UPGRADING INSTITUTIONAL CAPACITIES IN INNOVATION POLICY IN CHILE

CHOICES, DESIGN, AND ASSESSMENTS

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Abstract:
Innovation is crucial for development. A set of institutional capacities and coordinated actions between the public and private sectors are required to drive large mission-oriented policies (MOIPs) to address priority issues and set a direction for the path of development. This work identifies what restrictions exist in institutional and policy capacities that hinder the design and implementation of MOPs in Chile. This work is based on a case study design. The study analyzes the design and implementation of two strategic programs for innovation and development in the solar energy and mining sectors. The study showed that the capacities of the programs analyzed were evident in the construction of a shared vision and the identification of innovation-led solutions for the development of the two sectors, but the lack of leadership from the government hinders the implementation of the programs, particularly because of the lack of coordination between government agencies and ministries for budget allocation and strategy definition.

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1 INTRODUCTION

Fostering innovation is undoubtedly one of the most important challenges still facing countries in Latin America and the Caribbean. A strong innovation ecosystem is the best way to boost productivity and create the conditions for sustainable and inclusive growth. But, which is the best way to promote innovation? What is the role of the state?

Historically, approaches to tackling grand challenges through targeted innovation policies have very effectively created markets and demonstrated the roles the public sector and the government have within countries' innovation systems (Mazzucato, 2015). Many of the global challenges that countries are facing, such as climate change, sustainable growth, and an aging population, are not only political issues requiring traditional policy responses, but also innovation and technological challenges (see for example Mazzucato, 2017). Adopting a mission-oriented policy (MOP) approach implies designing, developing, and monitoring policy instruments where the public sector sets the objective of solving a specific technological or societal challenge that requires significant technological advances to be achieved (Mazzucato and Penna, 2016).

But how can MOPs be recognized? According to the most recent literature, mission-oriented projects are built around a concrete technological or societal challenge, involve diverse stakeholders from the public and private sectors, and set a relevant and verifiable (and quantifiable) target to be reached in a predetermined amount of time. The public sector has to play a leading role in bringing together the diverse stakeholders to co-create and govern the mission (Mazzucato, 2018a). Appropriate governance is the key feature of successful MOPs. The literature has pointed out that a successful MOP requires a set of institutional capacities and coordinated actions between the public and private sectors. Beyond governance, six factors have emerged as critical to the success of a mission (Mazzucato and Penna, 2016):

1. **The public resources needed to address the challenge and the ability to use these resources.**
2. **The technical capacity to translate the challenge into a quantifiable mission and the ability to concretely design the implementation framework.**
3. **The set of policy instruments to achieve the mission and the ability to harness the full potential of these instruments.**
4. **A sound and dynamic science and technology ecosystem able to create science-based solutions to the challenge.**
5. **The readiness of the productive sector and the capability to efficiently exploit existing productive resources and explore new productive possibilities.**
6. **Consumer and financial markets and the ability to meet demand (effective or latent) and attract financial resources.**

This approach to innovation policies seems particularly relevant for countries like Chile that have economies based on natural resources and industrial ecosystems characterized by low productivity and high labor intensity, and have relatively developed institutional frameworks. However, up to now, Chile's policies to foster and promote innovation have not been successful. In 2015, Chile's research and development (R&D) expenditures were reported to be 0.38 percent of GDP. This low level of R&D expenditures undoubtedly reflects a poorly diversified productive structure. However, it is also the result of a weak innovation ecosystem, with coordination inefficiency between actors and a lack of strategic focus, which is a direct consequence of several years of weak innovation policies.

Most importantly, Chile still needs to build stronger consensus regarding the role of the government and public investments to promote innovation. Nonetheless, during recent years, Chile has developed new approaches to innovation policies by broadening the sets of instruments and strengthening institutional capacities. Some of the actors operating in Chile's innovation ecosystem, such as the Corporación de Fomento de la Producción (the Production Development Corporation, or CORFO) and the National Council on Innovation for Development, have the capacity and the potential to become actors of change. In this context, a mission-oriented policy (MOP) approach could be a turning point for Chile's innovation policies, facilitating the identification of long-term priorities and setting the bases for sustained growth.

2 Research Design

To identify and analyze the institutional capacities and capabilities hampering the development of MOP in Chile, we conducted two case studies. The exploratory approach of a case study research strategy is useful to gather information on contemporary and multidimensional phenomena. Although case studies are not statistically representative of entire populations, they allow researchers to build analytical generalization.

The objective of the two cases was to identify institutional constraints to MOP implementation in Chile. We chose to study solar energy as an enabling factor for innovation-based development and mining as a platform for virtuous, sustainable, and inclusive development. The unit of analysis is the process of designing and implementing the programs. Both primary and secondary sources were used to analyze the cases. Semi-structured interviews conducted between the end of 2018 and the beginning of 2019 were the main source of information. The outcome of the interviews was presented, discussed, and validated in two one-day workshops with sectoral stakeholders.

3 Mission-Oriented Policies in Chile

In Chile, innovation, and public policies in general, are highly politicized and depend strictly on each political party's vision of the role of the public sector. During the past two decades, the focus of science, technology, and innovation (STI) policies in Chile has often been on improving competitiveness and fostering economic development, rather than on tackling specific challenges. Most of the policies have been designed following the market-failure correction framework, with limited focus on the opportunity to create new markets or set a direction for existing ones.

Since the mid-2000s, and independent of the political party of the administration, the focus of public policies has been promoting diversification of the productive structure through a more or less explicit focus on innovation policies. The only difference between the diverse administrations has been the nature of the policy mix to implement the diversification strategies: selective (in the case of center-left coalitions) or horizontal (in the case of center-right coalitions). During previous administrations, the policy discourse has mainly focused on social inclusion and public education.

Since 2014, diverse ministries and public agencies have started designing policies to tackle Chile's future development challenges. Since then, many initiatives have been designed to tackle strategic national challenges, such as Más goles para Chile (More Goals for Chile), an initiative promoted by the National Council on Innovation for Development and the Energy Agenda 2050 of the Ministry of Energy. Moreover, selective and sector-based policies have been implemented to build on the experience of the 2000s cluster policies (Ministry of Economy, 2007). Further, their scope has been broadened to create synergies between different sectors and identify inter-sectorial strategic areas. National challenges have been defined and the identification of synergies between the new sectorial programs has generated important horizontal complementarities (like providing green and sustainable energy to enable the sustainability of all other sectors). These new policies were intended to bring together public and private stakeholders to identify shared future challenges and design bottom-up strategies to respond to societal and private demand for a more sustainable development strategy.

We analyzed two initiatives developed within this new framework. Both initiatives have characteristics that resemble an MOIP[1] in terms of mobilizing various actors within each sector to find possible solutions to societal and technology challenges. The broad challenge was set at the national level: find new sources of sustainable development for the long term. Both cases have innovation and technological development at their core and seek to foster specialization and diversification by promoting investments in new technologies and upgrading technical capacities. Another interesting element is that in both initiatives the STI stimulus is directed toward developing or adopting sustainable technologies and practices. However, it is worth underlining that even if the environmental component is the basis for both cases studied, it has not been well communicated to the stakeholders' ecosystem. Most of the people we interviewed underestimated the sustainability component, especially in technological development.

However, the most important limitation to successfully identifying MOP experiences in Chile was linked to financing public STI policies. One of the most important elements characterizing MOPs is the role of patient, long-term financing of high-risk technological projects. Chile spends only the 0.35 percent of its GDP on R&D, with one of the lowest contributions to innovation activities from the private sector (only 34 percent of the total). Moreover, in Chile, public policy design is subject to the strict rules governing the national budget allocation, which reduces the political space to guarantee long-term financing of potentially transformative policies.[2] Considering the time-horizon of the Chilean budgetary system, we identified potential MOPs with financing expected for the medium term, being conscious of their limitations when framing the initiatives as MOP experiments.

Chile can be considered a conceptual evaluation of small-scale innovation policy experiments that took place within the framework of the CORFO productive transformation strategy between 2016 and the present.

The focus of our analysis was therefore the capacity of one national government agency, CORFO, and other actors in the innovation ecosystem to design and implement MOPs, and the institutional capacities that can facilitate this approach to STI policies.

The two cases we analyzed were developed within the framework of the Transforma program – involving specific strategies for seven sectors and three enabling areas – and aimed to create the necessary conditions to develop a shared vision for the future. The initiative focused on transforming Chile's economic structure by creating transformative activities in traditional and new productive areas.

Instead of studying the whole Transforma program, we restricted our analysis to the experiences in two sectors: solar energy and mining. The narrowed approach helped us identify the existing structures within each sector, the coordination mechanism between the diverse actors, and the links between the projects. The diverse development stages and industrial organization of the solar and mining ecosystems helped us better disentangle the missing links between the entities of the STI ecosystem and the institutional and political factors that hamper or facilitate the development of MOP initiatives.

Although the two cases analyzed represent a good example of a novel approach to designing and implementing new instruments to promote STI-based diversification and specialization, they are limited by the fact that they are the result of a strategy promoted and implemented by a specific – even if empowered – change agent, and therefore do not allow us to properly disentangle the state's capacities and capabilities. Indeed, these experiences lack a supportive state and policy structure setting long-term priorities and legitimizing a shared vision of the future. The risk that emerged during interviews and workshops is that these experiences will be subject to the political cycle and thus remain short-term experiments regarded as another policy failure, delegitimizing the role of the state in STI policies.[3]

We chose to analyze solar and mining because we believe this novel design and implementation approach could provide insights in terms of the capacities and capabilities that need to be strengthened in order to design MOIPs in Chile. Moreover, the Chilean public sector should exploit the outcome of these experimental initiatives to strengthen its capabilities and develop a more systemic approach to STI policies. The lessons learned from these experimental efforts could help the public sector legitimize the MOIP approach in the public discourse.

[1] We were not able to identify innovation policies explicitly designed as mission-oriented – meaning policies seeking to address societal challenges – in Chile.

[2] The Ministry of Finance allocates the budget annually. Each year, in April, the ministry evaluates the results of the programs included in the previous budget and analyzes the performance indicators of the public institutions (in terms of cost-efficiency and budget execution). This information defines a framework of initial expenses that considers those items required by law or by contract and the continuity of programs with satisfactory evaluation. Considering their priorities, all the public institutions submit to the Ministry of Finance proposals to expand successful programs or create new programs (application is required for new programs, which have to compete for funds).

[3] This public delegitimization was the case for the cluster policy implemented by CORFO in 2008. The policy, designed during the first government of President Michelle Bachelet and interrupted after the administration change in 2010, has been targeted in public debate as a complete public policy failure, despite the short time it was in force. Moreover, after this experience, the sectorial approach to productive diversification has lost consensus in the public and political debate.

CASE 1:

4 Solar Energy as an Enabling Factor for Innovation-Based Development

In this section, we first present why we identified solar energy as a potential MOIP, then we present the challenges, the mission, and the projects. We follow this with a characterization of the program as an MOP and then describe the process that led to designing and implementing the program and the main capacities and capabilities identified. We end with some conclusions and lessons learned from our analysis.

4.1. Developing the Solar Sector and Identifying It as a Potential Mission-Oriented Policy

Chile's undiversified and unsophisticated productive structure has been identified as one of its main constraints to sustainable and inclusive growth. Chilean exports are concentrated in natural resources and primary products characterized by low levels of technological sophistication and relatively low value added.

Chile's natural energy endowments (the northern regions of Chile have the highest solar irradiance in the world [IDB, 2011]) and the downward tendency in the renewable energy price represent a significant opportunity for the country. Developing solar energy can help green the energy matrix, promote more sustainable development, and foster diversifcation of the economy toward more sophisticated sectors.

Since 2008, the Chilean government has assumed an active role in designing policies to attract foreign and national investments in the solar energy sector.

- Law 20.257 of 2008 stated that at least 5 percent of the country's energy needs had to be covered by unconventional renewable energies.
- In 2015, 850 MW were produced by solar panels.
- In 2015, the Ministry of Energy approved the Energy 2050 Agenda, defining a national roadmap for energy toward 2050.

However, there was no specific policy designed to scale up the potential of the solar energy sector in Chile and most of the technologies employed in the solar industry have been imported. Unlike fossil fuel–based energy sources, solar energy does not require extraction but a manufacturing value chain and upward linkages to productive sectors.

In 2015, CORFO started a public–private consultation to define a long-term vision to sustainably develop Chile. During the first round of consultations, solar energy emerged as one of the most promising opportunities since solar is the leading energy source of the future. In 2016, CORFO designed the Solar Energy Program, aiming to foster innovation, develop technologies and skills, and reduce carbon emissions, with a roadmap toward 2025.

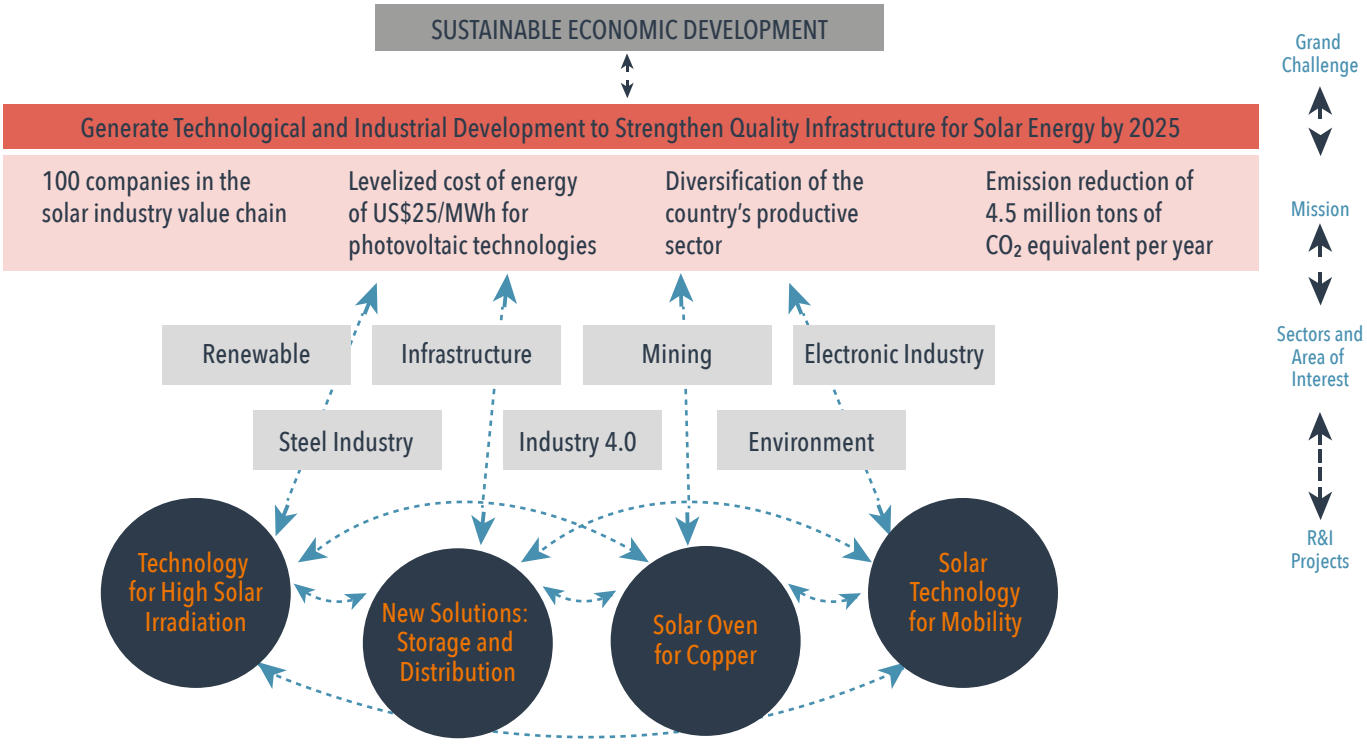
We identified this program as a potential MOIP for the following reasons:

- It was built on successful past policy experiences, taking into account societal, technological, and environmental challenges.
- The mission is reachable and relevant for society.
- Societal and stakeholder consensus was created through a bottom-up process.
- The challenge has been operationalized in a 10-year roadmap.
- Innovation and technological development are the core of the program.
- It has the potential to create a new market and involve an existing sector in the supply chain.
- The public sector plays a central role in designing, implementing, and financing the program.

4.2. Challenges, Missions, and Projects

Based on the working definition of MOIPs (Mazzucato, 2018a, 2018b), and taking into account all the limitations in Chile, we identified the strategy developed within the solar ecosystem as a potential mission-oriented innovation project. Figure 1 summarizes the program by characterizing it as an MOIP.

Figure 1. Characterizing the Solar Energy Program as an MOIP



Source: Authors' elaboration.

The program was developed in response to a grand challenge Chile faces as a developing country: it needs to generate sustainable sources of long-term growth, building on its natural endowments and particular conditions. As a country transitioning toward higher income levels, Chile is still facing important structural constraints to achieving sustainable and inclusive development. Historically, its economy had a poorly diversified productive structure, based on resource-intensive and unsophisticated sectors (primarily exports of basic mining products). The economy was too vulnerable to oscillating raw material prices and hampered fulfilment of the social inclusion agenda. However, in Chile, there is increasing demand for a greener and more inclusive development strategy.

In particular, three factors legitimize the country's focus on the solar ecosystem to tackle the sustainable development challenge (Bitran, 2015):

1. Societal and Environmental Pressure: In Chile, the energy sector is exposed to societal pressure because of the high level of pollution generated by the power plants of traditional energy sources, as well as the high environmental impact of large hydro plants and their impact on community life. At the same time, adopting international environmental regulations and national laws has increased society's awareness of environmental issues. In Chile, in response to increasing societal demand,[4] the planning process for new energy policies have been carried out in a participatory manner.[5]

2. Technological Challenges: In 2014, because of the high price of energy, the solar industry in Chile was emerging without any public planning. This led to the importation of all the technologies, basic components, and human resources necessary to install the large photovoltaic (PV) and solar power concentration plants. The growing foreign interest in Chile's solar potential increased expectations for the development of local technological and human capacities.

[4] Since 2010, civil society has increasingly demanded more inclusive and environmentally friendly energy projects. HydroAysèn, the thermoelectric project in Campiche, and the Barrancones thermal power plant are emblematic. Based on these three cases, citizen pressure on the government grew, leading to the definition of national standards for developing energy projects.

[5] In 2014, the government committed to improving civil participation in defining, planning, and implementing energy programs. In 2016, a guideline for civil society was launched (http://www.energia.gob.cl/tema-de-interes/nueva-guia-de-estandares-de).

3. Natural Endowments: Chile has one of the highest potentials for unconventional renewable energy generation in the world, with an estimated generation capacity of 2,000 GW, 90 percent of which is from the solar potential in the Atacama Desert (GIZ and Ministry of Energy, 2014).

The Solar Energy Program aimed to address these evolving societal expectations, pro-posing to create the conditions necessary to make Chile a solar power in the world. CORFO wanted to take advantage of this particular situation by fostering innovation and local technological development, increasing human resources capacity, and exploiting synergies with traditional industries in Chile, especially mining, where advances in solar-related technologies could improve the sustainability of mining processes.

The broad mission of the program – to "generate technological and industrial development in solar energy by 2025 (CORFO, Chile's Strategic Challenge for the solar sector) " – was articulated in four specific sub-missions:

1. **Technological upgrade:** 100 companies in the sector value chain
2. **Competitive energy:** levelized cost of energy of US$25/MWh for PV technologies
3. **Economic sophistication:** diversification of the country's productive structure
4. **Environmental sustainability:** emission reduction of 4.5 million tons of CO_2 equivalent per year

The mission is not limited to developing the solar sector; fulfilling it requires the coordination of efforts in diverse areas of the economy. Development of the solar energy sector will enable technological development and innovation in other sectors of the economy, from the steel industry in providing inputs to develop new solar technologies, to the electronics and hydrogen sectors to develop storage and transmission solutions. The most important complementarity is that with the mining sector. Efficient and reliable solar energy could imply a paradigm shift in terms of the sustainability and efficiency of mining processes, which would have a broad impact on the quality of life of workers and, more widely, the local population and civil society. Moreover, developing new and upgrading existing infrastructure will be key to ensuring the transmission and storage of solar energy and to exploiting the complementarity with other renewable energy sources, such as hydroelectric and thermal energy. Electromobility, and advanced manufacture, represent another possible complementarity.

The portfolio of instruments and initiatives designed to fulfil the mission toward 2025 included 57 projects developed within a framework of three technological areas (high solar irradiance, storage and distribution, and energy self-sufficiency) and four enabling areas (human capital, infrastructure, technological development, and innovation ecosystem).

Some of the most ambitious research, development, and innovation (R&D+i) solutions identified in the roadmap are:

- Development of new technologies specific for the high solar irradiance of the Atacama Desert
- Atamos, a new solar PV technology
- Hydrogen/diesel blending as a transition to introducing hydrogen fuel cells in heavy vehicles
- Development and deployment of green ammonia
- Storage batteries and hydraulic storage
- Solar ovens to produce copper cathodes
- Green ammonia for hydrogen development

Various instruments have been designed to enable the innovation ecosystem:

- An open innovation platform to facilitate collective solutions to technological problems
- Technology institutes to develop clean technologies
- Consortium bidding to develop high-irradiance solar PVs
- Standards tailored to desert conditions
- Certification for solar technicians
- Training programs
- Initiatives to advance human capital

4.2.1. MOP Characteristics

In what follows, we analyze the Solar Energy Program considering the five criteria for MOPs proposed in Mazzucato (2018a).

Bold and Inspirational with Wide Societal Relevance

The scope of the challenge the program seeks to tackle is broad: achieve sustainable economic progress. This is translated into a more concrete mission: generate technological and industrial development to strengthen quality infrastructure for solar energy by 2025. The relevance of the mission is twofold. First, the mission aims to diversify the Chilean economy, therefore matching societal demand for new sources of growth. Second it promotes the generation of green technologies, matching demand for sustainable sources of growth.

At first glance, the Solar Energy Program could appear to be a narrow initiative aiming to achieve a single objective: develop national capacities and capabilities in the Chilean solar sector. However, the program has been designed more broadly, seeking to address multiple themes, from productive and technological development to synergies between sectors and human capital, while reaching energy efficiency and cleaning the energy matrix.

The mission was legitimized by increasing societal demand for new and sustainable sources of growth; however, its potential in terms of environmental and societal relevance was not well communicated. Most of the people we interviewed expressed concerns that the environmental dimension of the program was never explicit during implementation.

Thus, this MOP criterion was not completely met. Even though the mission could have addressed societal values and been inspirational for society, it was not well developed or communicated. Better communication of the potential impact in terms of societal value could have helped legitimize the mission and therefore helped justify continuation of the program during the change of administration.

On the positive side, the Solar Energy Program was one of the first to identify broader missions, going beyond the traditional sector-based policies, into public STI policy experiences in Chile.

Clear Direction: Targeted, Measurable, and Time-Bound

The direction of change was explicitly stated: generate green technologies to foster energy efficiency while taking advantage of Chile's high solar irradiance. The program's ambition was to set the direction for developing the solar market in Chile by fostering investments and technological development. The ambitious nature of the program was in contrast with the market orientation of Chile's business and public sectors, which welcomed the challenge without great enthusiasm.

The targets were well defined in the roadmap both broadly (objectives toward 2025) and specifically (individual projects). The time horizon was set toward 2025, with mid-term checkpoints in 2016 and 2020. The 2025 time horizon was too ambitious according to some of the interviewees, especially in relation to generating local content in the solar energy value chain and technology development.

CORFO has monitoring systems to evaluate budgetary allocation (mainly required by the Strategic Investment Fund [FIE,[6] by its Spanish acronym] and the Ministry of Finance) and external monitoring of the program as a whole (i.e., IDB's evaluation). To our knowledge, no formal monitoring mechanism has been developed to assess the progress in implementing the roadmap. Creating such mechanisms is strongly recommended to evaluate progress and facilitate internal learning to re-tailor objectives and expected results.

[6] The FIE is a special fund established to secure sufficient resources to execute the programs of the Transforma strategy.

Involving Research and Innovation

The focus of the program is well defined: foster diversification of the Chilean economy while taking advantage of the high solar irradiance in the Atacama Desert. Technological development, innovation, and human capital generation are the three main pillars around which the program was designed. Technological development involved incremental innovation to adapt existing technologies to desert conditions and develop new products and processes. Fostering innovation and technological development and creating the conditions necessary to facilitate cooperation within the STI system played a central role in the program.

With regard to the technological feasibility of the Solar Energy Program, we analyzed background studies carried out by Fundación Chile and CORFO (Fundación Chile, 2015; GIZ and Ministry of Energy, 2014). These studies demonstrated that the technological developments from the program were feasible at the industry level and sufficiently ambitious in the Chilean ecosystem. The number of potential technologies and synergies involved in the roadmap is significant, including solar PVs, high temperature thermal energy, hydrogen, metallurgy, and heavy vehicles for the mining sector.

According to some of the interviewees, however, the process beyond identifying the technological challenges responded to the voluntarism of CORFO. This was probably due to the lack of institutionality at the central level, and the short political time horizon to implement the program.

During the interviews, we learned that, even if production of solar PVs for areas with high solar irradiance was a possible technological development, it was not a feasible one because of the competition on standard solar PVs from China. However, most of the respondents agreed that there is high technological potential in the solar sector, especially regarding the complementarity with the mining sector.

This criterion was substantially met in the roadmap, though some problems emerged during the first implementation phases due to budgetary restrictions and project prioritization.

Cross-sectorial, Cross-actor, and Cross-disciplinary

The mission is not limited to developing the solar sector; fulfilling the stated mission requires coordination of efforts in diverse areas of the economy. However, it is worth noting that the multi-sectorial dimension has to take into account the fact that Chile has a poorly diversified economic structure, with the most developed sector dedicated to producing primary products and mining activities. Therefore, despite the potential spillovers and feedback effects from other sectors, the program faced a structural barrier: the non-existent or early stage development of potential complementary sectors.

To facilitate coordination between the different actors and sectors, two new instruments were designed: an open platform to facilitate co-creation and information sharing, and a clean technology institute to foster cross-disciplinary research.

Even though the roadmap's ambitions were multi-sector, multi-actor, and multi-disciplinary, eventually the program narrowed its scope. The failure in addressing the multidimensional nature of the mission is the result of the scarce commitment to the program at the governmental level, which in turn resulted in lack of complementarity between the policies implemented by the diverse ministries and agencies.

Meeting this criterion was fundamental to guarantee the horizontal spillovers identified in the roadmap.

Multiple Competing Solutions

The program is ambitious in the potential number of solutions to achieve the mission. However, our interviews showed that the multiple solutions designed in the roadmap were not coordinated at the program level, which resulted in several independent, isolated solutions rather than a system of competing and interacting projects.

The lack of coordination between the projects dramatically reduced the program's potential. It is worth highlighting that this lack of coordination is seen as a direct consequence of the program's financing structure. The initial idea was to finance the whole program as a block and let the Executive Committee of the Solar Program (Comité Solar) – a technical team created by CORFO responsible for the implementation of the roadmap and the related activities – coordinate the ecosystem of solutions. Eventually, because of a national budgetary reprioritization, the diverse solutions had to compete individually for financing. This financing structure weakened the potential coordination and interaction between projects.

4.3. Dynamics: Developing and Implementing the Program

The idea behind identifying the mission was promoted after the 2015 presidential election by a small group of actors, from CORFO and the Ministry of Economy. Therefore, the challenge did not have the necessary political backup during the election campaign; it was identified a posteriori as an opportunity to design new instruments within CORFO.

To better capture the demands of solar industry stakeholders and to better identify the mission and the technological opportunities, CORFO, the Ministry of Economy, and the Ministry of Energy created a public–private entity – the Executive Committee of the Solar Program – comprising the main stakeholders in the solar and energy sectors. The committee was responsible for the program's strategic orientation and technical management and was presided over by the Ministry of Energy. It included representatives from STI, the energy sector, and the public ecosystem. The committee analyzed the solar sector, identifying the main challenges and the technological opportunities given the high solar irradiance in the Atacama Desert.

Table 1. Characterizing the Solar Energy Program as an MOIP

	Number of Actors	Percentage of the Board
Public sector (government and international cooperation agencies)	6	28
Private sector	10	48
STI	4	19
Civil society	1	5
Total	21	100

Note: This scheme refers to the composition of the first committee that was in charge of defining the strategic roadmap. The committee has changed slightly but has maintained its multi-actor structure.

Source: Official information from CORFO.

Building on the preliminary studies, the Executive Committee of the Solar Program started a bottom-up process to define the technological roadmap. This process started in 2015 and resulted in the publication of a technological roadmap toward 2025 (Fundación Chile, 2015a). The contract for the design and publication of the roadmap was given to Fundación Chile. However, its main pillars were designed through a validation process, taking into account the baseline studies and the output of technological workshops organized with the participation of the Institute of Manufacturing of Cambridge University to define the program's main pillars.

In 2015, an initial set of 57 initiatives with an estimated budget of US$836 million was presented to and approved by the CIPE (CORFO's committee for strategic programs). After approval, the strategic program was presented to the FIE to obtain financing.

In March 2016, the roadmap was approved by the FIE and, the Executive Committee of the Solar Program was institutionalized as the Solar Committee, a technical team responsible for the implementation of the roadmap and the related activities. The Solar Energy Program was officially launched in September 2016. At launching, the total budget approved by CORFO, the FIE, and the Innovation Fund for Competitiveness (Fondo de Innovación para la Competitividad [FIC]) to execute the strategic program was approximately US$80 million, less than 10 percent of the budget estimated in the roadmap. Thus the Solar Committee had to reduce the number of initiatives to be executed in 2016, leading to a prioritization of those with short-term results and lower financing needs.

According to the roadmap, the program was supposed to be managed and implemented by the Solar Committee, which was intended to be a bridge institution to facilitate the interchange among the solar, energy, and STI ecosystems.

Stakeholders of the solar and energy sector participated in monthly meetings during which they discussed implementing the program (Figure 2). The stakeholders' ecosystem includes actors from the public and private sectors, universities, international organizations, and technological centers. At the ministerial level, the Ministry of Economy, the Ministry of Energy, and the Ministry of Environment assist at stakeholder meetings.

Reprioritization of the budget increased the program's vulnerability to the political cycle. At the beginning of 2017, the program, which was in the middle of its implementation, started a process of political and institutional validation to ensure its continuity during the next political administration. Reprioritization implied the dedication of financial, human, and technical resources to validating the program. After going through this process, the continuity of the program was guaranteed until the end of the FIE contract (2019/20) and the Solar Committee was restructured, including STI in all unconventional energy sources.

Even though the process was well designed to facilitate the participation of all stakeholders, our interviews showed that the monthly meetings were seen more as follow-ups rather than as opportunities to define priorities and share decisions. Eventually, some of the most relevant stakeholders (ministries, big firms, and civil society) only attended the meetings occasionally. The lack of a common view resulted in a lack of coordination between the diverse ministries and consequently between the diverse agencies.

CORFO, as implementing agency, tried to coordinate the efforts of the different agencies, but the lack of political legitimacy resulted in a narrowing of the program's scope.

Figure 2. Ecosystem of Innovation in Solar Energy

Source: Solar Committee, 2018, under Creative Commons License https://creativecommons.org/licenses/by-nc-sa/4.0/deed.es/

The Solar Energy Program was designed in line with the policy ecosystem, in particular with the Productivity Agenda promoted by the Ministry of Economy and the Energy Agenda of the Ministry of Energy. The environmental agenda was not so clearly linked with the program, which narrowed its focus on technological and productive development.

The lack of coordination at the ministerial level resulted in a relatively narrow policy mix to support the program. The mix included support for R&D initiatives, promotion of technological development, human capital and skills creation, improvement in the quality of infrastructure, and creation of new standards and laws. No new financial instruments were created to implement the program. Instead, its structure was adapted to instruments already existing within CORFO, such as public tenders and R&D incentives.

The Solar Energy Program was one of the most ambitious innovation programs ever developed in Chile in terms of R&D projects and the total estimated budget. The reduction in the budget, implying a significant reduction in the size of the program, had a negative impact on the program's potential.

The main source of financing is public, executed by CORFO and by central and local governments. The budget originally estimated in the roadmap (US$836 million) was linked to the program's ambitions and the timescale to reach the objectives defined in it. Although most of the financing was expected to be from public funding, private investments also had a central role in the Solar Energy Program. The contribution from the private sector, in terms of both expected investments and R&D, should have been more than a half of the estimated budget. The budget – technically approved only to execute short-term initiatives – is significantly lower than the budget for the roadmap and is estimated at approximately US$100 million.

Matching between the instruments and the targets presented in the roadmap was therefore limited by two main factors: the lack of coordination between the different state agencies and the ambiguity that characterized the budgetary allocation process. Table 2 summarizes the main results of the case study in terms of the dynamics involved in designing and implementing the program.

Table 2. Designing and Implementing the Solar Energy Program

RESULTS OF CASE 1		
	Roadmap	**Implementation**
Selection of mission and projects	Initially semi-centralized, but bottom-up during the process.	Not constructed bottom-up; responded to the voluntarism of a group; lack of institutionality.
Impact-driven policy process	Identification of targets and milestones.	The targets and milestones were not considered realistic and thus more as guidance.
Portfolio management	A special fund (FIE) was created to finance the whole program (57 initiatives) as a block.	Static portfolio management, excessive bureaucracy, and short-term financing.
Flexibility	Initially, the policy process was relatively flexible.	Relatively static policy process; lack of systemic perspective.
Monitoring	Only cost-efficiency monitoring and accountability instruments.	Monitoring instruments at the project level; lack of systemic monitoring instruments.
Citizen engagement	Initially, civil society was involved, but the program did not trigger social imagination.	Poor citizen engagement.
Relationship to long-term strategies	Program coherent with productive, environmental, and energy strategies.	The potential policy complementarities were not successfully exploited.

Source: Authors' elaboration.

4.4. Results and Outcomes

The Solar Energy Program, which is still being implemented, was put in place less than three years ago. Therefore, it is not possible to disentangle its impact on growth or investments. However, in terms of results it is worth highlighting the following:

- The first bifacial and horizontal solar PV module was developed with new technologies for desert conditions and has been piloted. The product was to be launched at the end of October 2020.

- Important developments in hydrogen storage techniques have been presented and engine piloting is expected by the end of 2020.

The Solar Energy Program's financing has not been guaranteed after the 2019/20 administrative year; however, the Solar Committee has been refinanced with a mandate to coordinate STI initiatives in solar and other green technologies.

4.5. Implications and Reflections

Even though the Solar Energy Program is not specifically an MOP, the case study showed that its legitimization, design, and implementation were similar to an MOP in the Chilean STI ecosystem. The main contribution of this analysis is that it helps identify key mechanisms and capabilities that Chile needs to strengthen to legitimize MOPs in the public discourse. The analysis demonstrated the need to create a shared development vision within the public sector and with broader society. A shared development vision will be key to reducing the effect of political cycles on public policies.

Moreover, the bottom-up participatory process behind the design of the Solar Energy Program helped:

- **Set the basis to create a long-term shared vision for the future.** All of the stakeholders, including academia, the private sector, and civil society, participated in a bottom-up design process to construct the roadmap. This process successfully led to better consensus around developing the sector and its technologies.

- **Strengthen the trust between the public and private sectors to achieve sustainable development.** The participative construction of the roadmap improved trust among the different actors of the ecosystem by making public and private representatives work together to identify future challenges and concrete lines of action.

- **Identify the challenges that need a public lead.** In Chile, the state is often seen as a minimum intervention actor. The participatory process of identifying challenges has helped disentangle policy areas where state intervention will be more legitimated in the public debate. The main policy areas that would benefit from long-term, committed public action are:

    - identifying challenges and assessing risks for innovation and technological development,
    - developing skills, and
    - coordinating stakeholders of the STI ecosystem.

Another successful factor was the creation of an instrument to enable the innovation ecosystem: The open innovation platform created to facilitate the identification of technological challenges and cooperative solutions within the solar ecosystem has the potential to generate innovation and technology opportunities for the overall economy and to facilitate knowledge diffusion within and between sectors.

Many restrictions at the institutional and budgetary levels have hampered the program's potential. Based on the restrictions identified in this analysis, it is possible to identify some opportunities to improve Chile's MOP design:

- Improve the mechanisms to monitor and assess impact.
- Create the conditions necessary for patient financing.
- Strengthen the link between the policy mix and policy objectives at the government level.
- Improve coordination among public actors.

In terms of public capacities, this case study showed that, even though CORFO could have most of the capacities needed by an implementing agency in the STI ecosystem, the weaknesses in some of the key capacities at the state level have hampered any potential positive effect of the designed initiatives.

- **State capacity:** There is a lack of shared policy vision at the government level. At the agency level, it is not possible to create political legitimacy. CORFO has good knowledge of the ecosystem, but the lack of political support delegitimized its actions.
- **Technical-administrative capacity:** Though this is well developed within CORFO, there is a lack of coordination among agencies, and the public system does not have instruments that facilitate systemic learning.
- **Policy capacity:** Existing instruments and policies are inconsistent, bureaucracy is excessive, there is a lack of legitimized coordinating actors, there is no policy coordination at the government level, and implicit policies are not in line with long-term objectives.
- **Market capacity:** The market related to the solar energy sector was developed considering the needs of both demand and supply within the STI ecosystem and in identifying technological priority. The financial market has not been developed, and next policies should include specific strategies to attract private investment.
- **Productive capacity:** The private sector, especially small and medium enterprises, is engaged; however, largeinternational companies and market leaders are not sufficiently interested. The program led to improvement in capacity building on the productive side by involving the private sector in defining priorities and technological challenges.
- **STI capacity:** Connections within the STI ecosystem and between the STI ecosystem and the energy and solar-PV markets need to be strengthened. The program facilitated the creation of initiatives to vitalize the ecosystem, involving universities, tech centers, and the private sector. CORFO has good capacity to use public resources to foster technological development and innovation.

4.6. Summary and Highlights

In this section, we analyze the design and implementation of the Solar Energy Program within the framework of CORFO's Transforma initiative.

The Solar Energy Program was designed with some characteristics that resemble an MOP in terms of mobilizing various actors within each sector to articulate possible solutions to societal and technology challenges. The program was based on a well-defined vision created by diverse actors in the energy and STI ecosystems. The program should be seen as an experimental initiative to design and implement a novel approach to public policies.

Even though its characteristics resemble those of an MOP, the program is substantially different from the MOP concept proposed by Mazzucato (2018a), especially because it lacks ambition in terms of triggering the imagination of the different actors and patient financing. Eventually, despite the cross-sectoral design in the initial roadmap, the result was a narrow sectorial initiative.

The most successful result has been the bottom-up process of identifying the challenges and priorities, and this broad approach to policy definition should be followed in the future. The lack of coordination between state agencies and the lack of political legitmacy are important constraints. This case study has highlighted that Chile still has important structural gaps in the STI system in terms of generating human capital and coordinating efforts between the diverse actors from the private, public, and academic sectors.

However, the Solar Energy Program is an interesting case in terms of original features in policy design compared to traditional policy experiences in Chile. The program involved identifying a sector that had the potential to be transformative (based on the current state of development and expected long-term development), to catalyze the development of STI in other sectors, and to develop new sectors. The program started from identifying the STI capacities and opportunities deriving from focusing on solar energy as a potentially transformative sector. The Solar Program was based on a novel mechanism to identify shared priorities and technological challenges. Some of the instruments that were designed, such as the open platform to collectively resolve STI challenges, the technological centers for R&D in clean technologies, and the promotion of solar-based solutions for the mining sector, were completely new in Chile.

The main problem with the program is linked to the fact that this experiment was developed within an agency and not at the highest level, which led to a lack of complementary policies to facilitate implementation and exploit the program's horizontal potential. Moreover, CORFO's structure and bureaucracy made the program very rigid and difficult to adjust in the short time horizon of a government (four years).

However, CORFO is the government agency with characteristics that most closely approximate an entrepreneurial structure, since it is strategically positioned throughout the innovation curve. The original roadmap for the Transforma Strategy envisages CORFO's actions from the upstream to the downstream of the innovation curve – from professional training to piloting new technologies – and included all kinds of projects along the solar value chain. In practice, CORFO's experience has the potential to change Chile's mindset regarding policymaking and designing STI policies, bringing it closer to the MOP concept presented in Mazzucato (2018a). In our opinion, this could be an important message for Chile's current and future policymakers, especially given the challenges Chile faces as a country and the new MOP industrial policies approach.

CASE 2:

5 Mining as a Platform for Virtuous, Sustainable, and Inclusive Development

This section presents a case study of the mining sector in Chile. We first present the motivation for identifying the case as a potential MOP, then we present the challenges, the mission, and the projects. We then characterize the case as an MOP and describe the process that led to designing and implementing the program and the main capacities and capabilities identified. We end with some conclusions and lessons learned from the analysis.

5.1. Sustainable and Virtuous Mining and Its Identification as a Potential Mission-Oriented Policy

Chile is the biggest producer of copper in the world and it has a long history of being economically dependent on its mining resources. On average, the mining sector accounts for 13 percent of GDP and more than a half of Chilean exports. Mining, especially copper, has been a key driver for Chile's growth, but since the beginning of the 2000s, productivity has been declining and the inputs necessary to keep the sector working have dramatically increased, increasing environmental concerns. The National Productivity Commission reported an increase in energy use of about 79 percent between 2000 and 2014 (National Productivity Commission, 2017). The sector's natural cycle and the ageing of the mining sites will increase demand for water, posing a big challenge for the future.

Moreover, the Chilean mining sector is still unsophisticated, the foreign value-added content in mining exports is around 20 percent, and the embedded inputs from the manufacturing sector are less than the 7 percent of mining exports. Further, considering the ongoing technological revolution, it is likely that the mining sector has already reached its employment potential; in 2018, the sector employed almost the 3 percent of Chile's total workforce (6 percent considering mining-related sectors).

Since the beginning of the 2000s, the government of Chile has attempted to design policies to shift up a gear in the mining sector. In 2005, a royalty was introduced to mining production to foster technological adoption and innovation. In 2008, the mining sector was identified by the Boston Consulting Group as one of the clusters to develop, but the policy was abandoned a few years later.

At the beginning of 2015, CORFO identified the sustainability and competitiveness of the mining sector as a grand challenge for Chile's future development. CORFO started a round of consultations with mining's main stakeholders to define priorities and identify areas where public investments would be essential to developing the sector. The idea was that transformation and technological upgrading were key factors in tackling declining productivity and sustainability in the mining sector. The consultation process resulted in the definition of two initiatives Alta Ley[7] and Valor Minero.[8] Other initiatives were also carried out to increase the sector's sustainability and competitiveness. For example, in 2013, Codelco, through its technological development controlled firm Codelco Tech, launched a project to produce sustainable copper cathodes. A pilot experiment conducted in Antofagasta, covering the 85 percent of the energy needed to produce copper, resulted in a reduction in CO_2 emissions of 15,000 tonnes. At the same time, a consortium of private and public actors (the four leading mining companies and the National Council of Innovation for Development [CNID from the Spanish]) worked on a project to reduce mining waste and develop technologies to help the sector achieve zero net waste.

The challenge of upgrading the mining sector represents a kind of MOP common in natural-resource dependent countries, aiming to transform a core sector of the economy by boosting innovation and technological development and creating new markets and sectors around it. The challenge is extremely relevant for Chile since mining is the most relevant sector in the Chilean economy. During the interviews, most of the respondents considered Alta Ley and Valor Minero as results of the same political process and therefore impossible to evaluate separately. We decided to analyze the institutional capacities in the design and implementation of Alta Ley and Valor Minero. However, given the scarcity of formal information about Valor Minero, the analysis is based on Alta Ley and, where possible, its connections with Valor Minero.

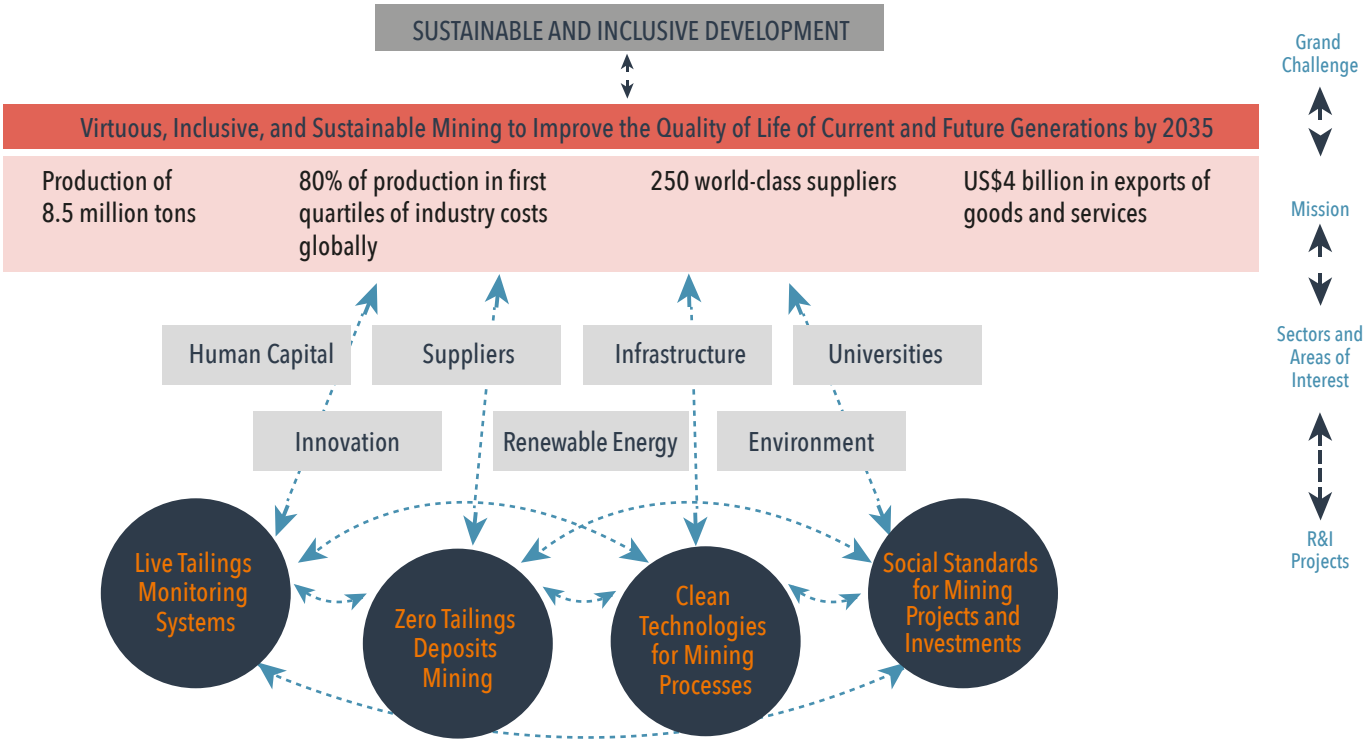
[7] The Alta Ley National Mining Program is a public–private initiative created by CORFO in 2015, with the participation of the mining industry, its suppliers, the state, academia, and R&D centers. The program's objective is to address productivity, safety, and respect for the environment while creating, strengthening, and energizing the mining innovation ecosystem (https://corporacionaltaley.cl/en/about-us/).

[8] Valor Minero is a public–private mining sector institution that seeks to represent ministers from different portfolios, public institutions, large mining companies, trade union organizations, social organizations, NGOs, trade union leaders, organizations of native peoples, study centers, and representatives of local governments (https://www.minmineria.cl/instituciones-mineras/alianza-valor-minero/).

5.2. Challenges, Missions, and Projects

Following the analysis conducted for the Solar Energy Program and based on Mazzucato (2018a,b), we identified Alta Ley, as potential MOP initiatives in Chile. Figure 3 summarizes the program by characterizing it as mission oriented. In what follows we refer to Alta Ley also as the Mining Innovation Program.

Figure 3. Characterizing the Mining Innovation Program (Alta Ley) as an MOP



Source: Authors' elaboration.

In contrast with the Solar Energy Program, Alta Ley was developed building on a shared view for the mining sector that evolved over the past decade as public and private actors responded to emerging productivity, sustainability, and inclusiveness challenges. Even though it focuses on the mining sector, the policy approach behind it should not be seen as sectorial or vertical. It was intended to address a dual problem – differentiation of the productive ecosystem and technological specialization – by fostering innovation all along the mining value chain while promoting adoption of green technologies. The identified technological solutions were tailored to the specific scale and maturity of the Chilean mining sector and to the country-specific strengths. Moreover, solutions were usually based on international experiences or experiences in other sectors.

The goal was to generate sustainable sources of long-term growth, building on mining activities as a platform for development.

The copper sector alone contributes almost 10 percent of Chile's GDP; however, mining activities have reached a critical point in the country. Productivity is at its lowest because of declining ore grade concentration and because the social acceptance of mining activities is being questioned, leading to increasing demand for more sustainable and inclusive processes.

The mission is to strengthen innovation and technology adoption in the mining ecosystem to generate a virtuous, inclusive, and sustainable platform for future development.

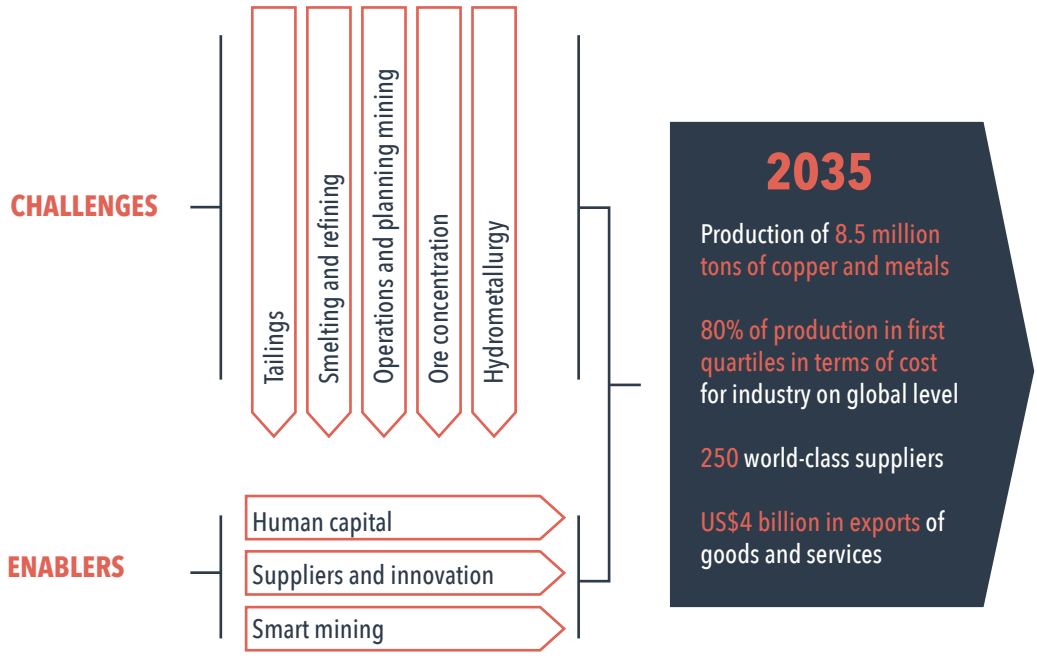
> **Virtuous:** By being competitive and productive, the program generates the conditions necessary for a strengthened innovation ecosystem to emerge. This requires the mining companies and suppliers, the scientific community, local communities, and the state to construct a shared agenda. This agenda should increase the sector's productive capacity and foster a transition within the mining value chain.
>
> **Inclusive:** The mining industry must create shared value and maintain a fluid and permanent dialogue with involved communities. The role of the state is to create an institutional environment to foster and facilitate this dialogue. In addition, to be inclusive, the industry must efficiently and fairly manage the income generated from exploiting natural resources to benefit development of the whole country.
>
> **Sustainable:** The program integrates the critical variables that affect the socio-environmental system in which it operates into designing processes and operations. The industry of the future must operate with world-class environmental practices, technologies, and standards.

Though the roadmap suggests multi-sectoriality, the objectives identified to fulfil the mission were mostly about the mining sector and not really related to the broader mission. However, the roadmap clearly shows that enabling the mining sector as a platform for future development will require a broader focus than just the sectorial one. New technologies to improve the efficiency of renewable energies will be key to fostering the transition to green inputs in mining activities and new processes for water desalinization and circular water employment, and will be necessary to minimize the impact mining activities have on communities and the environment. Sustainably managing and monitoring existing tailings, and employing new technologies to minimize and reduce waste production, will require the development and use of technologies such as the Internet of Things, artificial intelligece, and robotization. The new industrial revolution, and its mineral content, will represent a huge opportunity for the mining ecosytem.

Alta Ley focuses on fostering technology development and adoption and creating social capital so that the mining ecosystem can become a platform for future development.

To fulfil the mission, in the roadmap of the Alta Ley initiative, five challenges and three enablers were identified (Figure 4). For each, a set of potential R+D+i projects and human capital strategies were identified for three different time horizons: 0–5 years, 6–11 years, and 12–20 years.

Figure 4. Challenges and Enablers in the Mining Innovation Program (Alta Ley) in Chile



Source: Alta Ley Roadmap.

The portfolio of instruments and initiatives designed to fulfil the mission toward 2035 included more than 60 projects developed within the framework of the four strategic areas identified in the roadmap. The following are some of the most ambitious R&D+i solutions identified:

- Development of new technologies to monitor and map existing tailings.
- Zero-waste mining technologies.
- R&D+i activities to recover value from tailings.
- A dual hydrogen-diesel combustion system for mining extraction trucks.
- Technologies for climate smart mining.

Various instruments were designed to enable the innovation ecosystem:

- An open innovation platform to facilitate collective solutions to technological problems.
- Technology institutes to develop clean technologies.
- Interoperability standards.
- Pilot centers for technology transfer and collective innovation
- Training programs.
- Initiatives to advance human capital.

5.2.1. MOP Characteristics

In what follows, we analyze Alta Ley considering the five criteria for MOPs proposed in Mazzucato (2018a).

Bold and Inspirational with Wide Societal Relevance

The program builds on the increasing demand for a national policy to develop the mining sector that emerged within the mining ecosystem and civil society over the past decade.

Chile's economic development depends on and is hampered by management of its natural resources, mostly copper. The program responds to the sustainable and inclusive development challenges by fostering a knowledge-intensive and sustainable mining sector while including civil society and communities in the decision-making process. The mission of the program is to change the direction of the mining sector, which is currently based on exporting raw material, by fostering the adoption of green technologies and improving investments in the smelting and refining processes to help Chile become engaged all along the value chain the mining value chain.

The mining ecosystem, which faces significant productivity challenges, welcomed the program as an opportunity to reinforce the role of the sector in the economy. Even though the program started with a broad and bold mission and with a clear orientation, at its current development stage, its scope is too narrow, resulting in ambitious initiatives at the sectorial level but lacking the characteristics to be considered bold and ambitious at the national level, and thus triggering the imagination of the whole society. This narrowing of the scope is probably because the program has been supported and promoted on a technical and sectorial level, rather than at a political and social one. The program has the potential to stimulate the imagination of civil society, but government support is necessary to construct a stronger and more widely shared vision.

Clear Direction: Targeted, Measurable, and Time-Bound

The direction of change was explicitly stated: generate sustainable technologies to increase efficiency in the mining sector and develop an innovative ecosystem around mining. The time horizon is toward 2035, with mid-term objectives in the first, fifth, tenth, and twentieth years. The solutions identified are concrete and measurable; however, the number of solutions and lines of action identified seem more related to the evolution of the sector than to fulfilling the mission, and the monitoring and evaluation systems are limited to cost efficiency.

Involving Research and Innovation

The focus of the program is broad: foster the diversification and specialization of the Chilean economy while taking advantage of Chile's copper reserves, which have reached a maturity stages that requires more innovative solutions. Developing technologies, diversifying production, and generating human capital are the three main pillars around which the program was designed. Technological development and innovation are considered central at the process and product levels.

Considering the R&D projects and the total budget estimated to execute Alta Ley, the mission is ambitious compared to previous initiatives for the mining sector. The budget was reduced during the first year of implementation, thus significantly reducing the size of the program and negatively affecting its potential in terms of research and innovation. However, the Alta Ley Corporation[9] has been working to make the program more attractive to private investors interested in technological initiatives.

[9] The institutionalization of the Alta Ley National Mining Program.

To assess the technical feasibility of the program, we analyzed background studies carried out by Fundación Chile (2012, 2014) and Alta Ley (2016). These diagnostic studies showed that the technological development involved in each of the activities presented in the roadmap is feasible at the world industry level and in particular at the Chilean level, where the mining industry is transitioning toward a more mature phase. Many technological opportunities arise from the roadmap, including sustainable management of tailings deposits, more efficient techniques for smelting and refining, hydrometallurgy, and sustainable energy and water management. The STI ecosystem is part of most of the program's initiatives and further efforts are being carried out to increase the participation of universities and technological centers. One of the program's strengths is that the large mining firms (responsible for about the 80 percent of copper production) have participated in defining its objectives and targets.

Cross-sectorial, Cross-actor, and Cross-disciplinary

Impact: The impact the technological challenge could have on the mining sector in the short, medium, and long term. And the implications of tackling the challenge on the Chilean economy.

Transversality and horizontality: The potential impact of the same challenge on sectors other than mining (particularly copper).

However, the solutions identified within the program are poorly developed in terms of possible linkages with other sectors and remain too narrowly focused on the Chilean mining ecosystem. According to most of the people we interviewed, poor exploitation of the program's cross-sectoriality is due to the fact that the program once defined remained within CORFO and was not scaled up toan higher level. Further, respondents said keeping the initiative only within CORFO narrowed its scope and thus its potential impact.

In 2018, the Alta Ley was moved under the the Ministry of Mining (CORFO still plays a central role in implementation and financing) to increase the program's development potential.

Representatives of subsystems of the STI ecosystem were involved in identifying the priorities, developing the roadmap, and defining future steps. These broad, bottom-up processes, involving key players in the mining sector, resulted in a shared vision at the ecosystem level.

To facilitate coordination among actors and sectors, two new instruments were designed: an open platform to facilitate co-creation and information sharing, and a clean technology institute to foster cross-disciplinary research in clean technologies and green solutions.

Multiple Competing Solutions

The roadmap of the Alta Ley is ambitious in the potential number of solutions to achieve the mission. However, our interviews showed that the multiple solutions were not coordinated at the program level, which resulted in several independent, isolated solutions rather than a system of competing and interacting projects. The lack of coordination between the projects dramatically reduced the program's potential.

5.3. Dynamics: Developing and Implementing the Program

In 2013, 11 people from the mining ecosystem, led by the ex-president Ricardo Lagos, signed and presented a document titled "Mining and Sustainable Development in Chile: Towards a Shared Vision" (Minería y Desarrollo Sostenible, 2014), putting forward a set of political and technical proposals to empower the virtuous, sustainable, and inclusive elements of the mining sector. To implement this vision, in 2014, the government created the Mining and Development Commission (working within the framework of the CNID). This commission presented the report "Mining: A Platform for the Future for Chile" to the president (Comisión Minería y Desarrollo and CNID, 2014), providing concrete guidelines for designing a national mining policy toward 2035.

As a result of this report, two parallel initiatives were created. Alta Ley, within the framework of CORFO's Transforma initiative, and Valor Minero. The idea behind creating parallel initiatives was to create to strategic hubs to deal with productivity and sustainability (Alta Ley) and with inclusiveness (Valor Minero).

Though the legitimacy of the Alta Ley Program seems high within the mining ecosystem, it needs to be strengthened at the societal and government levels. Both Alta Ley and Valor Minero are working to increase the legitimacy of mining innovation policies at the societal level. At the government level, only CORFO was fully on board with the scope and implementation of the program, though the Ministries of Mining and of Economy came on in a subsequent phase. Other ministries, such as the Ministries of Finance and of Environment, have not fully joined the cause of Alta Ley, which is evident from their low involvement during the different phases of the program.

The creation of two initiatives, each with a different focus and strategic emphasis, generated some confusion in the mining ecosystem, especially because of the lack of coordination between the two. Sector actors and stakeholders had major doubts about the responsibilities, interests, and projects of each of the initiatives. During the last years, coordination of the two initiatives has significantly improved.

Because there is not much information about the governance of Valor Minero, the following analysis is based on the official documentation of Alta Ley.

According to the roadmap, Alta Ley was expected to be managed by a committee created by CORFO and the committee was to oversee tendering of the activities and managing the follow-up mechanisms. The committee was then intended to be a bridge institution to facilitate interchange among the actors in the mining ecosystem. Stakeholders participate in monthly meetings during which they discuss implementing the initiative. The ecosystem includes actors from the private sector, universities, and technological centers.

Since December 2018, Alta Ley has been organized as a public–private corporation under the Ministry of Mining. The corporation has its own executive board that is in charge of governing activities implemented within the roadmap. It is worth noting that most of the activities are formally executed by Fundación Chile, which, as such, seems to act as the initiative's co-manager. Analysis of the activities developed within the framework of Alta Ley shows that Fundación Chile manages the bulk of the activities and thus concentrates a significant share of the stakeholder's managerial power. With respect to monitoring activities presented in the roadmap, as in the case of the Solar Energy Program, Alta Ley has monitoring systems to evaluate budgetary allocation (mainly required by the FIE or the Ministry of Finance) and external monitoring of the overall program (i.e., IDB's evaluation). To our knowledge, no formal monitoring mechanism has been developed to assess the progress in implementing the roadmap or fulfilling the mission. Creating such mechanisms is strongly recommended to evaluate progress and facilitate internal learning to re-tailor objectives and expected results.

The main source of financing is public, with funds allocated by the FIE and executed by CORFO and by central and local governments. The budget initially allocated was linked to the program's ambitions and the timescale to reach objectives Although most of the expected funds are public, private investments play a central role in the mining ecosystem. The contribution from the private sector, in terms of investments and R&D, should contribute more than a half of the estimated budget.

No new instruments were created to implement the program. Instead, the program's structure was adapted to financing instruments already existing within CORFO (e.g., public tender and incentives for R&D) and some of Fundación Chile's instruments. The policy mix to support the program needs to be broadened, especially considering the program's ambitions regarding the role of the mining sector in shaping Chile's economic development. Coordination among the various ministries and public agencies has been poor and needs to be improved. Of note, most of the financing is through traditional CORFO instruments and thus funds are received through national budget allocation, creating a major limitation. In Chile, the national budget is approved annually and even multi-year financing schemes are subject to the availability of resources and review and approval. Therefore, Alta Ley lacks the patient financing required for continuity and to accomplish its mission, especially in the mining ecosystem, where technological development and innovation require huge investments.

Matching between the instruments and the targets presented in the roadmap was therefore limited by two main factors: the lack of coordination between the different state agencies and the lack of commitment to financing long-term targets. Table 3 summarizes the main results of the interviews in terms of the dynamics involved in designing and implementing the program.

Table 3. Designing and Implementing the Mining Innovation Program (Alta Ley)

RESULTS OF CASE 2		
	Roadmap	**Implementation**
Selection of mission and projects	Bottom-up during the whole process. Significant push from the mining ecosystem.	Eventually resulted in a semi-centralized structure, where most of the projects are being executed by Fundación Chile in partnership with other actors.
Impact-driven policy process	Identification of targets and milestones was too narrowly focused on the sector and not in line with the mission.	The targets and milestones were not considered realistic and thus more as guidance.
Portfolio management	A special fund (FIE) was created to finance the whole program (62 initiatives) as a block.	Static portfolio management, excessive bureaucracy, and short-term financing.
Flexibility	Initially, the policy process was relatively flexible.	New institutionality for Alta Ley (within the Ministry of Mining) could increase flexibility; lack of systemic view to manage instruments.
Monitoring	Only cost-efficiency monitoring and accountability instruments.	Monitoring instruments at the project level; lack of systemic perspective.
Citizen engagement	The initiatives have the potential to trigger social imagination, but focus has been too narrow. Initially, civil society was involved in both initiatives, and today it is a critical actor in Valor Minero.	Good citizen engagement in Valor Minero.
Relationship to long-term strategies	Program coherent with productive, environmental, and energy strategies; however, sustainability potential is underestimated by the ecosystem.	The potential policy complementarities have not been successfully exploited.

Source: Authors' elaboration.

5.4. Results and Outcomes

Alta Ley and Valor Minero, which are still being implemented, were put in place less than three years ago. Therefore, it is not possible to disentangle their impact on growth or investments. Of note, the Alta Ley initiative has been institutionalized within the Ministry of Mining.

5.5. Implications and Reflections

Even though not specifically MOP, the case study showed that in the case of Alta Ley, the legitimization, design, and implementation were similar to an MOP in the Chilean STI ecosystem. The main contribution of this analysis is that it helps identify key mechanisms and capabilities that Chile needs to strengthen to legitimize MOPs in the public discourse.

The bottom-up participatory process behind the construction of the shared vision for mining in the future has been essential to involve the private sector in the initiatives. The process that began more than 10 years ago has led to defining common strategies and priorities. The existence of a shared development vision for the future of mining is one of the most successful results of this experience. During the interviews and workshops, all actors agreed that what is missing is state support (at the ministerial level) to coordinate action to implement the vision.

Moreover, the participatory process used to develop the roadmap helped strengthen the trust between the public and private sectors, which is required to achieve sustainable development.

Many restrictions at the institutional and budgetary levels have hampered the program's potential. Based on the restrictions identified in this analysis, it is possible to identify some opportunities to improve Chile's MOPs design:

- Improve the mechanisms to monitor and assess impact.
- Create the conditions necessary to legitimize patient financing at the social and institutional levels.
- Strengthen the link between the policy mix and policy objectives at the government level.
- Improve coordination among public actors.

In terms of public capacities, this case study showed that, even though CORFO could have most of the capacities needed by an implementing agency in the STI ecosystem, the weaknesses in some of the key capacities at the state level have hampered any potential positive effect of the designed initiatives.

- **State capacity:** There is a lack of shared policy vision at the government level. At the agency level, it is not possible to create political legitimacy. CORFO has good knowledge of the ecosystem, but the lack of political support delegitimized its actions.
- **Technical-administrative capacity:** Though this is well developed within CORFO and Alta Ley Corporation, the public system does not have instruments that facilitate systemic learning.
- **Policy capacity:** Existing instruments and policies are inconsistent, bureaucracy is excessive, there is a lack of legitimized coordinating actors, there is no policy coordination at the government level, and implicit policies are not in line with long-term objectives.
- **Market capacity:** The market for mining technologies was developed considering the needs of both demand and supply within the STI ecosystem and in identifying technological priority. The financial market has not been developed; however, the mining sector has the scale and the critical mass to generate private investment.
- **Productive capacity:** The private sector, particularly the large national and international companies – leaders in the market – were engaged in defining priorities and targets; however, sector dynamics make innovation difficult. A more strategic focus, possibly like one of the European Union's strategic programs, might help.
- **STI capacity:** There is a lack of qualified human capital. Also, connections within the STI ecosystem and between the STI ecosystem and the mining technology market need to be strengthened. The program facilitated the creation of innovation spaces, such as the innovation platform, to vitalize the ecosystem, involving universities, tech centers, and the private sector. CORFO has good capacity to use public resources to foster technological development and innovation.

5.6. Summary and Highlights

In this section, we analyze the design and implementation of the Alta Ley program and its connections with Valor Minero.

The Alta Ley program was designed with some characteristics that resemble an MOP in terms of mobilizing various actors within each sector to articulate possible solutions to societal and technology challenges. The strategy for the future of the mining system is based on a well-defined vision created by diverse actors in the mining and STI ecosystems and has benefited from the support of representatives of big mining companies and associations, and the involvement of ex-president Ricardo Lagos.

Even though its characteristics resemble those of an MOP, this case is substantially different from the MOP concept proposed by Mazzucato (2018a). Despite the ambitions in the roadmap, the program did not stimulate the imagination of the various actors, being too focused on the private sector and lacking long-term financing.

The most successful result has been the bottom-up process of creating a shared vision for the future of mining and identifying the challenges and priorities. This broad approach to policy definition should be followed in the future. The lack of coordination between state agencies and the lack of political legitimacy are important constraints. This case study has highlighted that Chile still has important structural gaps in the STI system in terms of generating human capital and coordinating efforts between the diverse actors from the private, public, and academic sectors.

However, the Alta Ley experience represents an interesting case in terms of original features in policy design compared to traditional policy experiences in Chile and in the mining sector. The program involved identifying a sector that had the potential to be transformative based on the current state of the country's and the sector's development and expected long-term development.

The design of the program started from identifying the STI capacities and opportunities deriving from focusing on the mining sector as a development platform for the future. The vision was constructed based on a novel mechanism to identify shared priorities and technological challenges, for the first time involving a bottom-up process. Another distinct element, compared with previous initiatives, was the focus on research, technology, and innovation as factors enabling national development. Some of the instruments that were designed, such as the open platform to collectively resolve STI challenges and the multi-actor technological centers for R&D in clean technologies, were completely new in Chile.

As for the Solar Energy Program, one of the main problems is development of the program at the agency level without any commitment at the highest level. This lack of commitment has led to a lack of complementary policies to facilitate implementation and exploit the program's horizontal potential. Moreover, CORFO's structure and bureaucracy made the initiatives very rigid and difficult to adjust or modify in scope in the short time horizon of a government (four years).

However, CORFO is the government agency with characteristics that most closely approximate an entrepreneurial structure, since it is strategically positioned throughout the innovation curve. The original roadmap for the Alta Ley Program envisages CORFO's actions from the upstream to the downstream of the innovation curve, from creating human and social capital to testing new technologies in pilot centers and creating new standards for the interoperability of the mines. In practice, CORFO's experience has the potential to change Chile's mindset regarding policymaking and designing STI policies, bringing it closer to the MOP concept presented in Mazzucato (2018a).

This case shows how to overcome policy constraints in a traditional sector by reorienting the necessities of the sector and of civil society toward existing instruments and programs to achieve new shared goals.

6 Setting Priorities for Future Mission-Oriented Policies

The two case studies show that in Chile there are projects worth analyzing as MOP initiatives, providing an important source of knowledge about existing limitations and institutional capacities that must be strengthened, as well as capacities that need to be created to implement MOPs.

The analysis reveals many similarities between the solar and mining industries. The fact that both programs have the same implementation agency (CORFO) certainly explains some of these similarities, since they were developed under similar administrative and financial structures. The Solar Energy Program stands out for its design, with concrete objectives and well-defined intermedite goals. On the other hand, Alta Ley seems to be advancing naturally since the mining sector and mining companies are mature, mostly solid businesses with lots of resources.

In analyzing the mining and solar programs, we identified two main priorities to overcome current systemic limitations and provide a basis for future development of MOPs in Chile:

- Define common objectives for the STI ecosystem.
- Create a shared development vision.

6.1. Define Common Objectives for the Science, Technology, and Innovation Ecosystem

The National System of Innovation of Chile is one of the best institutionally structured, with an independent organization, the CNID, advising the president on national and global challenges and a recently created Ministry for Science, Technology, and Innovation.

Even though the institutional structure is very well conformed, historical frictions hamper its potential functioning. The first, and probably most resilient friction is the political (and social) belief about the role that innovation plays in fostering development. While there is consensus about the need to speed up the STI ecosystem in Chile, the diverse political parties have divergent ideas about how to foster innovation. Therefore, during recent decades, the political cycles have directed STI policies more toward fostering entrepreneurship, start-ups, and the innovation ecosystem than on identifying structural gaps and promoting policies tailored to increasing STI in specific sectors. This alternation of visions and policies has contributed to the polarization of the actors within the STI ecosystem.

The actors from the economic and productive sectors sustain the first strong position regarding national innovation policies. According to them, the fulcrum of an efficient institutional structure should be promoting entrepreneurial and productive innovation. Researchers (scientists and academics) have a broader vision about the role of STI policies. According to them, STI are necessary to develop the entire social system, not only the economic and productive systems. The persistence of two contrasting perspectives on STI policies has permeated the structure of Chile's innovation system. The system's current architecture is polarized in two ministries – the Ministry of Economy and the Ministry of Education – which implement policies in different areas and respond to different missions. This bipolar structure is reinforced by the allocation of funds through two main executing agencies, CORFO and CONICYT (the National Commission for Scientific and Technological Research). The current divergence in resource allocation and program implementation has been recognized as one of the main weaknesses of the STI ecosystem.

Improving the interaction between research and production will be key to strengthening cooperation between diverse agents. Both case studies demonstrate that academic and productive actors respond to different incentives, despite efforts to create platfoms for cooperation. Defining common objectives is fundamental to generating the conditions necessary to foster coopertion between STI supply (research) and demand (production).

6.2. Create a Shared Development Vision

The case studies highlight how lack of leadership from the highest government level, especially the president, restricts implementation of the programs, particularly because of the lack of coordination between government agencies and ministries for budget allocation.

Most of the people we interviewed were concerned about the long-term sustainability of the programs because of the impact of political cycles on the strategic direction of public policies. Many respondents agreed on the need to strengthen communication so that civil society, academia, and the private sector can internalize the proposed challenges and become instruments to ensure continuity of programs beyond political mandates. Since government is the only actor in the ecosystem that is subject to periodic renewal, it is up to the other three actors (society, academia, and the private sector) to stabilize policies, programs, and financing over time, pressing each administration to maintain the mission identified at the highest level of executive power.

The analysis shows that Chile must build a vision for the future to implement MOPs, sharing the vision with the private sector, academia, and civil society. Only society's commitment can legitimize public intervention in the long run and minimize the effect of political cycles on public policies and initiatives. One of the main weaknesses of the public sector in Chile that has clearly emeged from this analysis is its vulnerability to the political cycle. Vulnerability makes long-term policies unattractive to both the private sector and academia, and structurally constrains the potential of initiatives to trigger the imagination of all of civil society.

In future a strategy needs to be developed to make long-term policies more credible for society and the STI ecosystem. To reduce the short-term vulnerability, it is key that challenges and missions are identified by government, academia, civil society, and the private sector together. Thus, legitimizing such coordination will be key to continuing missions when the government changes. That is why it is important to develop an effective communication strategy adapted to each stakeholder. Communication of challenges, missions, and objectives must be tailored to civil society, academia, and the private sector based on the different objectives and motivations of each.

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