellsworth, 1956), and methods of analysis (Brunnschweiler, 2008). Critics from the institutional perspective argue that the provision of human capital, physical infrastructure and institutional capability has been omitted from explanations of the trade and growth link (Brunnschweiler, 2008). Evolutionary economics emphasise changes in knowledge and technology applied to NR-based activities (Iizuka & Soete, 2013; Marin, Navas-Alemán & Perez 2015; Perez, 2010). Furthermore, several historical case studies indicate that NR-based activities can help to increase productivity, propel diversification of the economy and create knowledge-intensive jobs when supported by sound institutions and policy interventions (David & Wright, 1997;; Upstill & Hall, 2006; Urzúa, 2011; Ville & Wicken, 2013). These studies suggest that NRs can be an ‘asset’ in economic development given enabling conditions, such as suitable human capital, physical infrastructure, knowledge (science, technology and innovation), institutions and policies to set a course onto more productive pathways. An important remaining question concerns the kinds of institutional mechanisms that could create such virtuous circles.

2.2 Key institutional designs for managing income generated from natural resources

a. Incremental improvements under static state

Natural Resource Funds (NRF) are a governmental financial institution, a type of sovereign wealth fund (SWF)³ that transfers excess NR rent to overseas funds in order to mitigate exchange rate appreciation, avoid Dutch disease symptoms, and reduce budget deficits when NR revenues decline—thereby promoting macroeconomic stability (Collier, 2010; Davis, Ossowski, & Fedelino, 2003; Hjort, 2006; Natural Resource Governance Institute & Colombia Institute on Sustainable Investment, 2014; Zhang, Garcia-Quiles & Thelen, 2015). They also create savings for future generations and allow a proportion of income to be earmarked for investment in national development projects.

Empirical studies on the impact of NRFs⁴ in the sound management of the economy, however, have not shown a clear association between economic growth and NRFs. The macroeconomic stability of states increased only in the presence of high-quality governance and institutions (Tsani, 2015), suggesting that NRFs are not the sole factor in sound management of the economy. Other research confirms this trend, showing a weak or inconclusive association between NRF and economic growth (Humphreys & Sandbu, 2007; Stevens & Dietsche, 2008).

Other literature on NR management points to the importance of strong government involvement, in particular in developing countries (Arezki, Gylfason, & Sy, 2012; Collier & Laroche, 2015). Collier & Laroche (2015) propose a framework to achieve higher levels of economic development. They advocate distinctive interventions at each phase of extractive activities in fixing market failures.⁵ In particular, they emphasise building capacity for public investment and improving the investment environment with better use of available local resources, something they refer to as ‘investing in investing’ (Collier & Venables, 2011). In fact, for low-income countries, several authors (Collier, 2010; Stiglitz, 2007) agree on using NR revenues for investment in public goods (i.e. human capital and physical infrastructure). This is because effective use of NRs depends on government capacity to make sound managerial decisions on 1) how much income from NRs should be integrated into the current government budget (setting an appropriate threshold), 2) how risks should be assessed, and 3) how funds should be invested in future (prioritisation). In making such decisions, governments face

³ NRFs are government-owned investment funds “whose principal source of finance is revenue derived from oil, gas and mineral sales” that invest “at least in part in foreign financial assets” (Natural Resource Governance Institute, 2014, p. 6).

⁴ To avoid confusion, the same acronym (NRF) is used; however, Tsani’s (2013) definition of RF is slightly broader than NRF as used in this paper.

⁵ For instance, in the discovery and extraction phase, geological exploration is a highly risky and costly activity that requires policy intervention. In the extraction phase, the role of the government includes engaging in negotiation with diverse agents (developers, trading houses, commodity markets) on upfront large-scale and long-term investments, and creating transparent tax mechanisms. Government intervention is also necessary to prepare the ground for large-scale investment to take place via training of personnel as well as provision of basic infrastructure (roads, electricity, and water).

political pressures and vested interests (Venables, 2016) in balancing short-term goals and social needs with longer-term goals such as accumulating knowledge for diversification of economic activity.

Some institutional features can be discerned from existing NRF mechanisms: 1) rule-based design providing quantitative limitations on use of funds to prevent discretionary decisions; 2) “multiple stakeholder governance” to avoid concentration of power over resources by introducing specialised third-party checks and balance mechanisms⁶ on decisions of spending and risk taking;⁷ and 3) ensuring transparency on the use of funds via promoting disclosure of information as well as involving civil society groups such as local communities, NGOs and international organisations⁸ in monitoring use of finances (Hamilton & Ley, 2012; Humphreys & Sandbu, 2007). These design considerations are purposefully made rigid and static in order to leave no space for political digressions or rent-seeking behaviours. This ensures stability and provide preconditions for incremental improvements to take place. In fact, NR-rich developed countries such as Australia, Finland and Norway built NR-specific knowledge infrastructure—i.e. universities and research centres linked with STI institutions—utilised NRs as an engine for productive development. In particular, the case studies on Australia and Norway (Upstill & Hall, 2006; Ville & Wicken, 2013) demonstrated how technological capacity can be built based on the need to overcome local problems and suggest the usefulness of more incremental improvements centred around daily ‘problem-solving’ activities. Similar experiences have been observed in emerging countries such as Chile and South Africa, albeit on a much smaller scale (Ebert & La Menza, 2015; Garcia, Knights, & Tilton, 2001; Kaplan, 2012).

While this rigidity appears to ensure stability throughout the political cycle and generates incremental improvements over many years, it falls short in terms of accommodating dynamic changes.

b. Radical improvement under dynamic status

The NRF is also a type of agency established to manage rents incurred from NR. Its main purpose is lessening the negative influences of rents on macroeconomic stability by removing excessive volatility in exchange rates and government expenditures caused by fluctuations of commodity prices and demand. NRFs are generally established with rigid legal parameters, with built-in checks & balance mechanisms to insulate them from political cycles. While the maintenance of macroeconomic stability can provide satisfactory conditions for development, it is increasingly recognised that it is insufficient to transform the economy. Above are typical characteristics of ‘agency’ by the New Public Management (NPM) approach. This claims that agencies are an efficient form of institution for carrying out specific services as long as their role is clearly defined by rules. While constant

⁶ Such as technical bodies or committees.

⁷ For instance, Norway’s State Petro fund requires approval from parliament for disbursement of funds from the Central Bank.

⁸ EITI, Natural Resource Charter.

performance is expected from the agency, it must endeavour to continuously improve the quality of activities while being subject to rigorous evaluation by the budgeting organisation of the central government (Breznitz & Ornston, 2013, 2016; Hood, James, Jones, Scott, & Travers, 1999; Pollitt, Talbot, Caulfield, & Smullen, 2004; Dunleavy, 1991; James, 2003). Its mission is often intentionally separated from the central government, allowing policy space to engage in new activities while being insulated from political interference, within legal limits.

The ‘agency’ approach was popular among OECD countries in the 1990s to seek efficiency when policy emphasis was placed on smaller government (Schick, 2002), however it has received mixed reviews due to difficulties in implementation under different contexts such as socio-cultural and historical conditions (Dan & Pollitt, 2015; Christensen & Laegreid, 2004; Cohen, 2016; Osborne, 2017). Furthermore, a social constructivist approach criticised the agency’s lack of capacity to manage finance, implement public services and assume risks to engage in radical activities (Dan & Pollitt, 2015; Breznitz & Ornston, 2016).

While such critics are present, two recent examples of agencies—the Finnish National Fund for Research and Development (SITRA) and the Israeli Office of the Chief Scientist (OCS)—demonstrated the potential for “agencies” to be dynamic entity for policy. The agencies described above—‘peripheral or Schumpeterian development agencies’—are able to transform low-technology economies into dynamic knowledge ones by continuously engaging in radical policy experimentation. In particular, ensuring sufficient technical skills and being insulated from unnecessary political interference were identified as key elements for success (Breznitz and Ornston, 2013).

What marked the difference between the ‘dynamic’ agencies like SITRA or OCS and ‘static’ one is their ability to deal with market and systemic failure—i.e. underinvestment in capability/knowledge, lack of public infrastructure (hard and soft) and the need to prevent capture by strong governance (strong network) as a result of rigid institutional design (Woolthuis, Lankhuizen & Gilsing 2005). More importantly, the ‘dynamic’ agencies also have to deal with transformative challenges—i.e. directionality failure (negotiated strategic decisions among stakeholders); demand-articulation failure (needs are not always explicitly expressed by all the actors); policy-coordination failure (i.e. failure to go beyond legal jurisdictions, mismatch of sequencing policy mix), temporal-coordination failure (future preferences are not considered or excessively discounted) and reflexivity failure (i.e. the ability to monitor systems) (Weber and Rohracher, 2012).

The earlier discussion on process of capacity building—‘investing in investing’—is considered essential as the basis for productivity development (as in the experiences of Norway and Australia: Upstill & Hall, 2006; Ville & Wicken, 2013). This requires long-term policy commitment that prioritises future transformative needs. However, implementation is deemed difficult in LA due to political cycles, which prevent governments from investing in long-term, strategic initiatives, particularly if these entail high risks and uncertainties. The institutional design for the agency should, therefore, balance rigid rule-based (Weberian) static components to ensure continuity while avoiding being captured by powerful stakeholders, and dynamic components that reflect the evolving local realities and needs through experimental and radical policies (Schumpeterian) (Kuznetsov & Sabel, 2011). A recent STI policy document on LA makes similar recommendations:

- 1) Invest in projects that match local endowments and capability;
- 2) Invest in “appropriate” knowledge and necessary technical skills;
- 3) Ensure continuity of investment for a certain period of time as there will always be a time lag before outcomes emerge;
- 4) Maintain an appropriate degree of involvement with the private sector, while avoiding being captured; and
- 5) Coordinate decision-making amongst different stakeholders with different intentions (Crespi & Dutrénit, 2014).

The above approach also reflects the need to deal with ‘policy volatility’, a common feature of Latin America, stemming from the design of each country’s government institutions and history (Murillo, Scartascini & Tommasi, 2008; Scartascini, 2008).⁹ These aspects are important because productivity of the economy is the outcome of collective decisions undertaken by actors within prevailing public policies and institutions (Murillo, Scartascini & Tommasi, 2008). This means that integration of both static and dynamic aspects need balancing as the guiding principles.

Table 1 shows the compiled design principles for an institution that manages knowledge funding under sound public management principles. The *static design criteria* in the table relate to the rule-based use of funds, thereby limiting corruption and capture. *The dynamic design criteria* concern implementation, where interactions play important roles in meeting policy goals that change over time, while maintaining path-dependence. In the sections to follow, these design criteria are applied to cases of NR4K funds to understand key features of these funds in Bolivia, Chile, Colombia and Peru, and to identify specific challenges for transformation.

The section to follow will describe the existing cases of NR4K in four Latin American countries: Bolivia, Chile, Colombia and Peru.

⁹ Latin American countries share some characteristics that cause ‘policy volatility’. This is due, among other things, to the strong but term-limited power of the president, limited coordination ability of cabinet and weak capacity of public administration (Murillo, Scartascini & Tommasi, 2008).

Table 1: Design criteria for managing innovation-oriented funds applied to NR4K funds

	Conceptual Institutional Design Guidelines	Operationalisation of concept/what to look for
Static design criteria	1) Clear purpose of establishment Rules and institutional arrangement that set the fund; must include a clear definition and its objective	Policy statement or legislation that explicitly includes the goals of the NR4K fund and ensures continuity; may include performance indicators and disbursement arrangements.
	2) Rule-based design: The clear rule principle exists and leaves limited scope for discretion or corruption by the government in power in collecting, using and allocating the resources of the fund	Rules define how much revenue is allocated to the fund, rules of allocation to activities/ objectives and institutions in charge of managing resources. Rules also define how and when funds should be used
	3) Multiple stakeholder governance Responsibility and authority is shared between multiple organisations regarding critical decision-making on use of the fund	Legal documents clearly outline who is involved in decision-making and managing; ensuring separate institutional bodies to decide on use of funds, division of power, and responsibility
	4) System to ensure transparency Information on inflow and outflow of funds is easily accessible to civil society	Ensuring channels of information such as publication of annual reports or providing facilities to access information on a website to avoid corruption
Dynamic criteria	5) Monitoring & Evaluation system The fund is permanently being monitored and evaluated by independent bodies	Establishment of a system that allows independent monitoring and evaluation. There is a clear output performance indicator. The continuity of managerial contracts and disbursement of operational budgets is based upon results of monitoring and evaluation of agreed output indicators
	6) Appropriate institutional/managerial capacity Institutions in charge of managing the fund have human, institutional and physical resources to carry out intended activities	Mechanisms to allow engagement in capability building via investment in experimental and transformative activities; mechanisms are strategic, incorporate a long-term developmental perspective that crosses over political cycles, and ensures freedom to implement and choose activities free from institutional capture by the firm and political interference
	7) Coordination with other related institutions: policy mix NR4K funds ensure sustained long-term experimental investments and complement traditional productive development policies	Presence of coordination body/mechanisms that maintain the stability of activities with shared consensus; clear separation of roles, missions and responsibilities from governmental agencies

Source: Authors' compilation based on Breznitz & Ornston, 2013, 2016; Cohen (2016); Collier & Laroche (2015); Collier & Venables (2011); Collier (2010); Crespi, Fernández-Arias & Stein (2014); Hamilton & Ley (2011); Humphreys & Sandbu (2007); Kuznetsov and Sabel, (2011); and Stiglitz (2007).

3 Background of Design of Natural Resource for Knowledge (NR4K) funds

3.1 Overview of countries studied

In the 2000s, Latin American countries—especially those endowed with NRs—grew economically, owing to a boom in commodity prices, while structurally, the economies became progressively more reliant on NRs (CEPAL, 2010).

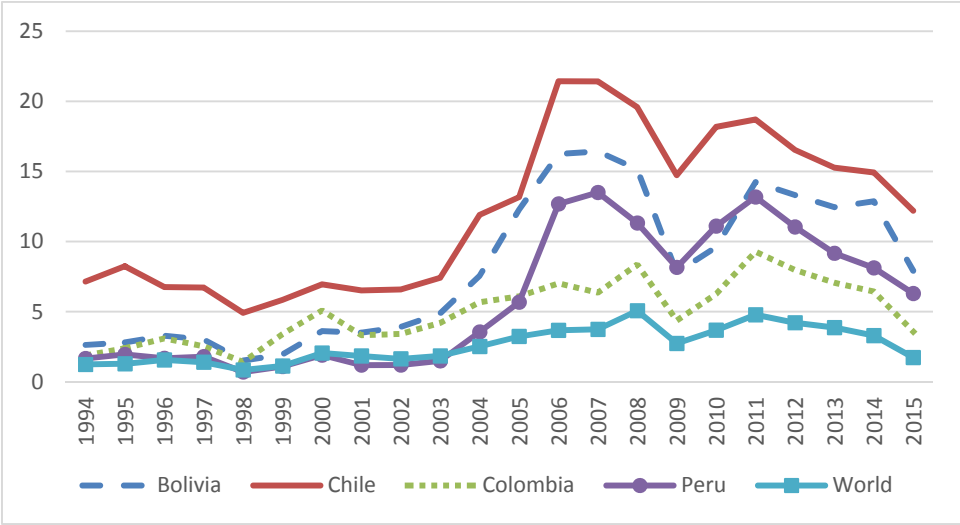


Figure 1: Total natural resource rent (% of GDP)¹⁰

Source: World Bank data, 2016

The timing of the commodity boom coincided with a gradual change in the orientation of productive development policies in many LA countries, which paid more attention to the role of science, technology and innovation for achieving long-term economic growth and the crucial role well-designed institutions can play in this regard (Crespi & Dutrénit, 2014). This change in focus has followed—and perhaps is a consequence of—many years of sustained improvements in social protection, which diminished policy pressure to meet basic needs. Despite some differences (see Table 2), these countries share the common challenge of transforming their NR wealth into development via linking this revenue to enhancement of knowledge-intensive activities. We refer to institutions that link NR revenue to the knowledge economy as NR4K funds and examine the existing system in each country according to the criteria listed in Table 1.

¹⁰ Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. The aggregation method is a weighted average. The estimates of natural resources rents are calculated as the difference between the price of a commodity and the average cost of producing it. This is done by estimating the world price of units of specific commodities and subtracting estimates of the average unit costs of extraction or harvesting costs (including a normal return on capital). These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of gross domestic product (GDP) (World Bank, 2011).

Table 2: Overview of countries being studied

Indicator	Bolivia	Chile	Colombia	Peru
Population (millions)	10.8	17.7	48.9	30.8
Poverty gap at \$3.10 a day (2011 PPP) (% of the poverty line) ¹¹	5.8	0.8	5.0	2.8
R&D expenditure (% of GDP)	0.16	0.38	0.20	0.11
Income group	Lower-middle income	High income	Upper-middle income	Upper-middle income

Source: World Development Indicators (2016), and CONCYTEC (2016). Data is from 2014 or latest available

3.2 Comparing NR4K funds & their impact

3.2.1. NR4K funds

This section compares the main characteristics of NR4K funds established in Bolivia, Chile, Colombia and Peru. From the general description, we can observe two main differences between the approaches used for NR4K funds (Table 3). On one hand, in Chile and Colombia, the management of the NR4K funds relies, to differing extents, on existing STI institutional structures. On the other hand, in Bolivia and Peru NR4K funds are allocated directly to the final recipients (universities).

Table 3: Summary of NR4K Funds¹²

	Bolivia	Chile	Colombia	Peru
Name	Direct tax on hydrocarbons (IDH) (part of*)	Innovation for Competitive Fund (FIC)	Science, Technology and Innovation Fund (FCTel)	Canon, mining royalties (part of*)
Legal framework	Law no. 3058 (IDH) Supreme decree no. 29322	Law no. 20026/20097/20469 Annual public-sector budget laws	Law no. 05/Law no. 1530	Law no. 28077 (canon) Law No. 298788 (royalty)
Year established	2007	2006	2012	2004 (canon) 2011 (royalties)
Source	Direct tax: hydrocarbons	Royalties: copper mining	Royalties: hydrocarbons, metals and other minerals	Canon: mining, hydropower, gas, fisheries, forestry. Royalties: metals and other minerals
Tax rules applied to mining firms	32% of production	Increasing marginal tax rate from 5% to 34.5% of operational income	1%-12% of production value	Canon: 50% of income tax Royalties: 1%-12% marginal rate increasing with operational margin ratio
Allocation rule	8.62% of allocation to each regional department	Decided by annual budget negotiation	10% of royalties collected	Canon: 20% of allocation in each region Royalties: 5% of royalties collected
Size (Millions USD)*	129.85	268.33	432.03	133.35
Size relative to GDP**	0.42%	0.10%	0.39%	0.07%

Source: Compiled by authors. Note: *Chile, Colombia and Peru: annual average between 2013 and 2015. Bolivia: 2013;**Calculated using annual average exchange rate for respective years.

Note: * indicates that for Peru and Bolivia, certain proportion of funds is allocated for STI purposes. Please refer to allocation rule.

¹¹ The poverty gap at US\$3.10 a day (2011 PPP) is the mean shortfall in income or consumption below the poverty line of US\$3.10 a day (counting the non-poor as having zero shortfall), expressed as a percentage of the poverty line. This measure reflects the depth of poverty as well as its incidence.

¹² Detail of contents will be explained in section 5.

Figure 2 shows the size of NR4K funds over the past ten years. This demonstrates that, overall, they are of sufficient size to spur science and technology activities in the sample countries. Indeed, the lowest figure is 0.05% of GDP in Peru, which is equivalent to 50% of the current percentage of research and development (R&D) in relation to GDP (GERD, see Table 2). By contrast, the NR4K in Bolivia is roughly 0.43% of GDP, more than 2.5 times larger than the national estimations of GERD.

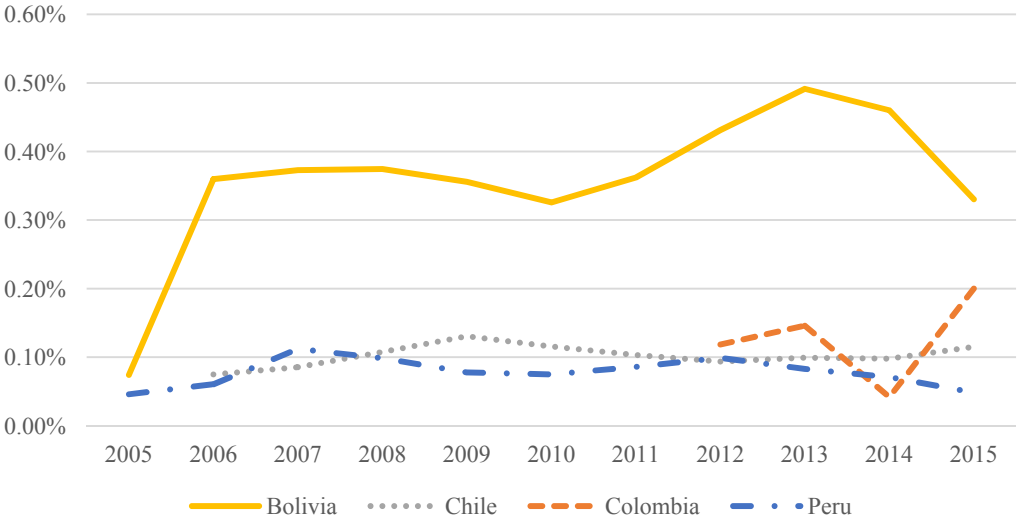


Figure 2: NR4K funds as a percentage of the GDP

Source: Ministerio de Economía, Fomento y Turismo (2015) Sistema General de Regalías (2015): <http://www.colciencias.gov.co/portafolio/gestion-territorial/fondo-fctei-sgr/recursos>, Ministerio de Economía y Finanzas (2017): <https://www.mef.gob.pe/es/transferencias-a-gobierno-nacional-regional-y-locales/que-es-y-como-muestra-la-consulta>

3.3 Impacts of NR4K

The increase in funds for financing knowledge activities did not translate into an acceleration of scientific output in all of the countries examined (Figure 3). Although imperfect, scientific publications are one of the few indicators for assessing the performance of knowledge production in our sample of countries. Here, the group of countries accelerated their knowledge production in publications from the early 2000s, reflecting renewed interest in STI policies in the Latin-American region (Crespi & Dutrénit, 2014). Overall—leaving aside the case of Colombia, for which the establishment of the NR4K fund is too recent to indicate a change in trends—the publication growth rate from 2000 remained the same, before and after the introduction of NR4K funds. It is particularly noteworthy that Bolivia showed signs of stagnation from 2008 despite using its NR4K to finance universities directly.

In Figure 4, we can see the evolution of the number of exported products by country, providing a proxy indicator of export diversification. For Chile, Colombia and Peru, stabilisation of the export diversification process followed the introduction of NR4K funds. However, the period after the NR4K

funds were initiated overlaps with the commodities super cycle, therefore ‘Dutch disease’ symptoms cannot be ruled out. At the same time, if the NR4K funds have helped to cope with the above-mentioned symptoms is a matter of further research. The case of Bolivia depicts a reverse of the diversification process after the introduction of the NR4K fund. This may be caused by the nationalisation of oil and gas industries in 2006.

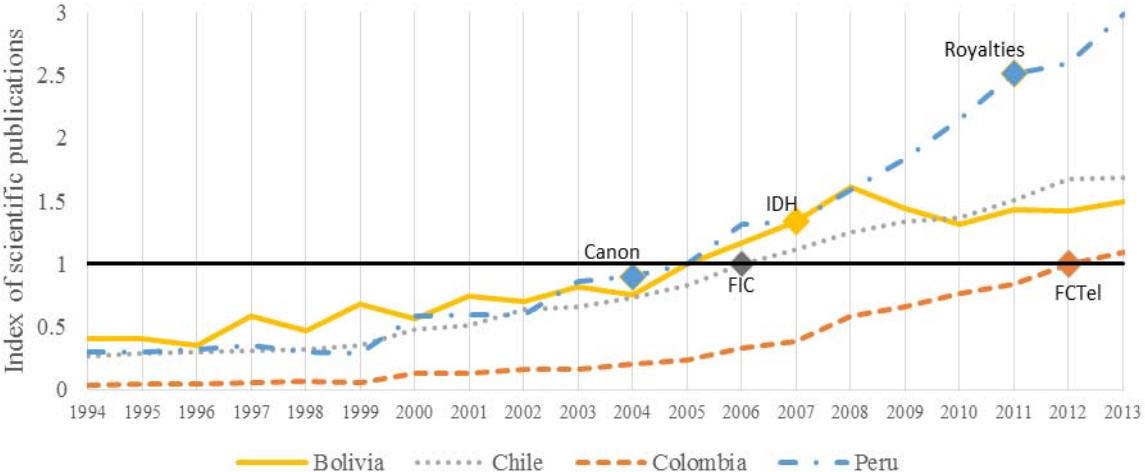


Figure 3: Number of scientific publications by year

Note: Each country’s figures are normalised by the number of publications at the year of the introduction of the NR4K Fund. Source: Own elaboration using World Development Indicators (2017). The markers on the line indicate the year (s) of establishment for respective NR4K (see Table 3). Markers indicate the year the NR4K was introduced.

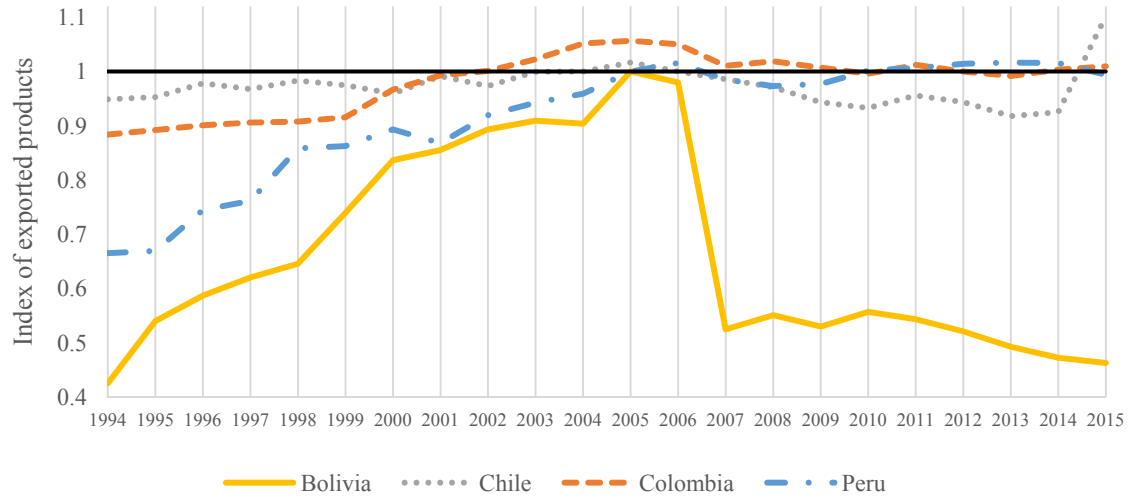


Figure 4: Number of exported products¹³ by year

Note: Each country’s figures are normalised by the number of products exported at the year of the introduction of the NR4K Fund. Source: Own elaboration using World Bank (2017).

¹³ Products are defined using the six-digit code of the World Customs Organization’s Harmonized System (HS 6-digit). 13

4 Methods for analysing NR4K in each country

In the following sections, NR4K funds in each country are examined referring to the design principles outlined in Table 1. Our analysis relies on published laws, regulations, presidential decrees, government budgets and official statistics as well as policy documents produced by both national and international organisations regarding the tax systems, STI policies and NR policies. The use of multiple official sources allows cross-checking and triangulation of information. Although formal institutional setups can be illustrated by using secondary information, it is unclear how many of these have been converted into institutional practice. Hence, in order to understand dynamic aspects of institutional functions, interviews were conducted with key informants and experts either working in or with each implementing agency to understand the actual flow of resources and the decision-making process. These interviews were conducted between late 2015 and early 2016 in Bolivia, Chile, Colombia and Peru (see Appendix3). This primary information also helps to triangulate the secondary information.

5 Assessment of NR4K funds according to static and dynamic criteria

Existing STI indicators showed limited impact from NR4K funds regarding knowledge production. In this section, each fund is examined according to the criteria mentioned in Table 1.

5.1 Static criteria

5.1.1. Clear purpose of establishment

A clear purpose statement regarding legal institutions for establishing NR4K funds would indicate the country's strong commitment to mobilising resources for investments in knowledge for diversification of economic activities. Legal constitution also supports the goal of overcoming severe 'policy volatility'. This is particularly prominent for LA where, traditionally, the president has time limited powerful position accompanied with weak public administration (Murillo, Scartascini, & Tommasi, 2008; Scartascini, 2008). A clear statement on NR4K by a government institution should direct the behaviour of stakeholders onto certain trajectories for the future. This statement should avoid frequent changes in government or policy caused by political cycle if the aim is to bring about broader economic transformation (e.g. via capacity development and R&D).

In fact, aims of NR4Ks are articulated by differing degrees of legal formality for the countries examined. Colombia and Peru have the strongest legal basis among our sample of countries. In Colombia, FCTeI is backed by a law (Law No. 05/Rev. Law no. 1530, 2011/2012) that explicitly defines the objective of these resources: "...to increase science, technology and innovation capacities and competitiveness of the regions, through projects that contribute to the production, use, integration and appropriation of knowledge by the productive sector and the broad society, including projects related to biotech and information and communication technologies, contributing to social progress, economic dynamism, sustainable growth, and greater prosperity to the entire population."¹⁴ In Peru, two legal frameworks (Canon Law, Law No. 28077, 2004; Mining Royalty Law, Law 29788, 2011) were passed to establish the funds. These funds have the explicit objective of exclusively financing "investments in scientific and technological research." The "canon" is the share of the total income and rent obtained by the state for the exploitation of NRs that goes to the regional and local governments (Article 1, Law No. 27506, 2001). For every canon, 50% of the corporate taxes that firms pay to the Peruvian government are devoted back to the regions. Canons exist for the following sectors: mining, hydropower, gas, fisheries, and forestry¹⁵.

¹⁴ Free translation from Spanish.

¹⁵ A proportion of both Canon and Royalties goes to finance regional universities. Details explained in next section. The same applies to Bolivia's IDH.

In Chile, the FIC does not have a specific law; its continuation is tacitly decided on an annual basis when its resources are allocated as a part of the public-sector budget. In these public-sector budget laws, there is no explicit objective set for the FIC except for the operational goal of financing the STI institutions of the country. Similarly, in Bolivia, the allocation of IDH (the direct tax on hydrocarbons) resources to universities has been backed and confirmed by a series of Supreme Decrees promulgated by the presidency, therefore making it highly dependent on the government in power. Although the recipients of the fund are clear, the fund itself does not have explicit objectives.

Colombia and Peru provide a legal base that offers more stability for the continuation of these investments. On the other hand, in Bolivia and Chile, NR4K funds are highly dependent on the government in power, which does not ensure the continuity in these activities.

5.1.2 Rule-based design

In Chile, there are no clear rules defining the allocation of resource revenues to the FIC. Allocations are determined by negotiations in the process of determining the regular public-sector budget. The regional investments from this fund are also highly dependent on the central government since a share of these resources is allocated through centralised STI implementing agencies. These are subordinated to ministries. FIC budgets allocated to STI agencies are used to finance programmes, which are selected according to regular selection procedures¹⁶ that exist in each agency. The remaining resources of the regional FIC finance projects are selected by the regional government council, comprised of a mix of central government members and locally elected representatives.

In Colombia, the law clearly states the amount of resources to be allocated to the FCTeI, leaving no room for misinterpretation. The distribution between regions is also defined in advance. The project selection process consists of three stages. The first one is the local/regional government. Private and public entities that apply to FCTeI finance send their proposals first to the regional government, which checks the suitability of the project for regional needs and its strategy. If approved, the project is sent to COLCIENCIAS (Administrative Department of Science, Technology and Innovation), which verifies its compliance with technical requirements. The approved proposals are sent to the Governing Bodies of Administration and Decision (Organo Colegiado de Administration y Decision: OCAD) for a final decision on approval or rejection. This council is represented by the central government, regional government and universities, each with one vote.¹⁷ Projects are approved by a minimum of two favourable votes.¹⁸ COLCIENCIAS, the main national science and technology agency, acts as the technical secretariat of this OCAD but, despite its screening role, it does not have major decision-

¹⁶ This is mostly based on anonymized evaluations

¹⁷ The representative of the regional governments is elected on an annual basis, while the university representative changes every two years (Decree No. 1075, 2012, Art. 12).

¹⁸ Article 31 of Law No. 1530 (2012).

making power over the final selection process (Decree No. 1075, 2012) (Cuervo & López Fonseca, 2013).

In Bolivia and Peru, the rules for NR4K funds mandate preset amounts of resources to recipients. There are no intermediary agencies and funds are allocated directly to the universities. In Peru, 20% of the *canon* funds allocated to regional governments are redirected towards the public universities in the region. On top of that, public universities based in mining regions receive the 5% of the correspondent mining royalties of the region. In Bolivia, 8.62% of the IDH allocated to each regional department must be transferred to public universities. The use of funds by universities is strictly limited to research, allowing little flexibility.¹⁹ The funds in Peru and Bolivia are similar except for the presence of a stronger legal framework in Peru. While in Bolivia the rule-based design is defined by the (presidential) Supreme Decree, in Peru laws guarantee the flow of resources (Law No. 28322, and Law No. 28258), regardless of changes in government.

5.1.3 Multiple stakeholder governance

The management of funds in Chile and Colombia is shared across multiple agencies that are involved in different stages of the decision-making process, allowing for checks and balances. In the case of Chile, the Ministry of Finance has, annually since 2006, decided on the allocation of copper royalties for the Innovation for Competitiveness Fund (Fondo de Innovación para la Competitividad: FIC). The FIC finances projects related to scientific investigations, business innovation, and technology transfer via specialised public agencies in a range of sectoral areas as outlined in the National Innovation Strategy (CNIC, 2007). The operational rules of the FIC state that 25% of the budget must be invested in regional²⁰ projects (60% of which is allocated to regions where copper mines are located, with 40% going to the other regions), while the other 75% ('national') is not subject to any geographic restrictions (OECD, 2013). However, in practice, the regional allocation share has varied between 19% and 27% of the total FIC (national plus regional). The 'national' share of the FIC is managed by an executive secretariat at the Division of Innovation in the Ministry of Economy,²¹ which evaluates and selects the public programmes²² to be financed. The programme proposals are designed and prepared by STI implementing agencies.²³ The guidelines that the Division of Innovation follows for selecting the programmes to be financed are defined by the Inter-Ministerial Committee on Innovation (CMI),

¹⁹ In Bolivia, recent Supreme Decrees have broadened the scope of eligible expenses to include student scholarships.

²⁰ For all administrative regions except for Metropolitan region.

²¹ <http://www.economia.gob.cl/subsecretarias/economia/innovacion-2/el-fondo-de-innovacion-para-la-competitividad-fic>

²² It refers to initiatives managed by public agencies, such as a PhD scholarships programmes, or a programme that provides subsidies to innovation projects in companies.

²³ The major implementation agencies of FIC are: Chilean Economic Development Agency (Corporación de Fomento de la Producción: CORFO), Science and Technology Research Council (Comisión Nacional de Investigación Científica y Tecnológica: CONICYT), Foundation for Agricultural Innovation (Fundación para la Innovación Agraria: FIA), and the Subsecretariat of Economy of the Ministry of Economy through the Millennium Scientific Initiative (Iniciativa Científica Milenio: ICM).

which was established in 2007²⁴ to take charge of the design, coordination and implementation of the innovation policy. The CMI, chaired by the Ministry of Economy, includes several ministries²⁵ related to STI activities. The regional share of the FIC is incorporated into the regional budget, the National Fund for Regional Development (Fondo Nacional Para Desarrollo Regional: FNDR), managed by the Sub-secretariat for Regional Development (Subsecretaría de Desarrollo Regional: SUBDERE). A discretionary share of the regional FIC goes directly to national STI implementing agencies that have programmes tailored to target specific regional needs. The rest of the regional FIC is allocated through an open “call-for-proposals” to finance projects with a regional impact. Only universities and registered²⁶ R&D centres can apply for these calls.

In the case of Colombia, the General Royalty System (Sistema General de Regalias: SGR) defines the institutional arrangements for managing NR rents, with 10% of the SGR dedicated to NR4K through the Science Technology and Innovation Funds (FCTel). The FCTel is allocated to (regional) departments (there are 32 plus the federal district of Bogota, aggregated in six regions) based on a formula defined by Ministry of Finance, which provides more resources to lagging regions. The departmental government receives proposals of projects with local impacts from private and public entities, checking for suitability against the listed requirements on points of sustainability, viability and coherence in accordance with the national development plan for STI. Thereafter, these proposals are submitted to COLCIENCIAS (Administrative Department of Science, Technology and Innovation/Departamento Administrativo de Ciencia, Tecnología y Innovación), the main agency of STI policy, for screening on compliance with the rules set out by the SGR and departmental strategies. The approved proposals are sent to Governing Bodies of Administration and Decision (Órgano Colegiado de Administración y Decisión: OCAD) for final decision on approval or rejection while COLCIENCIA acts as the technical secretariat of the OCAD for the FCTel (Decree No. 1949, 2012) but does not have decision-making power over the selection process (Decree No. 1075, 2012) (Cuervo & López Fonseca, 2013).

OCAD is composed of representatives from three bodies (central government, regional governments, and universities). The representatives of each regional stakeholder rotate yearly or, in the case of universities, biannually. Any approval of a project requires votes from two out of the three representative bodies. It is important to note that the first screening process for each project is undertaken by the corresponding local government, an institution highly exposed to political cycles.

²⁴ This followed recommendations from the OECD and World Bank concerning the separation of the advisory and monitoring role from the design and implementation role.

²⁵ These are the Ministry of Finance, Ministry of Education, Ministry of Foreign Affairs, Ministry of Public Works, Ministry of Transport and Telecommunications, Ministry of Agriculture and Ministry of Social Development.

²⁶ Defined by Law No. 20241 (2008) and Decree No. 68 (2009) of February of 2009 by the Ministry of Economy.

In Bolivia and Peru, on the other hand, universities themselves (recipients) decide on the use of funds. However, central governments have discretionary power over this, as well as providing strict rules on its use, which are enforced by an auditing system.

5.1.4 Transparency

All of the cases analysed provide some transparency—disclosure of information on allocation of resources. In Bolivia, allowing for a couple of years of lag, it is possible to track the resources of the NR4K funds allocated to each university in a given year. In the case of Peru, information related to transfer of canon²⁷ and royalties to each region is accessible but it is difficult to obtain data disaggregated by level for each university. In Colombia, the FCTeI has an allocation described on the website of the General Royalty System (SGR), while in Chile the allocation to each public agency is clear from the public-sector budget law.

Although information on disbursements is mostly available, the expenditure records of NR4K funds are unavailable even at the institutional level as, once the funds flow into the coffers, these are converged with other funds, making them difficult separate. For example, in Bolivia, records are not publically accessible at university level regarding its NR4K financing. In Chile, once the resources from FIC have been transferred to the respective implementation agency, the recipients of FIC funds are less clear because these agencies categorise recipients by programme and not by the source of finance (all count as part of the public budget). The Peruvian case also lacks centralised information regarding investments provided by recipients of the NR4K funds. Colombia is the most transparent amongst our sample since, in addition to the clear rules of allocation; it also has a public database of projects on budgets financed by the FCTeI.

5.2 Dynamic Criteria

5.2.1 Monitoring and evaluation (M&E) system

Monitoring and evaluation (M&E) are critical to ensuring that NR4K mechanisms can be adjusted in response to changing context when necessary. The references to M&E in NR4K fund policy documents are rather scarce across the cases examined. In Chile, M&E on the use of NR4K funds is embedded in the evaluation of the national STI strategy, making it difficult to extract exclusive data. M&E is undertaken by CNID; however, as its role is determined by the President, implementation of evaluations is subject to the political cycle.

²⁷ The “canon” is the share of the total income and rent obtained by the state for the exploitation of NRs that goes to the regional and local governments (Article 1, Law No. 27506 (2001)).

In Colombia, the Department of National Planning (DNP), as part of its regular evaluation responsibilities, conducts selective evaluations of programmes that may include NR4K Fund projects. On top of that, the SGR have established a System of Monitoring, Oversight Control and Evaluation of Royalties (SMSCE), allocating 1% of NR revenue to oversee the investments of all funds that are part of the SGR. SMSCE collects, analyses and provides statistics and reports about the performance of the whole SGR and its executing agencies. Based on these processes, the SMSCE can detect, sanction, and prevent improper or inefficient use of the resources of the SGR. Furthermore, it is entitled to conduct evaluations of projects in each of four dimensions: managerial, operational, output, and impact.

In Bolivia and Peru there is no specific M&E system for the funds. The approach of these central governments is the same as for other public initiatives, with government audits of selected programmes. Since recipients (public universities) have a high degree of autonomy, measures to prevent the misuse of resources are focused on the regulation of eligible expenditures financed with NR4K Funds. Indeed, these tend toward investment in tangibles that may be verified with less difficulty. In Peru, there are external entities (such as international NGOs, Extractive Industry Transparency Initiative (EITI) and civil society) that play a role in M&E on use of NR revenues, which includes their use by regional public universities. The most important external entity is EITI, a global standard to promote open and accountable management of natural resources, of which Peru has been a member since 2007. A National Multi-sectoral Commission (*Comisión Nacional Multisectorial*)²⁸ is responsible for the implementation of the EITI standard in Peru; it comprises representatives from the government, from companies from the extractive industries, and from civil society. The latest publication is the 2014 EITI Report.²⁹ Nevertheless, these are not legally binding and, despite its political advocacy, these institutions are not formally incorporated into to the policy-learning process.

Despite the importance of M&E in overcoming transformative failures, its role is less apparent as a mechanism for ‘self-correction’. Rather, for those countries with some M&E systems, it functions as a means for checking on project implementation, and thus might be considered a fairly static approach.

5.2.2 Appropriate institutional/managerial capacity

Once finances are allocated, it is critical that institutional and managerial capacities are present to ensure the expected goals are attained. In Chile, implementation of the national FIC is concentrated within the two main STI implementing agencies, CORFO and CONICYT. These two agencies have been implementing STI policies for many decades, during which managerial and technical skills for

²⁸ List of members: http://eitiperu.minem.gob.pe/quienes_somos/index.html.

²⁹ 2014 EITI Report: <https://eiti.org/document/peru-2014-eiti-report>.

the design and implementation of programmes have accumulated. The FIC allocated to regions is managed by, on one hand, agencies of the central government (mainly CORFO and CONICYT), entities that may not be able to identify regional needs, capacities or challenges, hampering efficient use of these resources. On the other hand, universities and R&D centres at the regional level may not currently have the capacity to respond to open calls for FIC. Information from various sources (OECD, 2014b) indicates the wide heterogeneity of STI capacities across regions as a potential challenge, although decentralisation is progressing.

In Colombia, the FCTeI fund is implemented at the sub-national, department level. As in the case of Chile, the tacit assumption is that local capacities are sufficient to design and implement relevant STI projects to match the conditions of the department. However, observed differences in utilisation of available funds (Cuervo and Fonseca, 2013) suggest³⁰ the presence of a knowledge gap between STI challenges in the regions and knowledge-producing organisations, with a shortage of capacities for implementing projects at the departmental level.

Peru and Bolivia exhibit a similar problem. Although regional universities receive resources to increase their scientific activities, the evidence shows heterogeneity in execution. This diversity suggests that regional universities are not ready to invest in research due to lack of managerial and technical capacities. This is particularly the case in Bolivia, with a considerable portion of funds remaining unused or spent on infrastructure (academic) rather than research. In the case of Peru, however, CONCYTEC is currently collaborating with universities to take over the administrative role so that funds accumulated by the university during the mining boom can be released for research to enhance productivity (Kuramoto, 2017).

5.2.3 Coordination with other related institutions

Initiatives financed by NR4K funds need to be coordinated with STI institutions in order to have synergistic policy impacts. Coordination between implementing organisations is thus critical for the effectiveness of each country's efforts, yet this is often a difficult task for various reasons.

In Chile, where most FIC resources are embedded into STI policy infrastructure, there is a high level of policy coherence between FIC management and STI institutions. FIC resources are exclusively invested by public agencies with considerable experience in STI policy. However, this also can mean that any design and operational flaws of current STI institutions will be replicated with FIC resources. For instance, since the main STI authorities are appointed by the government, the incentives to invest

³⁰ For example, in Colombia, in 2012-2014, out of 33 departments, 7 did not use their allocated FCTeI funds, and 20 used less than 50% of the amount allocated. In 2015-16, utilization improved somewhat with just 1 department using none, 4 using less than 50%, while 27 used more than 50%. A similar tendency can be observed in regional universities in Bolivia. Interviews in Peru also indicate the same trend.

in projects that generate short-term impacts or with broad coverage to gain popularity are considerable. These types of projects may only provide marginal increases in already existing capabilities. Since FIC resources are channelled through STI authorities, there is limited space for funds to be used in complementary or exploratory activities with impacts that extend beyond the political cycle. In addition, coordination with regional stakeholders is rather weak. FIC-financed regional projects are selected by locally elected authorities, which respond, rightfully, to local demands. However, since this regional attribution is driven mostly by a decentralisation policy target (Aninat et al., 2010) it is not obvious whether the regional FIC funds are addressing local STI targets or merely duplicating the policy of central government..

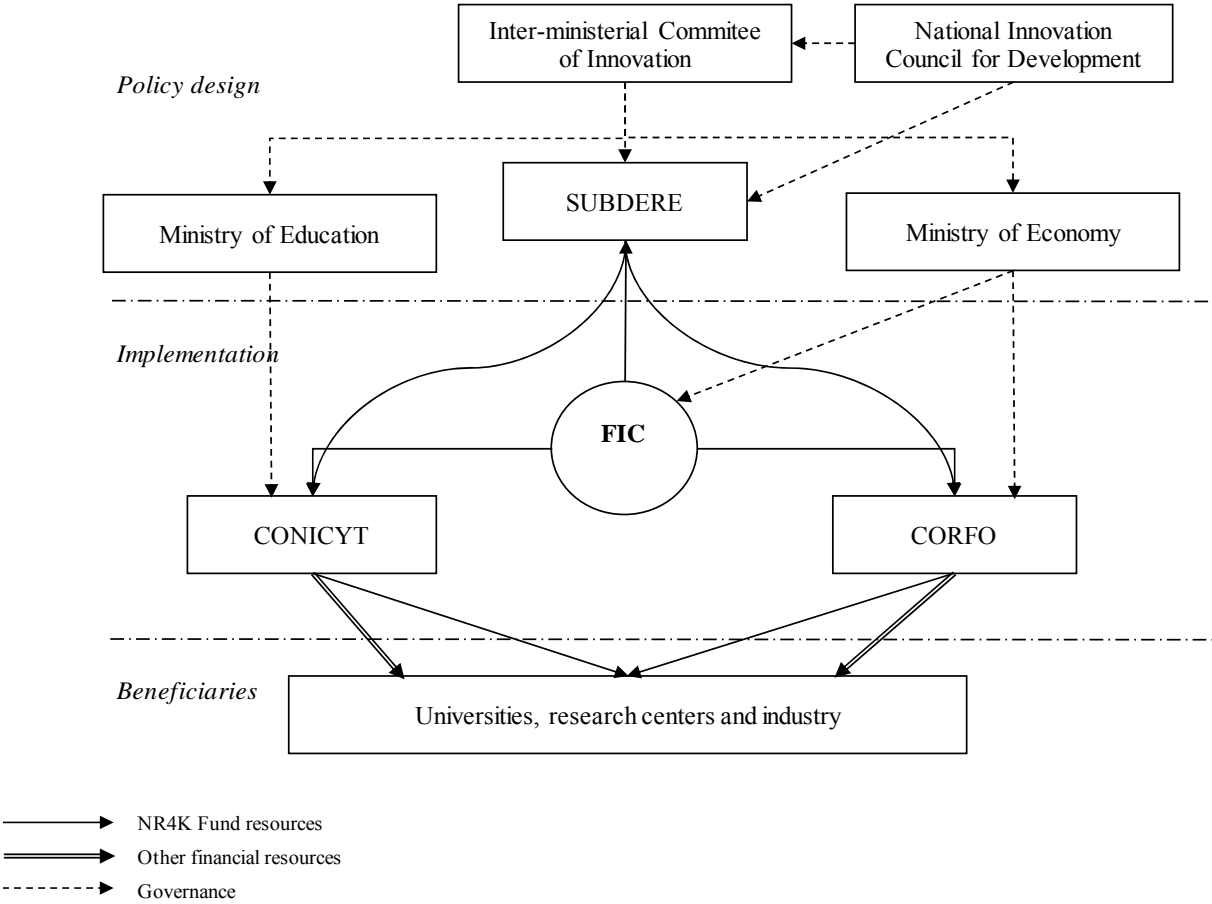


Figure 5: Simplified diagram of STI institutions and NR4K funds in Chile

Note: SUBDERE: regional government, CONICYT: National Science and Technology Research Council, CORFO: Chilean Economic Development Agency.

In Colombia, COLCIENCIAS is the coordinating agency for CTeI for the national STI strategy. However, funds are invested in regional projects according to regional priorities. COLCIENCIAS can only intervene in use of FCTel in two ways: a) directly checking compliance with the basic requirements for projects in the early phase, and b) indirectly supporting regional governments in the

development of departmental strategies. COLCIAENCIA’s control is becoming increasingly limited as its budget has been regularly downsized since its establishment. This has undermined its power to negotiate and its capacity to introduce complementary policies that could increase returns on FCEI-backed investments.

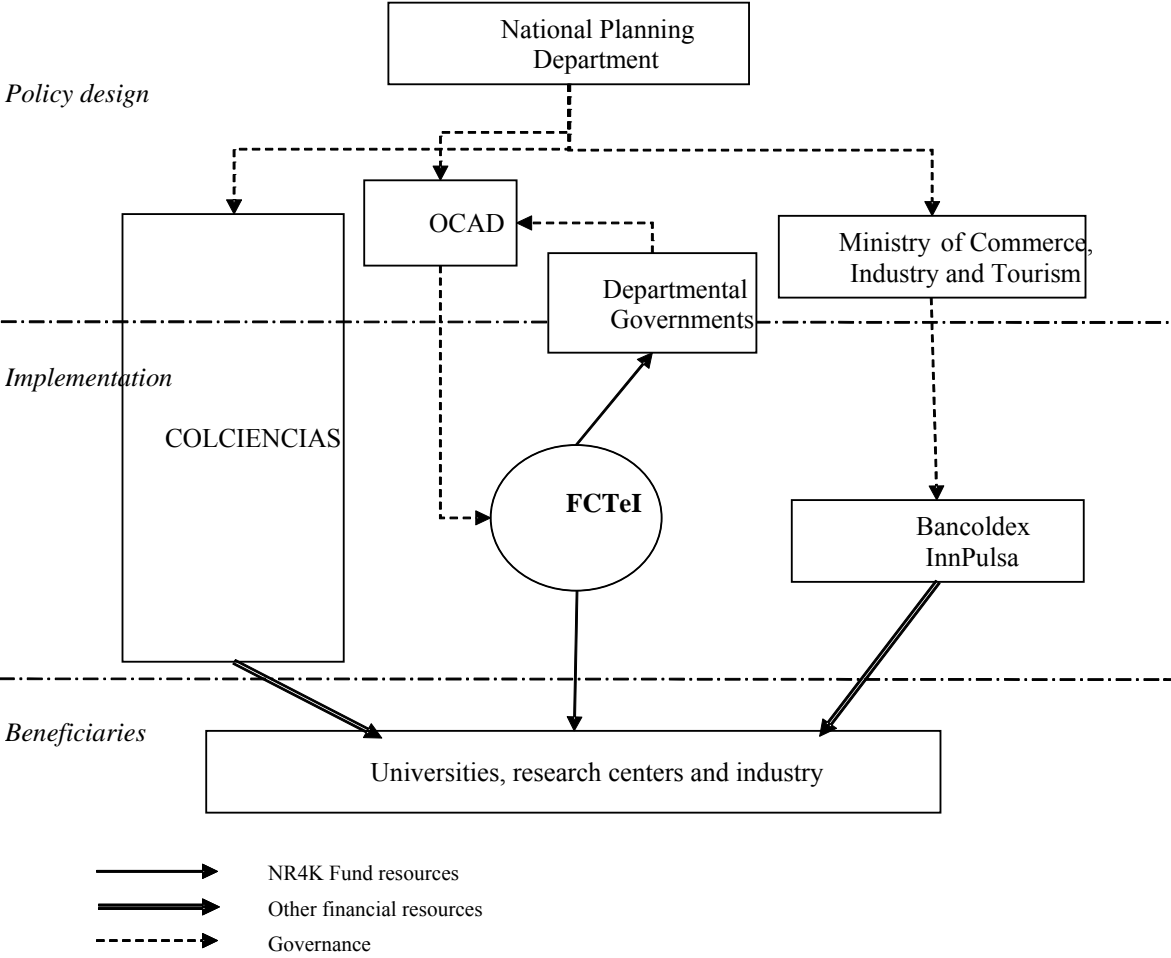


Figure 6: Simplified diagram of STI institutions and NR4K funds in Colombia

Note: OCAD (Organo Colegiado de Administracion y Decision); Cociencias (Administrative Department of Science, Technology and Innovation); COLCIENCIAS (Administrative Department of Science, Technology and Innovation).

In Peru, although the main goals of the canon are related to STI policy objectives, there is no clear link between STI institutions and use of the funds. The recent publication of the national STI strategy, coordinated by CONCYTEC (National Council of Science, Technology and Technological Innovation), is somehow independent of NR4K funds’ investment decisions. Nevertheless, formal agreements between public regional universities and CONCYTEC are being implemented in an attempt to provide the managerial skills needed to invest in research (Kuramoto, 2017). Such interactions may create policy space for coordination with national policies.

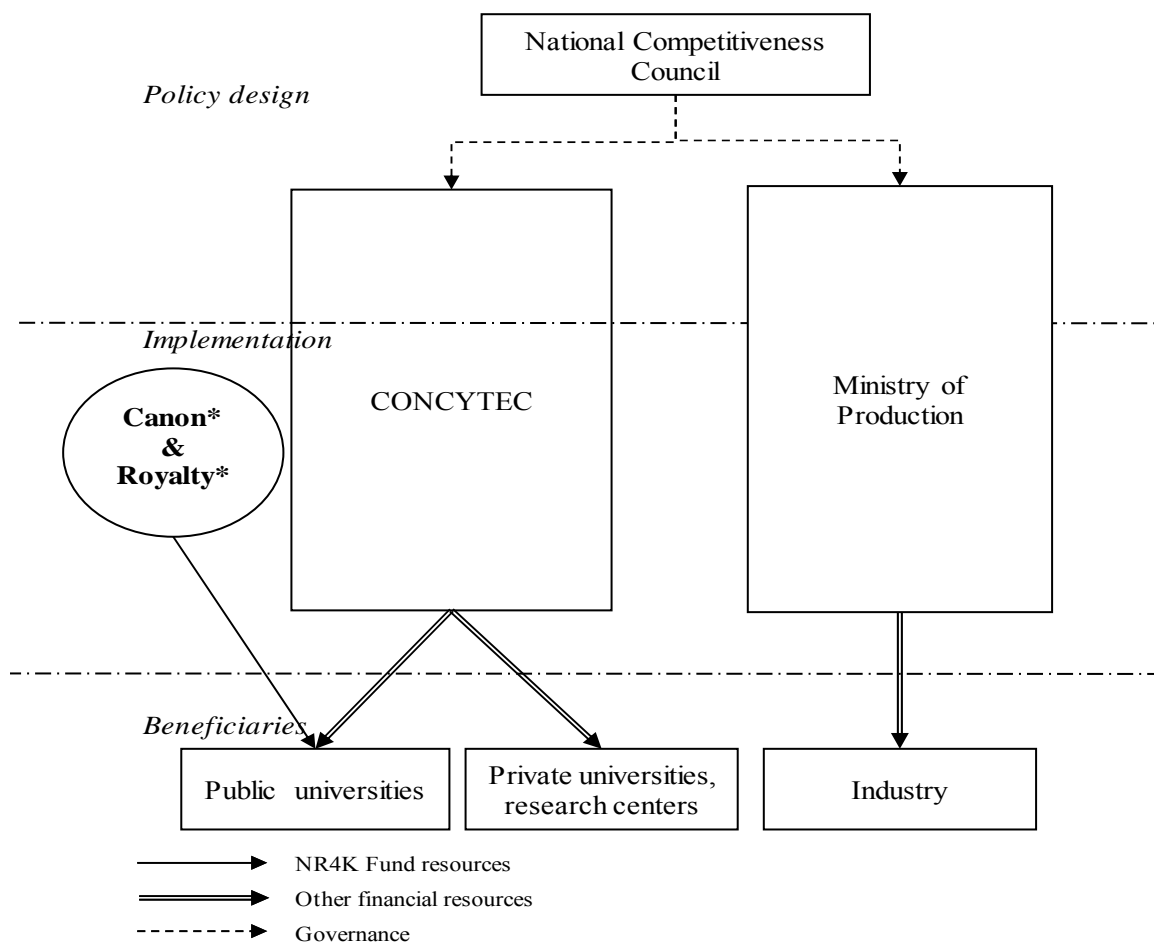


Figure 7: Simplified diagram of STI institutions and NR4K fund in Peru

Note: CONCYTEC: National Council for Science and Technology, *partially

In Bolivia, STI institutions are still at an embryonic stage. The country has strong policy commitments towards the use of NRs to diversify the economy and propel economic development, at both the policy-design or implementation level. However, public agencies do not have decision-making authority over the role and use of NR4K funds, with the funds coming from IDH. At the same time, the STI system is under-capacity in comparison to the size of the NR4K fund. Hence, there is a lack of coordination between investments of NR4K funds and the national strategy of diversification.

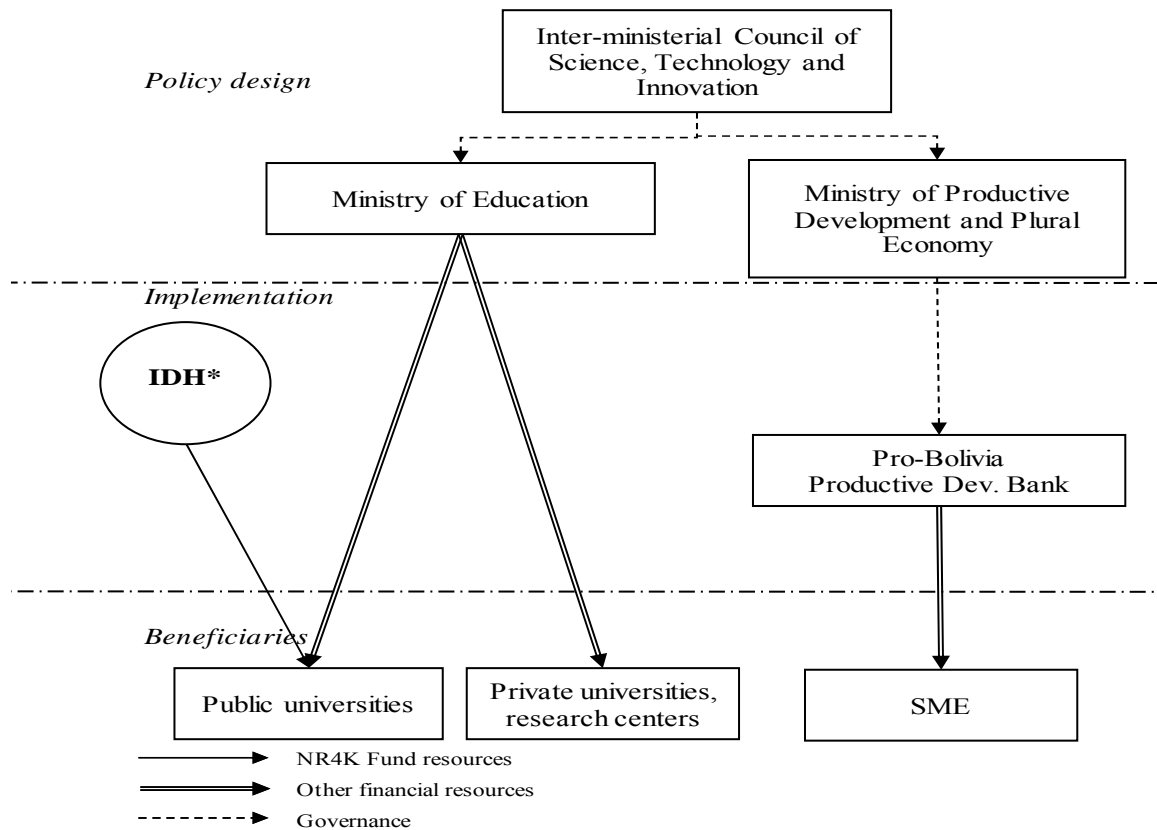


Figure 8: Simplified diagram of STI institutions and NR4K funds in Bolivia

Notes: IDH: Direct Tax on Hydrocarbons (partially), SME: Small and Medium Enterprise

5.3 Discussion

Diversifying an economy through investment in knowledge (STI) requires a combination of short, medium and long-term goals, as well as a mix of traditional and experimental approaches. If these are not set out clearly in the design of the funds, investment decisions are likely to be influenced by political cycles, and thereby be biased towards projects with short- (or medium-) term objectives that offer a low degree of risk and may be under the influence of powerful stakeholders. While static design principles attempt to ensure consistency and transparency to diminish the possibility of corruption, rigid rule-based design may hamper efficient use of the funds over the long term without some flexibility. For example, in Bolivia and Peru, due to the shortfall of capacities in research management, universities appear unable to cope with sudden increases in inflow of research funds, especially lacking the means to convert them into research output. This problem is compounded by the fact that the funds cannot be used for salaries to hire researchers, as they are exclusively targeted towards research. The management capacity problem is even more marked for universities in regions³¹ where the shortage of personnel is severe. As a result, a higher proportion of funds is left unused in

³¹ Information on Peru was obtained from interviews with Juana Kuramoto Huamán and Claudia Suaznabar and, for Bolivia, with Mauricio Céspedes Quiroga.

some regions. Even when used, the funds are spent on investments in physical infrastructure (ICT equipment and research facilities), which do not generate sufficient new human capacity to ensure sustainability.

In contrast to static design criteria, dynamic design criteria can be used to examine institutional abilities to implement policies and improve effectiveness in meeting ‘evolving’ policy goals. Under this category, the striking finding across the cases is the absence or scarce use of monitoring and evaluation (M&E) systems. Even where M&E is present, the political cycle often interrupts projects, preventing them from undergoing an adequate evaluation process. For instance, in Chile, CNID’s activities after the change of government were substantially reduced, with many projects discontinued even before the M&E phase was able to internalise the experiences at the institutional level.

The country cases also demonstrate great variations in the level of institutional capacity to manage and use the funds for their intended purposes. All the countries studied are in the process of decentralisation and enhancement of regional knowledge bases and capacities. This is being accomplished through the transfer of resources from NRs by utilising NR4K funds. While these are desirable policies that allow the promotion of bottom-up economic development, the cases demonstrate weak administrative capacity and technical expertise in the regions. The necessity of complementary measures in upgrading capacity is increasingly being recognised.

Lastly, there are also differences in the degree of coordination between NRs and STI activities. In Chile and Colombia, NR4K funds rely, to differing extents, on current STI institutions, which ease the disbursement of the funds. However, integration into existing STI institutions exposes the activities of NR4K funds to ‘policy volatility’ caused by political cycles. Such policy settings deter decisions on investments that, although riskier, may have more transformative impacts.

Furthermore, misaligned incentives between central and regional branches of government are reducing the effectiveness of the use of the NR4K funds. The coordination among key stakeholders is critical. This was particularly observable in Colombia where most of the resources are invested at the regional level which had weak coordination with the central level due to decline of COLCIENCIA’s intermediary role reflected in reduction in its own budget. The lack of coordination between STI institution systems and the use of funds by universities is evident in the cases of Peru and Bolivia, where there is no formal link between NR4K funds and STI institutions. This missing space to link important stakeholders hinders the provision of complementary public policies that may increase returns on NR4K fund investments.

6 Challenges and policy implications

Many LA countries suffer from low productivity growth. The importance of enhancing productivity was recognised when the commodity cycle was in boom. This enabled some countries—such as Bolivia, Chile Colombia and Peru—to introduce institutional mechanisms for transferring revenues from NRs and investing in knowledge (STI areas) by utilising NR4K funds in the hope of diversifying their economic activities. These policy interventions (Arrow, 1962; Nelson, 1959) are, in theory, steps in the right direction to overcome market failures of underinvestment in knowledge. Nevertheless, a brief examination of available indicators on knowledge output demonstrates that such attempts have not generated the expected results.

This paper utilised the design principle of managing public finances for innovation to examine existing attempts to promote NR4K in LA. The goal was to understand factors that may potentially hamper NR4K funds to improve productivity and diversification of economy by examining existing cases. These insights may prove useful for resource-rich countries in other regions, especially considering ways of shifting their developmental pathways.

6.1 Need for ‘investing in investing’: capacity building of public agencies

Activities to build capacity are usually targeted at recipients of funds, while training for implementing agencies is often not included in the policy package. The cases of the four countries examined in this paper demonstrate that a major bottleneck for implementation is the lack of capacity in agencies, especially for those located in the regions. This has particular importance, as each country examined in this paper is undergoing a process of decentralisation with a graduated allocation of funds in favour of remote and socio-economically weak regions. While such attempts are intended to even out regional disparities, without complementary policies to support capacity building in the transitional phases, the effective use of funds cannot be expected.

For instance, monitoring and evaluation processes can provide good learning opportunities via building effective feedback loops, but these require the presence of capable public officers following the logic of absorptive capacity (Cohen and Levinthal, 1990). This is consistent with Collier's (2010) claim regarding the need for ‘investing in investing’ to create policy-inducing environments. The successful use of funds is not just a matter of providing appropriate financial resources but also in ensuring systemic resources—as public goods—such as infrastructure (social and economic) and human resources.

6.2 Introduce controlled flexibility in rigid rule-based design

Achieving a balance between rigidity and flexibility for rule-based design is difficult. A cautious approach is understandable, especially regarding the use of funds from NRs designated for a specific purpose, even if this is sometimes rather vague. At the same time, to ensure effective implementation, design principles should be made adjustable to the changing realities of a given context. For instance, the prohibition on using NR4K funds for salaries of researchers and administrators is important in ensuring that such funds are targeted towards research activities. While this is true, owing to the shortage of human resources in regional universities, the provision of a ‘phase out’ period may encourage researchers to move to the regions to ease acute shortages in human resources. In fact, CONCYTEC in Peru is initiating programmes to support the transfer of managerial know-how for research funds to some of their regional universities (Kuramoto, 2017). This flexible and nuanced implementation of given policies can contribute to creating a ‘policy inducing environment’, thereby enabling the more effective use of funds.

6.3 Ensuring a long-term and overarching strategy while executing short-term projects

Finding a balance between long-term strategies and short-term projects is difficult without good coordination and understanding of shared goals among the diverse stakeholders involved. As the political cycle often favours policies that generate clear impacts in the short-term, various programmes do not survive long enough to be subjects of evaluation to bring about policy learning. This tendency is particularly pronounced in LA countries.

As seen in the examples of SITRA and OCS, the goal of transforming an NR-based activity into a knowledge-based one requires an organisation that consistently implements radical programmes (Breznitz & Ornston, 2012). Such organisations need to be insulated from the political cycle with a steady flow of resources yet with flexibility to ‘auto’-adjust to suit changing policy contexts. Such mechanisms are the missing linchpin for LA countries characterised by their ‘policy volatility’ due to the historical design of their governance systems (Murillo, Scartascini & Tommasi, 2008).

As the use of extractive NRs demands consideration of how current benefits can be distributed to future generations, it is desirable to isolate a part of the resources within the static design of NR4K funds to finance the tasks of ‘Schumpeterian development agencies’ (OECD, 2014a). This does not entail taking more risky options in the future but creating a portfolio of projects to spread out risks, by mixing short, medium and long-term prospects (e.g. portfolio approach). The dynamic capabilities in identifying the agenda and identifying appropriate policies are critical for countries aiming to diversify the economy. The institutional framework that aims to transform the economy, therefore, requires both static and dynamic design criteria as overarching guidelines.

6.4 Limitations of this study

This paper examined unique cases in LA where similar yet different institutional setups appear to link NR finances in diversifying the economy through enhancing the knowledge base. While these cases are of relevance to other resource-rich countries, the following limitations may apply. First, a favourable political climate was present at the time of the introduction of NR4K funds in all the cases in LA, which may not be the case for the other countries. Second, the commodity boom, by providing increasing inflows of money, made it easier to introduce changes in institutions that involved allocation of resources from non-renewable NRs.

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Appendix 1 : Detailed description of the organizational structure of NR4K funds

A.1 Chile

Since 1987, Chile's Copper Stabilization Fund has successfully insulated fiscal revenues from the cyclical fluctuations of copper prices (OECD 2014c). In 2005, a new tax specific to mining activities was created (Law No. 20097, which came into force on January 1, 2006) (Olivari, 2016). This tax is paid by mining companies based on their taxable operational income depending on the amount of copper that is produced in a given year (between 0.5% and 34.5%) (Law No. 20026, 2005; Law No. 20469, 2010). Reflecting the increasing relevance of STI policies for the country the Innovation for Competitiveness Fund (*Fondo de Innovación para la Competitividad*: FIC), a NR4K fund, was founded in 2006. The initial idea was to finance the FIC with the entire amount collected by the recently created copper royalties.¹ However, the bill to establish a formal mechanism was never passed. Since then, the FIC has received an amount equivalent to a variable share of the royalties, which is decided annually when the public-sector budget is approved by law.

The FIC provides finance for projects related to scientific investigations, business innovation, and technology transfer via specialized public agencies in a range of sectoral areas as outlined in the National Innovation Strategy (CNIC, 2007). The operational rule of the FIC states that 25% of the budget must be invested in regional² projects (with 60% allocated to regions where copper mines are located, and 40% to other regions). While the other 75% (the 'national' allocation) is not subject to geographical restrictions (OECD, 2013), in practice, the total regional allocation share (national plus regional) of the FIC has varied between 19% and 27%.

The national share of the FIC is managed by an executive secretariat at the Division of Innovation in the Ministry of Economy,³ which evaluates and selects the public programs⁴ to be financed. The program proposals are designed and prepared by STI implementing agencies.⁵ The guidelines that the Division of Innovation follows for selecting the programs to be financed are defined by the Inter-Ministerial Committee on Innovation (CMI), which was established in 2007⁶ to take charge of the design, coordination and implementation of the innovation policy. The CMI, chaired by the Ministry of Economy, includes several ministries⁷ related to STI activities.

The regional share of the FIC is incorporated into the regional budget, the National Fund for Regional Development (Fondo Nacional Para Desarrollo Regional: FNDR), managed by the Sub-secretariat for Regional Development (Subsecretaría de Desarrollo Regional: SUBDERE). A discretionary share of the regional FIC goes directly to national STI implementing agencies that have programs tailored to target specific regional needs. The rest of the regional FIC is allocated through open "call-for-proposals," to which universities and registered⁸ R&D centres can apply, for financing projects with a regional impact.

A.2 Colombia⁹

The General Royalty System (Sistema General de Regalías: SGR) is an institutional arrangement that manages the revenues from the exploitation of non-renewable natural resources in Colombia. Article 16 of Law No. 756 (2002), determines the percentages to be paid in terms of royalties for mineral resources and hydrocarbons. Depending on the mineral resource, royalties can range from 1% up to 12%. For hydrocarbons, royalties are set between 8% and 25%. The current system¹⁰ was established via the enactment of Law No. 05 (2011) which went into force in 2012 (Cuervo & López Fonseca, 2013; DNP, 2011). The SGR's main objective is to support social, economic, environmental, and regional development (Cuervo & López Fonseca, 2013).

A part of SGR is an NR4K fund. It is called the Science Technology and Innovation Funds (FCTel),¹¹ which receives 10% of the resources of the SGR (Cuervo & López Fonseca, 2013). The main objective of the FCTel is to finance scientific and technological activities that stimulate productive development, such as research and development, innovation, scientific and technological capacity

building, and scientific-technological services (Article 32, Law No. 1530, 2012; OECD, 2014a). The FCTeI is allocated to (regional) departments (there are 32 plus the federal district of Bogota, aggregated in six regions) based on a formula defined by Ministry of Finance,¹² which provides more resources to lagging regions. The same law stipulates that distribution is determined by the percentage of the total population of Colombia living in each respective department, as well as relative poverty. Moreover, Article 2 of Law No. 05 (2011) holds that resources belonging to the FCTeI should be used in accordance with national and regional development plans.

The departmental government receives proposals of projects that are expected to have a local impact from private and public entities, and checks for suitability against the listed requirements on points of sustainability, viability and coherence in accordance with the national development plan for STI. Thereafter, these proposals are submitted to COLCIENCIAS (Administrative Department of Science, Technology and Innovation/Departamento Administrativo de Ciencia, Tecnología y Innovación), the main agency of STI policy, for screening on compliance with the rules set out by the SGR and departmental strategies. The approved proposals are sent to the Governing Bodies of Administration and Decision (Órgano Colegiado de Administración y Decisión: OCAD) for final approval or rejection. Through the OCAD, project ideas for funding are identified and formulated into proposals, essentially those that are bottom-up from the department level. In this council, universities, central government and regional governments are represented, each possessing one vote. The representative of the regional governments is elected on an annual basis, while the university representative changes every two years (Decree No. 1075, 2012, Article 12). COLCIENCIAS acts as the technical secretariat of the OCAD for the FCTeI (Decree No. 1949, 2012) but does not have decision-making power over the selection process (Decree No. 1075, 2012) (Cuervo & López Fonseca, 2013). According to Article 31 of Law No. 1530 (2012), decisions are taken by a minimum of two ‘yes’ votes, with the national government, departmental governments, and universities each having one vote.

A.3 Peru

There are two NR4K funds in Peru that, in practical terms, work as one. These funds are set by the laws concerning NRs called *canon* law¹³ and mining royalty law.¹⁴ Both allocate resources to support science and technology activities. The *canon* collects 50% of the corporate taxes paid by firms to the Peruvian government, which are devoted back to the regions. Canons exist for the following sectors: mining, hydropower, gas, fisheries, and forestry. On the other hand, royalties are paid only by mining companies and the rate depends on the operating margins of mining companies (between 1% and 12%).

The canon is distributed to subnational governments at various levels (Law No. 28322, 2004):¹⁵ 10% to municipalities, 25% to district municipalities and provinces, 40% to local governments and departments of the regions and 25% to regional governments (Article 3). Regional governments are obliged¹⁶ to transfer 20% of their received “canons” to public universities in the region to be used for investment in scientific and technological activities. Mining royalties are allocated to NR-producing regions. The percentages of the allocations are laid out in the old mining royalties’ law from 2004 (Law No. 28258). As laid down in Article 9, the amount that goes to the universities should be spent on scientific investigations and investment in technology, with the remainder used for sustainable development in the regions. Five percent is allocated to national universities of the region where the exploitation of the natural resource takes place.

Based on the *canon* and royalty laws, the objective of the NR4K is to finance “...exclusively investments in scientific and technological research that promote regional development” (*canon* law), and “... exclusively investments in scientific and technological research” (royalty law). Although the NR4K funds are transferred directly to universities, the investment decisions are restricted by rules on eligible expenditures set by the Ministry of Finance on an annual basis and formalized through the public-sector budget law.

A.4 Bolivia

In Bolivia, several taxes related to exploitation of NRs have been established over the last 20 years.¹⁷ Amongst these, the direct tax on hydrocarbons (IDH) (Law No. 3058, 2005) has provided the resources for establishing a NR4K fund. The tax rate of the IDH is 32% and is paid on the total production of hydrocarbons measured at the point of audit (Law No. 3058, 2005, Article 55). The Supreme Decree No. 28421 defined the distribution rule of the IDH: 12.5% of the total IDH to be distributed between producers' departments,¹⁸ and 6.25% of the total IDH to each non-producer department. Supreme Decree No. 28421 (2005) also created the NR4K fund, stating that the 8.62% of the IDH allocation to each department must be transferred to public universities. In 2007, Article 2 of Supreme Decree No. 29322 (2007) modified the allocation rule within departments, although maintaining the share of the NR4K fund, to the following:

- Municipalities of the department distribute funds based on the number of inhabitants receive 66.9%;
- public universities¹⁹ of the department receive 8.62%; and
- the prefecture of each department receives the remaining amount (Supreme Decree no. 29322, 2007).

The NR4K fund does not have a specific objective, but the Supreme Decree states that all beneficiaries of IDH resources should invest their funds following the National Development Plan (Supreme Decree No. 29272, 2007). While public universities possess considerable discretion on how to spend this income, the central government can, at its own discretion, define new eligible types of investments through Supreme Decrees (such as Supreme Decree 961, 2011; Supreme Decree 1322, 2012). On top of that, the central government has auditing power over IDH expenditures through the Ministry of Economy and Finances (IMF, 2010).

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¹ In the same year, the Fiscal Responsibility Law (FRL) transformed Chilean Natural Resource Funds (NRF), the Copper Stabilization Fund was transformed into a broader sovereign wealth fund and renamed it the Economic and Social Stabilization Fund. This change strengthened its fiscal framework with a clearer set of rules to maintain macroeconomic stability (de Melo, 2008).

² Includes all administrative regions but the Metropolitan, where the capital, Santiago, is located.

³ <http://www.economia.gob.cl/subsecretarias/economia/innovacion-2/el-fondo-de-innovacion-para-la-competitividad-fic>

⁴ This refers to initiatives managed by public agencies, such as a Ph.D. scholarship programme, or a programme that provides subsidies to innovation projects in companies.

⁵ The major implementation agencies of FIC are: Chilean Economic Development Agency (Corporacion de Fomento de la Produccion: CORFO), Science and Technology Research Council (Comision Nacional de Investigacion Cientifica y Technologica: CONICYT), Foundation for Agricultural Innovation (Fundacion para la Innovacion Agraria: FIA), and the Subsecretariat of Economy of the Ministry of Economy through the Millennium Scientific Initiative (Iniciativa Cientifica Milenio: ICM).

⁶ This follows recommendations by the OECD and World Bank concerning the separation of the advisory and monitoring role from the design and implementation role.

⁷ These are: Ministry of Finance, Ministry of Education, Ministry of Foreign Affairs, Ministry of Public Works, Ministry of Transport and Telecommunications, Ministry of Agriculture and Ministry of Social Development.

⁸ Defined by Law No. 20241 (2008) and Decree No. 68 (2009) of February of 2009 by the Ministry of Economy.

⁹ Development of the STI policy in Colombia is well documented in OECD (2014, Chapter 4, Section 2).

¹⁰ Prior to the most recent reform in 2011, the General System of Participation of 1994 (Sistema General de Participaciones: SGP) was in place to manage mining royalties. This allocated 80% of natural resources (NR) royalty revenue to NR producing regions (65% royalties to the oil/mineral producing department and 15% to the producing municipalities) and the remaining 20% to the NRF. As the NR-producing regions in Colombia represent only 17% of the total population, this law significantly favours the NR-producing regions in financial terms (OECD, 2015). The use of funds allocated to regions (80%) was earmarked to finance improvements in education, healthcare, clean water and sewage within the general guidelines, while the royalties distributed to the National Royalty Fund (20%) mainly financed the development of infrastructure for the mining sector.

¹¹ <http://www.colciencias.gov.co/blog/regal-para-la-cienciatecnolog-e-innovaci-n>.

¹² Unmet Basic Needs Index.

¹³ The “canon” is the share of the total income and rent obtained by the state for the exploitation of NRs that goes to the regional and local governments (Art. 1, Law No. 27506 (2001)).

¹⁴ Mining royalties are the economic remunerations paid to the state for the exploitation of metallic and non-metallic mineral resources (Art. 1, Law No. 29788, 2011).

¹⁵ The canon is distributed among regional and local governments according to rules set by the Ministry of the Economy based on criteria such as population and unmet basic needs (necesidades básicas insatisfechas) <https://www.mef.gob.pe/es/politica-economica-y-social-sp-2822/150-transferencia-y-gasto-social/2296-canon-metodologia-de-distribucion>

¹⁶ Law No. 28077 (2003)

¹⁷ These are: a mining royalty (Law No. 535, 2014), a hydrocarbons royalty (Law No. 3058, 2005), a special tax on hydrocarbons and its derivative (IEHD) (Law No. 1606, 1994), and a direct tax on hydrocarbons (IDH) (Law No. 3058, 2005).

¹⁸ Primary regional subdivision of the country. Bolivia has nine departments.

¹⁹ If there are two or more public universities in the department, distribution is agreed upon between Ministry of Finance, Ministry of Education and CEUB (Executive Committee of the Bolivian Universities, Comité Ejecutivo De La Universidad Boliviana, and the benefiting universities).

Appendix 2: Acronyms

CEPAL	Economic Commission for Latin America and the Caribbean
CMI	Inter-Ministerial Committee on Innovation
CNID/CNIC	National Council for Innovation and Development
COLCIENCIAS	Administrative Department of Science, Technology and Innovation
CONCYTEC	National Council for Science and Technology
CONICYT	National Science and Technology Research Council
CORFO	Chilean Development Agency
CTeI	Science, Technology and Innovation
DNP	Department of National Planning
EITI	Extractive Industries Transparency Initiative
FCTeI	Science, Technology and Innovation Fund
FIC	Innovation for Competitiveness Fund
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
IDH	Direct Tax on Hydrocarbons
LA	Latin America
M&E	Monitoring and Evaluation
NGO	Non-Governmental Organization
NPM	New Public Management
NRs	Natural Resources
NR4K funds	Natural Resources for Knowledge Economy Funds
NRF	Natural Resource Fund
OCAD	Public Sector Management Body
OCS	Israeli Office of the Chief Scientist
OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
SGR	General Royalty System
SITRA	Finnish National Fund for Research and Development
SME	Small or Medium Enterprise
SMSCE	System of Monitoring, Oversight Control and Evaluation
STI	Science, Technology and Innovation
SWF	Sovereign Wealth Fund

Appendix 3. List of interviews conducted

Name: Ms. Juana Kuramoto Huaman, Director of Politics/Policies and programs related to STI at CONCYTECH (National Science and Technology)

Date: 5th August, 2015

Interviewer: Jakob Baumann via Skype

Date: March 1st, 2017,

Interviewer: Michiko Iizuka in person in Lima, Peru.

Name: Ms. Claudia Suaznabar, Senior Specialist, Division for Competitiveness and Innovation in IADB

Date: 7th and 10th of September, 2015

Interviewer: Jakob Baumann via Skype

Name: Mr. Mauricio Cespedes Quiroga, Coordinator of Bolivia's Science and Technology System, Vice Ministry of Science and Technology, Ministry of Education

Date: 12th August, 2015

Interviewer: Jakob Baumann via Skype

Date: April 4th, 2017

Interviewer: Michiko Iizuka in person in Maastricht, the Netherlands

Name: Mr. Juan Carlos Navarro, Division for Competitiveness and Innovation in IADB

Date: 28th January, 2016

Interviewer: Michiko Iizuka in person in Panama City, Panama

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