



SCIENCE, TECHNOLOGY AND INNOVATION FOR A NEW SUSTAINABLE AND INCLUSIVE DEVELOPMENT PACT

Strategic Guidelines for 2030 after ten years of trajectory

*"A call to
get out of the
comfort zone."*
Ma. Eliana Arntz

*"Sincere intention
of approaching
and improving the
STI."*
Olga Barbosa

*"A multifaceted
analysis that
invites you to work
for the quality of
life of Chileans."*
Juan Claro

*"An invitation to be
great, to strengthen
bridges between
country challenges
and collective
capacities."*
Andrés Couve

*"Accurately analyzes
our shortcomings
and challenges."*
Carlos Montes

*"An invitation to
work together for a
better Chile."*
Alejandra Mustakis

*"A good sign of the
urgency to move
forward."*
Sonia Pérez

*"Excellent report with
concrete proposals
that may lead to
consensus."*
Klaus Schmidt-Hebbel

cnid | Consejo Nacional
de Innovación
para el Desarrollo

**SCIENCE, TECHNOLOGY AND INNOVATION
FOR A NEW SUSTAINABLE AND INCLUSIVE
DEVELOPMENT PACT**

Strategic Guidelines for 2030 after ten years of trajectory



NATIONAL COUNCIL OF INNOVATION FOR DEVELOPMENT

CONTENTS



9	Letter from the Chairman of the National Council of Innovation for Development Now more than ever, we need science, technology and innovation	26	II. Old and new challenges for development Nature and our production methods limit our growth	44	Climate change is a critical issue on the path to development
13	National Council of Innovation for Development Advisors Ministers Permanent Guests	28	We continue exporting practically the same	46	The sustainability imperative: a quantum leap, urgent, unavoidable <i>By Barbara Saavedra Perez</i>
14	The news we want to read in 2030 How did Chile do it?	30	Our productivity differences between companies are a root cause of inequality	48	In Chile, global change has particularly critical manifestations
16	Executive Summary	32	Social spending reduces inequality, but it cannot be the only answer	50	Our current productive structure is particularly affected by climate change
19	SECTION I Chile and the world have changed: STI contribution is key to relaunch our development	34	An ageing population is another factor putting pressure on our economy and social policy	52	Rapid and uncertain change affects all spheres of social life and poses unprecedented challenges
20	Chapter 1 Old and new challenges for Chile's development in a new context	36	We must take on the challenge of improving productivity	54	A change that affects the way we live together
21	Presentation	38	A strong drive to innovation and productivity <i>By Carlos Álvarez Voullième</i>	56	Complexity has become the rule
24	I. We've grown, but... The pride of a Chile that has advanced, the concern for a Chile that staggers slowly forward	40	And take on the challenge of employment	58	The country where I would like to live <i>By Claudia Bobadilla Ferrer</i>
		42	III. Today we face an increasingly demanding and pressing context An uncertain global economic scenario	60	The new path to development challenges us to mobilise talent
				63	A manifesto of Emerging Innovation Agents A generation committed to development

- 64 **Chapter 2**
The opportunities provided by science, technology and innovation
- 65 **Presentation**
- 66 **I. Aid for economic growth**
Innovation helps countries to perform
- 68 **II. Facilitator to address the challenges no one else will face for us**
Denmark decides to transform its energy grid
- 70 We can make mining a virtuous industry
- 72 Ensuring availability of water is another challenge that no one else will take on for us
- 74 Sustainable water resources management: an urgent and collective task
By Margarita D'Etigny Lira
- 76 **III. Platform to leverage technological advances to improve our well-being and inclusion**
Adapting technologies developed by others can lead to major improvements
- 78 Construction and health, two areas where technological adaptation would allow us to take a giant leap
- 80 **IV. Improving our comprehension skills to face the new scenarios**
Integrate and take advantage of the impacts of scientific and technological progress on society
- 82 **V. Options to take advantage of our particular characteristics**
Many countries have taken advantage of their distinctive characteristics as an opportunity for development
- 84 We have an opportunity in the knowledge and experience we have accumulated from natural disasters
- 86 A country that stands up to take care of its people and the world
By Juan Carlos de la Llera Martin
- 88 Magellan Natural Laboratory: participating in the world conversations, anchored in this territory
- 90 Unique natural laboratories
By Alvaro Fischer Abeliuk
- 92 **VI. Conditions to deploy people's creativity**
The knowledge created by STI can be appropriated and multiplied by people and citizens
- 94 Social innovation has earned its space
- 96 STI can help to even the playing field faster, more effectively and, above all, with more dignity
By Rodrigo Jordán Fuchs
- 98 New dynamics of science-based entrepreneurship are being developed and installed
- 101 **SECTION II**
The road travelled
- 102 **Chapter 3**
Our science, technology and innovation in the last decade: we have done so much with so little, but we need so much more
- 103 **Presentation**
- 104 **I. Today we can give a much more decisive boost to our sciences, technologies and innovation**
Our innovation ecosystem is beginning to take shape

106	We have made significant efforts to train people	126	Companies - particularly large ones - can do more	148	III. The most important thing is to create and foster connections, the vital links in the system Institutions that connect scientific and technological research with public interest issues are emerging
108	Educate to innovate <i>By Gonzalo Vargas Otte</i>	128	How could we develop the business innovation we would like?	150	Scientific Collaboration <i>By Servet Martínez Aguilera</i>
110	We still have space to connect more researchers to our challenges as a society	130	Research and development in production companies <i>By Patricio Meller Bock</i>	152	The every-growing interest to connect is fertile ground for the leap we need
112	The digital revolution offers huge possibilities that we must seize	132	Innovation is not the same for everyone: the wide world of small-sized companies	155	2030 vision of Emerging Agents for Innovation
114	We need a paradigm shift to drive the digital world	134	Information and communication technologies offer great opportunities for smaller businesses	156	Chapter 4 Our public policy on science, technology and innovation
116	A paradigm shift in digital development <i>By Juan Rada Mladinich</i>	136	Small-sized businesses face multiple obstacles to their development	157	Presentation
118	II. STI Actors: we have talent, we need to nurture it to take a big leap The quality of our science encourages us: few researchers but great skills	138	Innovating from the regions <i>By Pamela Chavez Crooker</i>	158	I. The STI policy over the years: more words than action We have not succeeded in having decisive public efforts in science, technology and innovation
120	We have world-class science and technology <i>By Juan Asenjo De Leuze</i>	140	The irruption of our entrepreneurial culture has gained worldwide recognition	160	We need a policy that gives us purpose, facilitates coordination and above all adds more hands
122	D&I Actors: technicians and engineers	142	The challenge of driving innovative entrepreneurship	162	The case of Corfo: an active agency that has accumulated knowledge, what does it need to do more?
124	We have deployed the research: it needs to be strengthened throughout the territory, companies and the State	144	The disruptive potential of foreign direct investment in R&D&I		
		146	The State could be much more active by using and promoting R&D&I		

- 164 The Conicyt case: a key institution in the history of Research. How to further boost collaboration and connection with country challenges?
- 166 Ambitious goals that bring us together and mobilise more resources: a story we can tell about the future
- 168 Aspiration and need to reconcile perspectives: country and regions
- 170 Innovation, universities and territories
By Gonzalo Herrera Jimenez
- 172 II. We have an opportunity to broaden and deepen public action to boost STI**
The State has different ways of boosting science, technologies and innovation, that we still have not seized
- 174 We have become entangled in conflicting ideological positions, but are the differences really that big?
- 176 Continuity of entrepreneurship policies
By Cristóbal Undurraga Vergara
- 178 The discrepancies about the role and value of science that divided us, begin to dissolve
- 180 Trapped in myths and rhetoric: What were other OECD countries doing when they had our current per capita income?
- 184 SECTION III**
Starting a new stage
- 185 Chapter 5**
A new transformational drive towards development
- 185 More people benefit from science, technology and innovation**
- 187 Participation and Collaboration: conditions for science, technology and innovation in a complex context**
- 190 Five proposals for a new transformational drive**
- 192 An invitation to be big: National Development Challenges
- 196 A way to act collectively: Business investment meetings for sectoral R&D&I
- 200 Ability to look ahead: A State that understands and anticipates
- 204 A condition to take-off: Broadband and Digital government from Visviri to Cape Horn
- 208 A an opportunity to continue flying high: STI at the heart of schools
- 211 A note on the tasks of the new science, technology and innovation institutional structure
- 212 At the end of a document.**
At the beginning of a process
- 215 Annex No. 1**
More researchers proposed by the Commission on Science for Development
- 217 Acknowledgements**

LETTER FROM THE CHAIRMAN OF THE NATIONAL COUNCIL OF INNOVATION FOR DEVELOPMENT



Now more than ever, we need science, technology and innovation



The National Innovation Council for Competitiveness (CNIC) was created in response to the need for an independent collegiate body to guide the country's efforts in science, technology and innovation. Yesterday and today, the Council is expected to look beyond the current situation and to help integrate medium and long-term challenges into the decisions we make today.

In its more than ten-year history, the Council has been a space for dialogue and reflection that has sought to influence, sometimes more successfully than others, the definitions and priorities for action of the relevant actors in the field of science, technology and innovation (STI) in Chile. It has also been a meeting space to promote initiatives that require the agreement and coordination of actors from diverse backgrounds.

A key channel through which the Council seeks to exercise its influence is the creation and dissemination of strategic lines of action to promote innovation. Over the years, these efforts have adopted different perspectives that enrich and add complexity to our perspective on the challenges we face in this field.

The New National Innovation Strategy aims to integrate these perspectives and reflect on what has been learned over the last ten years.

We begin by acknowledging that, although there have been some specific advances, we still have not made science, technology and innovation a substantive factor for Chile's development. Likewise, we are aware that we are in a very different context from ten years ago. During this period, both Chile and the world have undergone fundamental changes that we cannot ignore, making the STI's contribution even more significant and necessary today. However, we also perceive that there is more collaborative drive among different actors to jointly take charge of development, as well as a greater awareness of the global challenges we share with the rest of humanity.

On the one hand, the phenomenon of global warming is practically unchallenged and has acquired a sense of real urgency. Today, environmental sustainability is a major non-residual issue for society and the economy to function properly. On the other hand, globalisation and the increased levels of transparency associated with the expansion

In its more than ten-year history, the Council has been a space for dialogue and reflection that has sought to influence, sometimes more successfully than others, the definitions and priorities for action of the relevant actors in the field of science, technology and innovation in Chile.

of modern communication devices have revealed situations of exclusion and injustice contradicting the promises of inclusion and greater well-being for all. In the eyes of many, democracy and economic growth are in debt, and the demands for greater participation, both in the decisions and benefits of collective progress, multiply.

Certainly, environmental protection and conservation or greater social inclusion goals have been present for a long time. The novelty, however, is that today citizens have many more channels through which they can make their voices heard more strongly. A voice that mobilises, questions, demands transparency, that today makes these wishes not just an appeal to ethics, but also defines a new framework for collective action.

In short, it is clear that without sustainability and social inclusion, we will not have the development that will make us feel worthy as human beings and that can be sustained over time; neither will growth be possible.

The very concept of development is undergoing a transformation process. Humanity, and this includes Chile, is living a transition from a univocal equivalence between development and economic growth, to a conception where the former is seen as a process where sustainability, inclusion and growth advance in a balance that, we must admit, is always precarious and conflictive.

In this context, scientific knowledge, technological development and innovation are more necessary than ever. It is through the possibilities they open up to us, in a context of dialogue and agreements, that we can decrease major conflicts that necessarily arise between the different dimensions of development. It is through greater and broader knowledge that we can approach an understanding that will improve the quality of our social dialogue and enable us to take more solidly based decisions with greater prospects for the future. It is by having more spaces and tools to deploy creativity that people can advance in their personal fulfilment projects, whether individual or collective.

Science, technology and innovation are undoubtedly key to increasing our productivity and boosting our growth. But they are also paths to creating value in the social sphere, in the generation of public goods, in environmental conservation and certainly fundamental in the understanding of our worlds and their transformation. That is why we believe that their contributions are crucial to help us move towards what we can understand as a new dynamic, inclusive and sustainable development agreement. This more comprehensive search motivated the change from competitiveness towards development by this Council.

Today we need more science, more technology and more innovation,

not less. Chile is certainly facing major challenges, but also opportunities. In order to move forward, we need more than just good ideas and proposals. We need to agree on what we want to achieve and how we are going to achieve it. An agreement that, to be effective, must be able to lead, project and sustain this task over time. STI results are not achieved in a few years. We need to be persistent in our goals and efforts, and those who hold leadership positions in different spheres of society cannot escape their role or responsibility.

The strategic orientations proposed in this document have been based on multiple studies and numerous consultations with actors in our society. But it is also, and above all, the result of the dialogue between those of us who participate in the National Council of Innovation for Development (CNID).

Our background is as diverse as our main interests and concerns. Such interests include scientific and academic advances, environmental conservation, promoting entrepreneurship, overcoming poverty, the quality of public policies, improving competitiveness and productivity, and balanced territorial development. But it is also our political position and, consequently, how we value and understand cultural, economic and social dynamics.

Therefore, reaching an agreement within the CNID has not been easy. We did not want the results of our dialogue to be a set of general recommendations or commitments. Nor did we want, in order to achieve broader identification with what was proposed, to end up with a long list of initiatives. We wanted to make a difference, hence, we set ourselves priorities.

In this process we did not ignore our differences, nor did we want to dilute them in an inconsequential exercise. Our efforts were aimed at rolling out a proposal guided by intellectual honesty and love for our country.

Those of us who sign this document are convinced that Chile is at a critical crossroads in its development and that continuing to turn our backs on STI is a historical mistake. Without a more significant contribution from science, technology and innovation, not only will we not be able to continue to make progress, but we will also continue on a downward path, with inevitable implications for our coexistence and for the quality of life of future generations.

We know we cannot control the future and that our opportunities for effective action are limited. For this reason, we have tried to present a path of progress emphasising the progressive development of capabilities and the need to generate knowledge on how to carry out far-reaching actions. We have also agreed on a limited, but powerful range of initiatives that we believe should be promoted without delay.

Today we want the results of this collective effort to be available to the country, because we are convinced that it can make a real difference between a stagnating Chile and a Chile that is moving forward for the benefit of present and future generations.

Gonzalo Rivas Gómez
Chairman
National Council of Innovation for Development

NATIONAL COUNCIL OF INNOVATION FOR DEVELOPMENT (CNID)

**PRESIDENT****Gonzalo Rivas Gómez****ADVISORS****Carlos Álvarez Voullième**

Director of InvestChile.

Juan Asenjo De Leuze

National Prize in Applied Science and Technology. Director of the Center for Biotechnology and Bioengineering (CeBiB).

Claudia Bobadilla Ferrer

Director of the RAD Foundation.

Pamela Chávez Crooker

Founder member of Aguamarina S.A.

Marguerite D'Etigny Lira

Director of IdeaConsultora.

Juan Carlos de la Llera Martin

Dean of the Faculty of Engineering of the P. Universidad Católica de Chile.

Álvaro Fischer Abeliuk

Founding partner of Resiter S.A.

Gonzalo Herrera Jiménez

Vice-rector of Innovation and Technology Transfer of Universidad de Talca.

Rodrigo Jordan Fuchs

Vice President of the National Foundation for Overcoming of Poverty.

Servet Martínez Aguilera

National Prize in Exact Sciences. Researcher at the Mathematical Modelling Centre.

Patricio Meller Bock

President of Fundación Chile.

Juan Rada Mladinic

Consultant.

Bárbara Saavedra Pérez

Director for Chile of the Wildlife Conservation Society

Cristobal Undurraga Vergara

Ekonométrica Development Manager.

Gonzalo Vargas Otte

Rector of Inacap.

**MINISTERS****Luis Felipe Céspedes Cifuentes**

Minister of Economy, Development and Tourism.

Adriana Delpiano Puelma

Minister of Education.

Carlos Furche Guajardo

Minister of Agriculture.

Rodrigo Valdés Pulido

Minister of Finance.

**PERMANENT GUESTS****Eduardo Bitrán Colodro**

Vice President of Corfo.

Mario Hamuy Wackenhut

President of Conicyt.

Gabriel Rodríguez García-Huidobro

Director of Energy, Science and Technology and Innovation of the Ministry of Foreign Affairs

Maximiliano Santa Cruz Scantlebury

Director of the National Institute of Industrial Property.

Paula Gonzalez Frias

Head of the Innovation Division of the Ministry of Economy.

**EXECUTIVE SECRETARY****Katherine Villarroel Gatica**

THE NEWS WE WANT TO READ IN 2030

~~~~~  
World Times:

# HOW DID CHILE DO IT?

It's incredible: Chile is the world's best prepared country to face and recover from natural disasters.

Chile has an extraordinary capacity to materially, functionally and emotionally stand back up again and learn from its history marked by earthquakes. Chile has been able to transfer and adapt lessons learned to other natural disaster situations, which are getting more frequent around the world, such as floods, fires and tsunamis.

Moreover, Chileans have become stronger and more resilient to the impact of their biogeographic environment. They have also learned to make this a field to develop broad and multidisciplinary knowledge, as well as different types of technologies, which today have made it the undisputed leader in this field.

It is this field that has earned it more media headlines and posts, however, it is a process that has permeated different areas of the lives of its people, institutions and organisations. Fifteen years ago, a study showed that people were far removed from the world of science and technology. Today, most people not only value science and technology, they also assert they form part of their

interests and have a key function in different areas and preferences of their daily life.

How science, technology and innovation started to focus on the “cultural DNA” of Chileans with unique characteristics that have earned it the first places in the global medal table (see table), is a story that weaves several threads together.

The quietest has been deployed at the heart of Chile's schools, where for almost fifteen years an official programme has enabled scientists and teachers to work side by side, each with their own field of expertise, so students can develop curiosity, problem solving, cognitive flexibility and other skills typical of this century. These **scientists are not making didactic presentations to support teachers. These scientists and technologists are making themselves available for the educational challenges of each school and its environment.**

The programme evaluations have been clear: much more important than improving student performance measured

by international tests (which do exist), are the quality, importance and value of knowledge generated in schools.

Entrepreneurs have also done their part and are increasingly involved, not only in spending but also in Chile's R&D quality. What began as **investment boards to address sectoral challenges** has gradually become a new way of tackling problems and turning them into opportunities.

In turn, **the State has made serious and systematic efforts to develop its internal capabilities** to understand and adapt to the accelerated and complex phenomena of the century. And today it is known as "the smartest State in the region". Not only because it has highly skilled people and access to high-quality data, thanks to a system that requires each service to allocate fixed amounts of funds for this purpose. It also knew when to take the first step to create knowledge, connection and collaboration opportunities for everyone.

Thanks to the extensive modernisation and digitalisation of government services, today everyone who is in Chile - even in those remote areas that made it famous in last century's adventure tourism guides - **has access to one of the best digital infrastructures on the planet**. Someone in the southernmost region can send information to a termi-

nal in the north desert that connects to a 3D printer and creates a specific spare part for a solar inverter. Let's not forget the big data processing centres that have helped to develop neglected regions and areas, as well as digitalise micro and small enterprises, improving the quality of life of most of the population and workers of this country.

Over the last decade, the now world-renowned "**Development Goals**" competition has enabled them to tackle Chile's major issues jointly and swiftly. Low-cost, non-conventional renewable energy, pollution prevention in the mining sector, water resources availability, are some of the key challenges they have tackled with this public-private method combining efforts and resources with a dynamic and transparent management system.

Science, technology and innovation have truly helped Chile become more inclusive and sustainable, and it has even improved its mental health indicators! But, at the end of the day, it seems that the most important lesson learned by its inhabitants is that they have learned to look beyond their personal or corporate interests and agree to work together towards a common goal.

## Chile's new top five

1. Resilience to natural disasters
2. Solar energy
3. Biosphere studies in the southern hemisphere
4. Reducing childhood obesity
5. Green tailings technologies

**If you want to know how this is possible, we invite you to read on...**

## EXECUTIVE SUMMARY



Ten years ago, this Council was founded to create guidelines for the contribution of science, technology and innovation (STI) to our country's competitiveness. This view is no longer enough. Today we are living in a rapidly changing world, where science, technology and innovation are challenged by the desire for development that cannot ignore the integration of economic, social and environmental dimensions.

From the recognition of this necessary transformation and of the path we have travelled so far, this document is, above all, an invitation to a major agreement that will allow, in diverse spaces and across the board, STI to contribute to the challenges and opportunities opening up for Chile in this world in transition.

To this end, we have organised this text as a journey that starts from the need to create a sense of urgency to transform the way we conceive and address what we understand by development, and how promoting STI can help us make this a smoother and successful transition. Subsequently we analyse the strengths and weaknesses of the progress we have made in this field. We conclude this journey with a limited set of proposals, from this renewed perspective, to boost the contribution of STI to our development and coexistence.

Based on this logic, the document is organised into five chapters.

The first chapter addresses the challenges and opportunities faced by Chile in the current domestic and global context. We begin by setting out Chile's extraordinary achievements in recent decades, such as a sharp decline in poverty and a significant increase in material welfare. At the same time, we acknowledge there are other key areas where we have not been as successful and which we tend to ignore.

The slow progress made in reducing inequalities and promoting social cohesion, as well as limited concern for ecosystem conservation and

environmental sustainability are areas where we still have a great deal of work to do and which are increasingly recognised, domestically and internationally, as fundamental areas of development, rather than as areas that can be subordinated to the pursuit of economic growth. The international agreement reached on the Sustainable Development Goals is undoubtedly the clearest expression of this transformation.

But this process also takes place in the context of a rapid wave of technological change with enormous economic, social and even ethical implications. Its repercussions are already being felt in areas as varied as job profile and content; the ways businesses are deployed and the conditions where social coexistence occurs. But it is also beginning to raise major questions such as the very limits of human life or the potential transfer of fundamental decision making to artificial intelligence. Opportunities and threats coexist in this process, but our decisions will ultimately define the path we take. What is clear, however, is that today all actors, perhaps even the State, are challenged to make decisions at a time when old certainties are being replaced by growing perplexity.

Based on this context, marked by a change in our idea of development and the scope of the wave of technological transformations that, in the second chapter, we invite you to look at the contribution that science, technology and innovation can make, illustrating it with examples from Chile and the world. Science, technology and innovation, in the broadest sense, can help us to understand the present and the impact of the changes currently underway, to reduce the tension between growth, inclusion and sustainability, to improve our well-being, to open new spaces of opportunity, at an individual and collective level, to tackle our own challenges and then to create value for the world.

But this is not magic nor a stress-free path. This virtuous possibility requires the decision and willpower to coordinate the efforts of different actors in pursuit of what we have in common.

Therefore, in the third chapter, we review what we have done so far from a perspective that, celebrating achievements, does not hesitate to admit we need a collective leap of faith and decision. This view of our reality in generating and using knowledge recognises actors, capabilities, users and, above all, the need for connectors to breathe life into the system. This overview is complemented in the fourth chapter, with a look at the policies of the past ten years in the field of STI, recognising the decisive role they have played in defining the space of the actors in the system.

We have undeniably made efforts and contributed to this evolution, but we are even more convinced that we need to make STI a cross-cutting theme in the State, where different mechanisms are deployed and where the tremendous value of STI is shown to its citizens. Today in this new context, we see emerging willpowers and movements that prove we are ready to do it.

In the fifth and final chapter, we invite you to multiply the spaces so that more Chileans can benefit from science, technology and innovation. To this end, we put forward five transformative proposals that will contribute to this transition.

The proposals are:

1. **An invitation to be big: national development challenges.** Agree on a procedure that, by incorporating people's concerns, facilitate the selection of key challenges where STI can make a significant contribution with at least a ten-year time horizon.
2. **A way to act collectively: investment boards for sectoral R&D&I.**<sup>1</sup> To set a compulsory contribution to conduct R&D&I centred on the collective challenges faced by an economic sector, managed by the companies of the sector organised for this purpose.
3. **Ability to look ahead: STI for a State that understands and anticipates.** Allocate a percentage of the total spending of each ministry to finance R&D&I, in response to long-term challenges and key public issues, agreed across the board.
4. **A condition for take-off: broadband and digital State, from Visviri to Cape Horn.** Promote widespread digitalisation of the services provided by the State, thereby creating digital infrastructure conditions to enable an intense deployment of networks and their use by SMEs and citizens.
5. **An opportunity to continue flying high: science, technology and innovation at the heart of schools.** Over a period of 5 years take STI to all primary and secondary schools in Chile, through meeting and co-design spaces for the worlds of science and education.

In these rapidly changing, complex and uncertain times, this limited set of ambitious, but achievable, initiatives are an invitation to generate transformative dynamics that will allow us to take advantage of and develop capabilities, break down barriers and come together around a major national agreement to make science, technology and innovation essential to Chile's development.

1. Research, development and innovation.

## SECTION 1



Chile and the world have changed: STI contribution  
is key to relaunch our development







## CHAPTER 1



## Old and new challenges for Chile's development in a new context



### Presentation

We have made great progress, but the time has come to learn to do things differently, a process that will not be immediate or easy. The tools we have at our disposal, as well as the way we think and act, must be able to deal with the increasing complexity. And the ethical, social and productive dilemmas that appear in this period of rapid technological change increase the magnitude of the challenge.

Today, Chile is very different to what we had in 1990. In just over 25 years, poverty has declined substantially, life expectancy has risen to above the average rate across OECD countries, access to housing, consumption and higher education has expanded significantly. In short, the population's material progress and well-being indicators have improved to levels that seemed impossible for this country.

Economic growth, so elusive in previous decades, has certainly been one of the key pillars of this transformation. During this period, increased, private and public, investments and exports led Chile to be the only country in Latin America to reduce the gap with the world's highest income per capita countries.

However, when we were the closest to achieving our ambition to become a developed country, it seems to stay out of reach.

Looking back over these years, we see how difficult it has been for us to deal with these problems that have been with us for a long time. Today, we also face

new challenges. Our economic dynamism has been based on exports, which have benefited from our considerable natural resources and mild climate. There is certainly nothing wrong with that. However, practically all the areas that support our sales abroad show a declining growth rate. In some cases, this is caused by natural limits (e.g., lower copper grades); in others, it is caused by overexploitation of resources (e.g., fishing), or by attempts to reach unsustainable production volumes (e.g., salmon farming). Several are also affected by the higher restrictions set by communities.

On the other hand, the effects of climate change are already being felt in our territory, and forecasts indicate we will be one of the countries most affected by decreased rainfall.

Thus, if we maintain our traditional export base, Chile faces significant technological and sustainability challenges that we have not addressed decisively

enough. But neither have we successfully diversified our export basket. On the contrary, evidence indicates that over the years we have reduced our ability to develop or discover new products to sell advantageously abroad.

Undoubtedly, Chileans have embraced entrepreneurship as an attractive option. However, figures indicate that most of our companies have very low productivity. Furthermore, there is an enormous production gap between companies of different sizes. A low productivity growth rate limits opportunities to continue improving our living standards, while production heterogeneity explains our persistent income inequality. If we fail to raise the low level of productivity of most jobs, higher wages will not be possible, and the pressure to raise compensatory social spending will continue to increase. Moreover, population ageing and an increase in life expectancy are an additional source of transfer demand from the working population to the population that is no longer active. If we do not improve productivity, we will not be able to maintain dignity in older age for most Chileans.

In the global context, Chile's current progress is challenged by the limits posed by global change, the search for environmental sustainability, and by the growing demand for social inclusion and cohesion. Certainly, the ethical call to balance growth, environmental sustainability and inclusion is not new in the world. What is new is that today this is an important demand, for international agreements and for human groups, at a global, national, regional and local level. We can no longer ignore these demands.

In fact, the deployment of modern information and communication technologies has not only connected the world in near-real time, but it has also made it transparent. We live in a world where our behaviour and actions, both in the public and private spheres, are constantly monitored and compared with our own statements and with the highest standards in the world. And these communication networks allow us to organise ourselves more smoo-

thly and make our voices heard more quickly. Practices that until recently could remain hidden or were considered acceptable are simply not tolerated any more.

Thus, the signs that we must reinvent our approach to development are finally too obvious to ignore. To continue on the same path is simply not feasible, as it does not take into account the changes that have occurred both in our country and in the world.

We must learn to do things differently and this process will not be immediate or easy. The tools we have at our disposal, as well as our way of thinking and acting, are not always adequate to deal with the growing complexity of the challenges posed by these scenarios. And the ethical, social and productive dilemmas associated with this period of rapid technological change only increase the magnitude of the challenge. It is in this complexity that we must submit for consideration the contribution we need from science, technology and innovation.

## I. WE HAVE GROWN, BUT...

~~~~~

The pride in Chile's progress, the concern for a Chile that staggers slowly forward

~~~~~

In today's world, environmental sustainability and effective social inclusion can no longer be seen as developmental achievements, but as a condition to become an authentic and sustainable developed nation.

Undoubtedly in the last two decades Chile has made unprecedented progress. Economic growth, significant poverty reduction, increased opportunities and material well-being are obvious achievements that have made us proud.

Chile has never been as close to achieving its goal to become a developed country as in these last decades. However, when this goal looked closer than ever, we realised our progress had slowed down and become difficult.

The Council's previous reports already showed significant weaknesses in our progress, such as low export diversification and high dependence on natural resources; high productivity gap and its negative impact on income and wealth distribution; and the burden the enormous inequali-

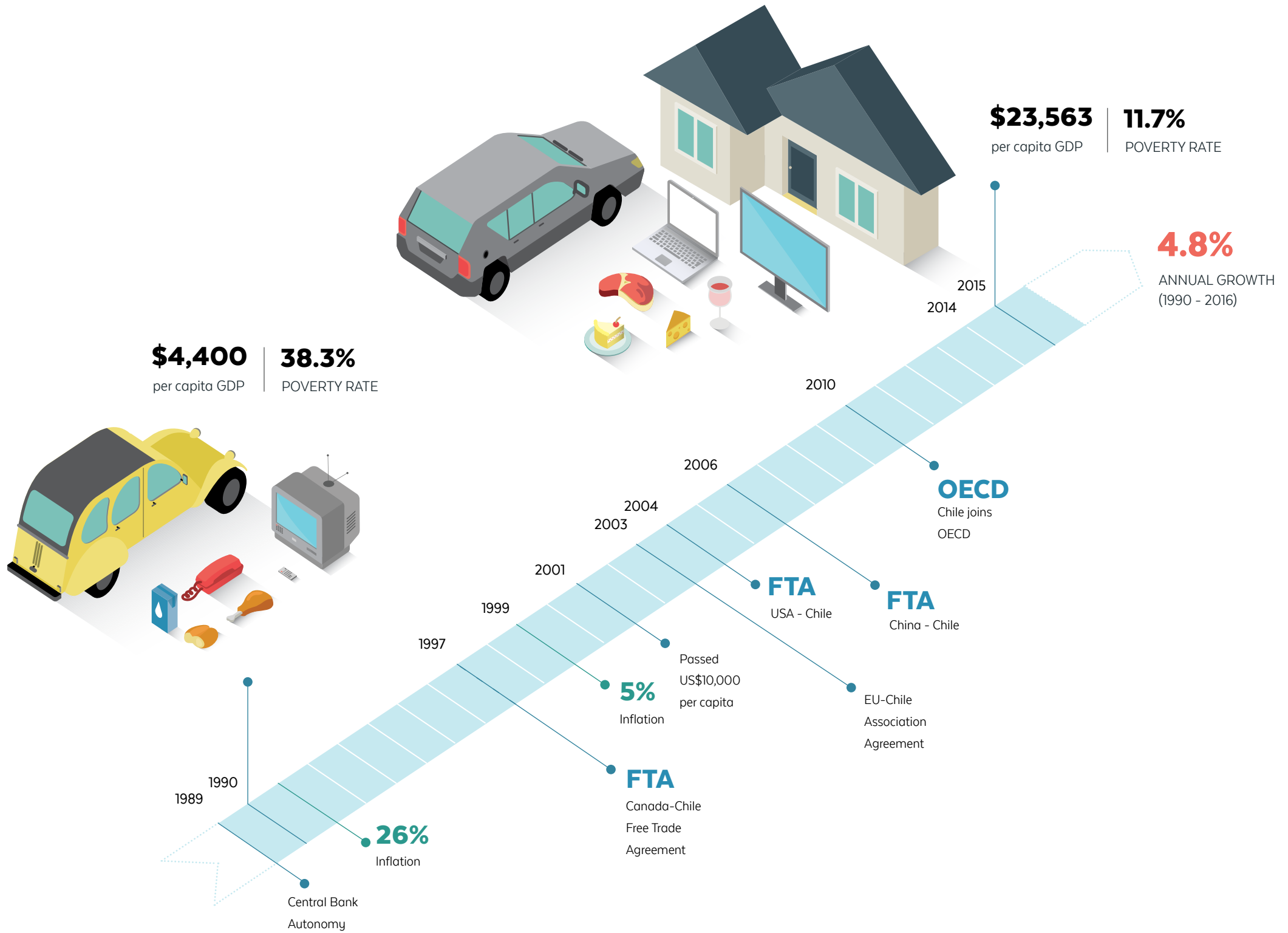
ties impose on our coexistence and on the country's own progress. These weaknesses not only continue to exist, they also progressively hinder further progress. Moreover, the environmental, social and technological changes that have been occurring in the global context are particularly evident in Chile, shaping a much more demanding scenario.

Our view is that, beyond the conjunctural factors, our progress has evidently lost strength and part of its foundations is also being questioned. Today it is evident that we did not address the delays and gaps on the road we travelled, and now they are catching up to us.

Today, environmental sustainability and effective social inclusion are challenges, in Chile and the world, that have taken on a much greater scale than just a few years ago and we are lagging behind on this issue. In today's world, they will no longer be viewed as results achieved through development, but rather as a prerequisite to become an authentically and sustainably developed nation.

Therefore, to continue moving forward, we must come together to find a different way of doing things.

Source: Author's own work based on World Bank, National Statistics Institute and Ministry of Social Development data.



**\$4,400**  
per capita GDP

**38.3%**  
POVERTY RATE

**\$23,563**  
per capita GDP

**11.7%**  
POVERTY RATE

**4.8%**  
ANNUAL GROWTH  
(1990 - 2016)

**OECD**  
Chile joins  
OECD

**FTA**  
USA - Chile

**FTA**  
China - Chile

EU-Chile  
Association  
Agreement

**FTA**  
Canada-Chile  
Free Trade  
Agreement

**5%**  
Inflation

**26%**  
Inflation

Central Bank  
Autonomy

1989  
1990

1997

1999

2001

2003  
2004

2006

2010

2014  
2015

## II. OLD AND NEW CHALLENGES FOR DEVELOPMENT

## Nature and our production methods limit our growth

The way Chile has grown is not a path we can continue on. In fact, it is not clear if this way is still viable.

In Chile we have maintained uninterrupted economic growth for three decades now. However, today we are facing clear signs of exhaustion, which go beyond circumstantial factors.

Chile's economic dynamism has been based on increased exports. We have certainly been very successful in leveraging our natural comparative advantages. There is nothing wrong with that. However, today our natural resource-intensive sectors face natural, economic and social barriers.

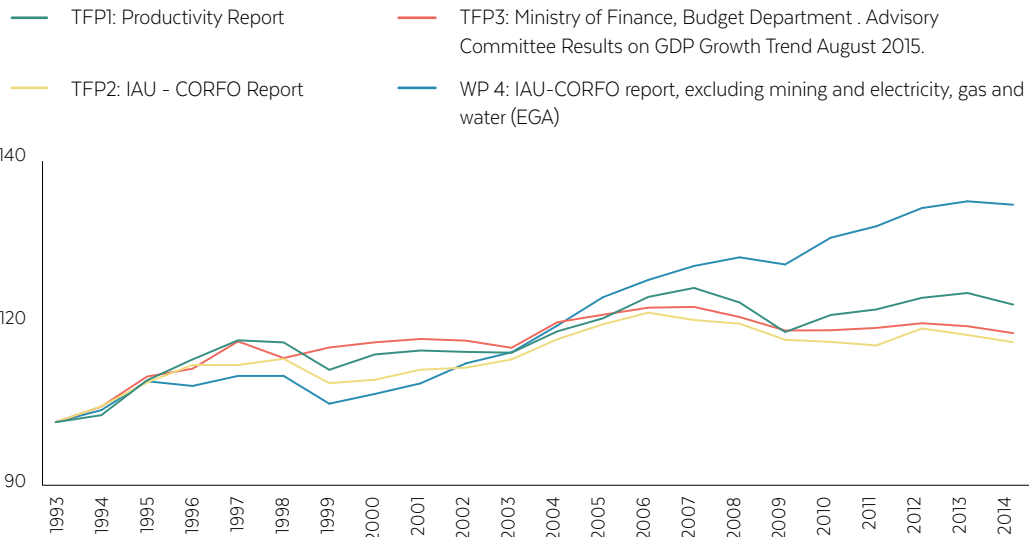
We acknowledge that the boom period we lived a few years ago was more associated with high copper prices than with our ability to produce more with less. And without persistent increases in productivity, sustained growth is not achievable.

Furthermore, in several cases, we are at a stage of diminishing returns on our natural resources. In fact, our declining total productivity is largely due to the lower-grade copper ore and major challenges associated with mining at greater depths<sup>4</sup>. But we must also recognise that, in the case of several renewable natural resources, we have adopted an extractive production logic that does not respect ecosystem cycles, causing over-exploitation or exceeding production limits, putting at risk the sources sustaining these natural resources<sup>5</sup>. Additionally, consumers and communities are more demanding and aware of their rights, and are increasingly making their voices heard regarding the environmental, social and labour standards that should prevail in economic activities.

Thus, the way we have grown is not a path we can continue on. Moreover, it is not clear that such a way is still viable. We just have to acknowledge the scenario of escalating socio-environmental pressures is here to stay.

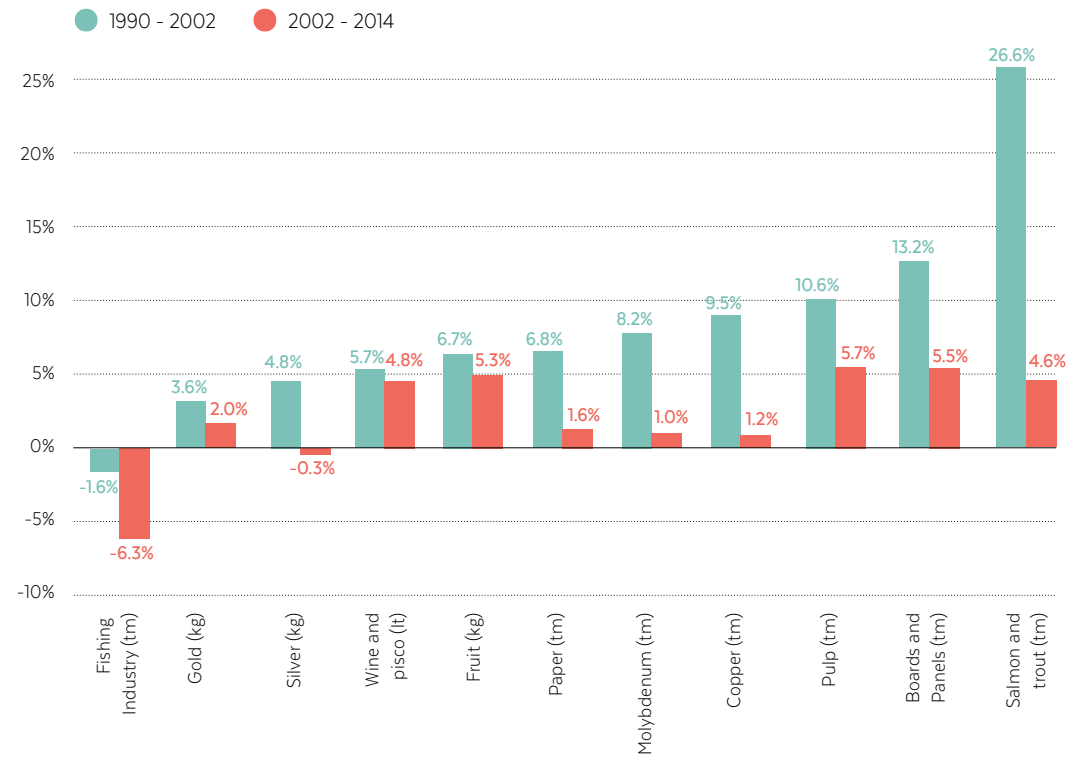
1. Author's own work based on Central Bank, Cochilco and Odepa data.
2. Author's own work based on Central Bank, Cochilco and Odepa data.
3. AGEA (2016). "Evaluación de los conflictos socioambientales de proyectos de gran tamaño con foco en agua y energía" (1998 - 2005). CNID, Santiago de Chile.
4. CORFO-UAI, Productivity Report, 2016.
5. Over-exploitation refers to extracting a resource from its habitat without respecting the cycles that would allow its renewal, as in the case of fishing. Overproduction, on the other hand, is the transfer of certain production volumes or standards that make it unsustainable, as in the case of salmon farming that exceeded the number of fish per cage and caused an ISA virus outbreak.

### TOTAL FACTOR PRODUCTIVITY (1993-100)

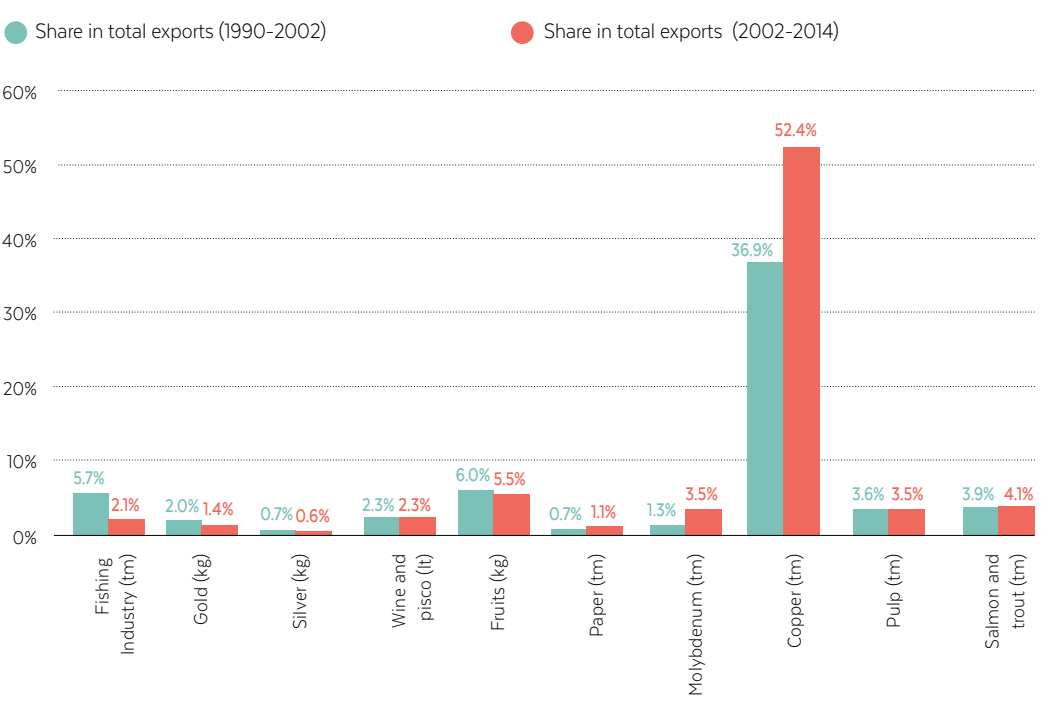


If the mining and electricity, water and gas sectors, affected by external phenomena such as lower ore grade or draughts, are excluded, domestic productivity has increased rather than decreased. However, its growth rate has slowed down, even stagnated, in the last few years.

### REDUCTION OF PHYSICAL VOLUME GROWTH OF NATURAL RESOURCE-BASED EXPORTS<sup>1</sup>



### AVERAGE SHARE IN TOTAL EXPORTS (CURRENT US\$)<sup>2</sup>



### SOCIO-ENVIRONMENTAL CONFLICTS IN INVESTMENTS (1998-2015)<sup>3</sup>



## We continue exporting practically the same

We have the potential to be competitive in knowledge-intensive sectors. We must persevere on this path, knowing it takes time and that we must regularly check if we are using the right or sufficient tools.

In the last twenty-five years, Chile has added few new products to its export basket. Moreover, our capacity to create new exportable products has clearly declined. And our export goods continue to be linked to natural resources.

Between 2003 and 2013, Chile added only eight new export products, ahead of the average for other countries; in 2013, its total exports were US\$ 687 million. In contrast, Argentina added 27, its total exports were US\$ 19.9 billion. Chile's exports were all natural resource-based products, while in the case of Argentina, eight were manufactured.<sup>2</sup>

We have tried to develop companies that supply goods, equipment, and services for natural resource sectors, to increase the variety and complexity of our exports, but so far, we have had little success. Thus,

for example, between 2010 and 2014, external sales of mining suppliers only grew marginally: from US\$ 503 million to US\$ 537 million<sup>3</sup>. In salmon farming, with few marginal exceptions, suppliers have not developed export capacity<sup>4</sup>.

There are opportunities to develop sophisticated suppliers of goods and services for natural resource-based sectors. We must persevere on this path, but we must bear in mind that it takes time and we must regularly review whether we are using the right or sufficient tools.

The services sector offers interesting opportunities, although it is still small scale; the growth rate of service exports is lower than in goods. However, sales of IT services and other business services practically tripled between 2003 and 2015, and became one of the most dynamic export sectors.

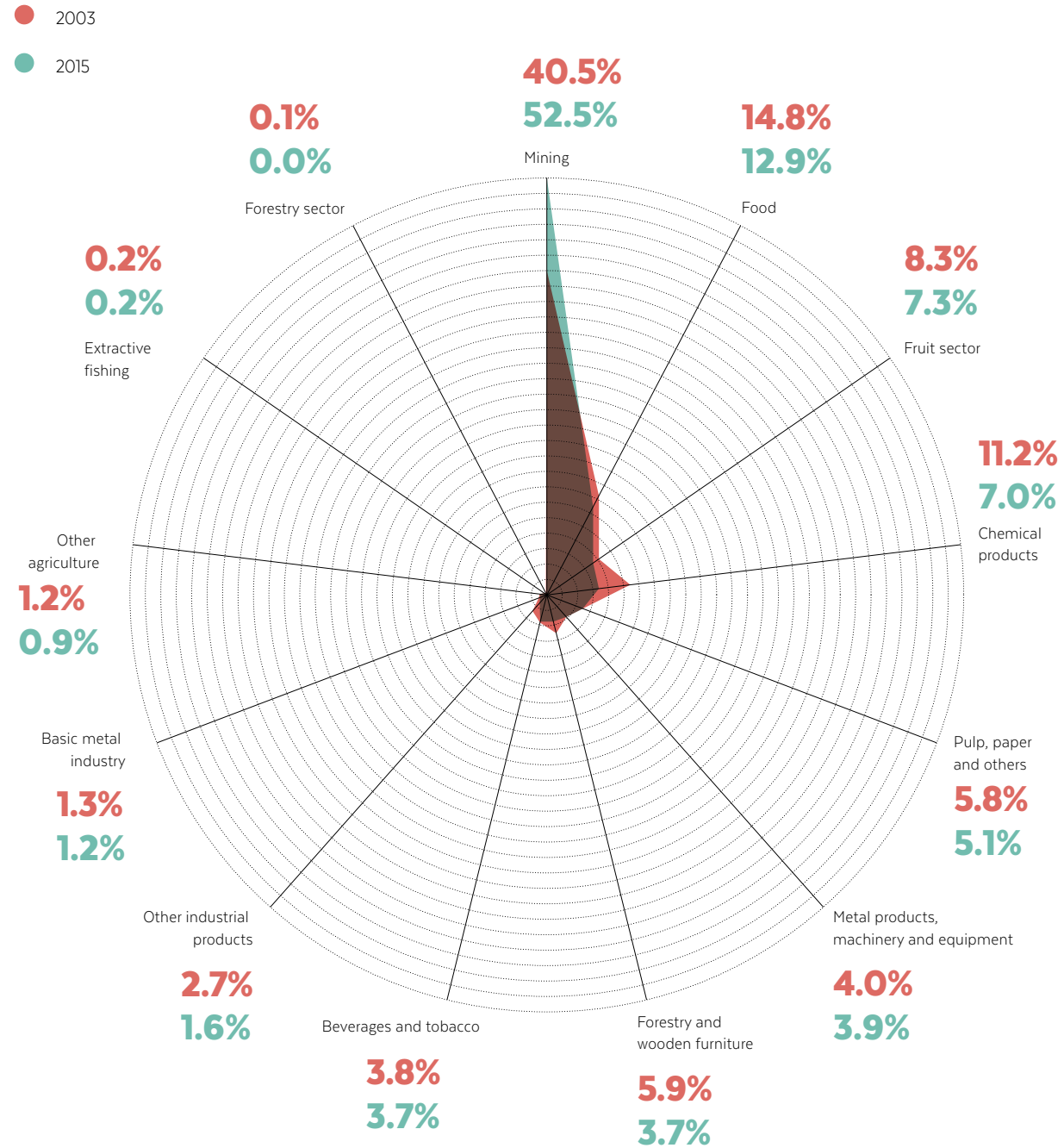
This proves we can be competitive in knowledge-intensive sectors.

1. Lauterbach, R. (2016) "Chile y la Complejidad de sus exportaciones." CNID, Working Papers Collection. Santiago, Chile.
2. Lauterbach, R. (2016) "Chile y la Complejidad de sus exportaciones." CNID, Working Papers Collection. Santiago, Chile. Lauterbach, R. (2016). "Chile y la Complejidad de sus exportaciones." CNID, Working Papers Collection. Santiago, Chile.
3. National High-Grade Mining Programme (2015), Export Suppliers Report for Chilean Mining Suppliers, Santiago de Chile.]
4. Katz J. and Araya C., (2015), "Reflexiones en torno al largo plazo de la salmonicultura chilena." CNID, Study Collection. Santiago, Chile. In edition.

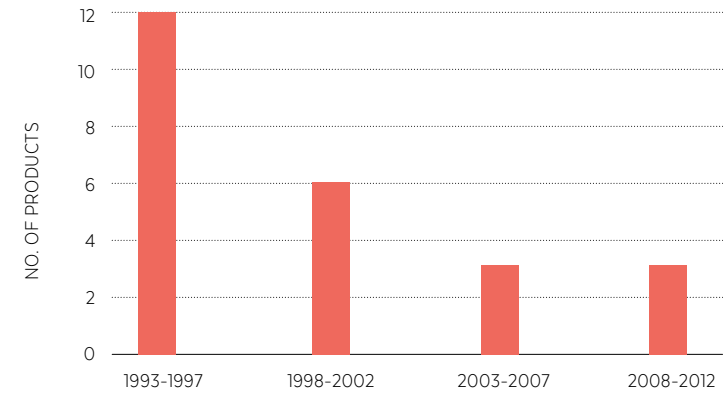
Gerens S.A., (2016), "Análisis de proveedores especializados para la industria salmonera." Santiago, Chile. In edition



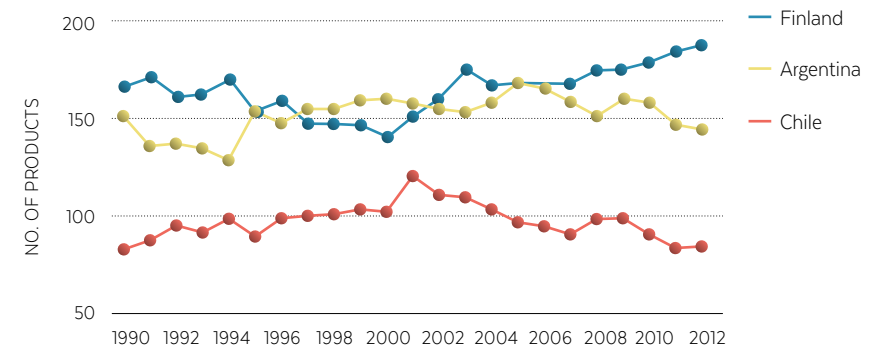
EXPORTS OF GOODS  
(IN % OF TOTAL, 2003 AND 2015)



EXPORTED GOODS WITH A COMPARATIVE  
ADVANTAGE REVEALED, AMOUNTS US\$1 MILLION



NEW PRODUCTS OF WHICH AT LEAST US\$1 MILLION  
WAS EXPORTED<sup>1</sup>



PRODUCTS EXPORTED WITH COMPARATIVE ADVANTAGE  
IN 2012, BUT NOT IN 2013 (MM US\$)

- Edible offal of all headings (83,16)
- Oil seeds and oleaginous fruits (12,35)
- Waste of sheep, lambs, wool (1,09)
- Vegetable material species used primarily for basketware and wickerwork (1,82)
- Animal oils and fats (49,22)
- Olive oil (63,64)
- Mineral or chemical nitrogen fertilizers (286,80)
- Fungicides packaged for sale (98,25)
- Starches, inulin and wheat gluten (92,10)

Note: Author's own calculations based on UN Comtrade data.  
All products based on classification 772.

## Our productivity differences between companies are a root cause of inequality

Besides other factors, such as educational level and bargaining power, there is a direct relationship between productivity differences by sector and company size, and the differences in income distribution.

Low overall productivity makes us less prosperous. The less productive companies are, the lower the wages they can pay.

Most of our companies are much less productive than those in the United States, except for the mining sector.<sup>4</sup> This situation is particularly evident in the trade and service sectors, which concentrate most companies and employment in Chile.

But productivity differences between companies of different sizes are also significant: in Chile a small company is much less productive than a large one compared to the rest of the OECD countries. In these countries, working in a large or a small company does not represent such a big difference in terms of productivity. As a result, they have relatively similar wage and working conditions. In Chile, however, these differences are astronomical. Working in large-scale copper mining is very different from working in a small mine.

We have many micro and small businesses with very low productivity, this means that their employees have very low wages. Furthermore, since there are major productivity differences compared to large companies, directly affecting the way labour income is distributed. Given that smaller businesses are important in regions, this increases the differences in employment opportunities at territorial level.

Productivity gains are not immediately and linearly reflected in wage increases, but as overall productivity increases and gaps narrow, there are more conditions for workers to increase their wages.

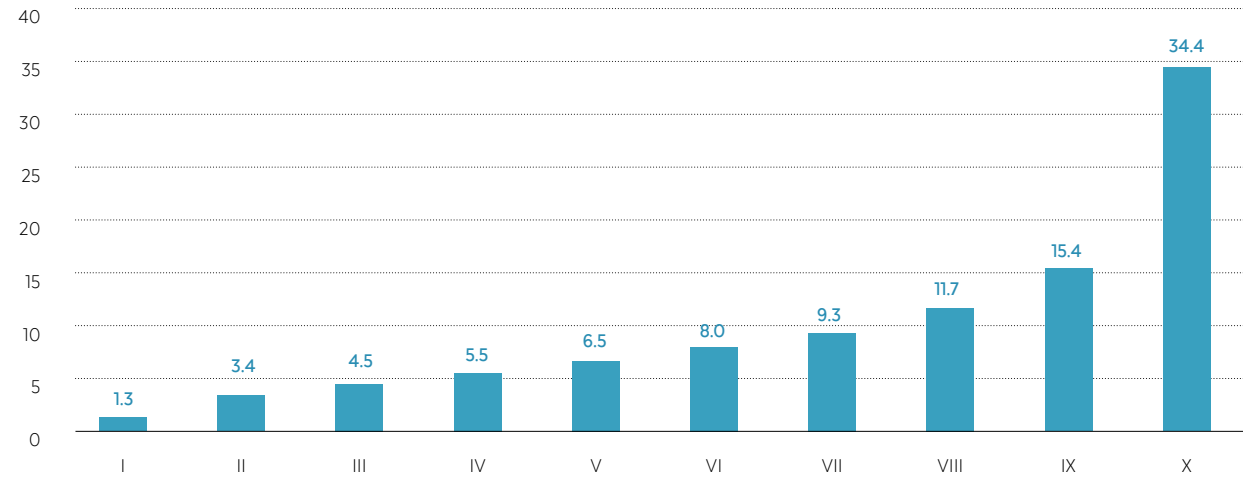
Besides other factors, such as educational level and bargaining power, there is a direct relationship between productivity differences by sector and company size, and poor income distribution. Therefore, efforts to improve productivity should be extended to all business sectors and segments and, at the same time, we should avoid creating conditions that artificially maintain low-productivity activities.

Through its direct effect on income distribution, in the current context of widespread commodification of life in society, productive heterogeneity also becomes a source of greater social disintegration.

1. IDB 2010.
2. Casen 2015.
3. Latin American Economic Outlook 2013 - © OECD 2012.
4. Pagés, Carmen (2010) *"The Age of Productivity. Transforming Economies from the Bottom Up."* Inter-American Development Bank. Washington, D.C.

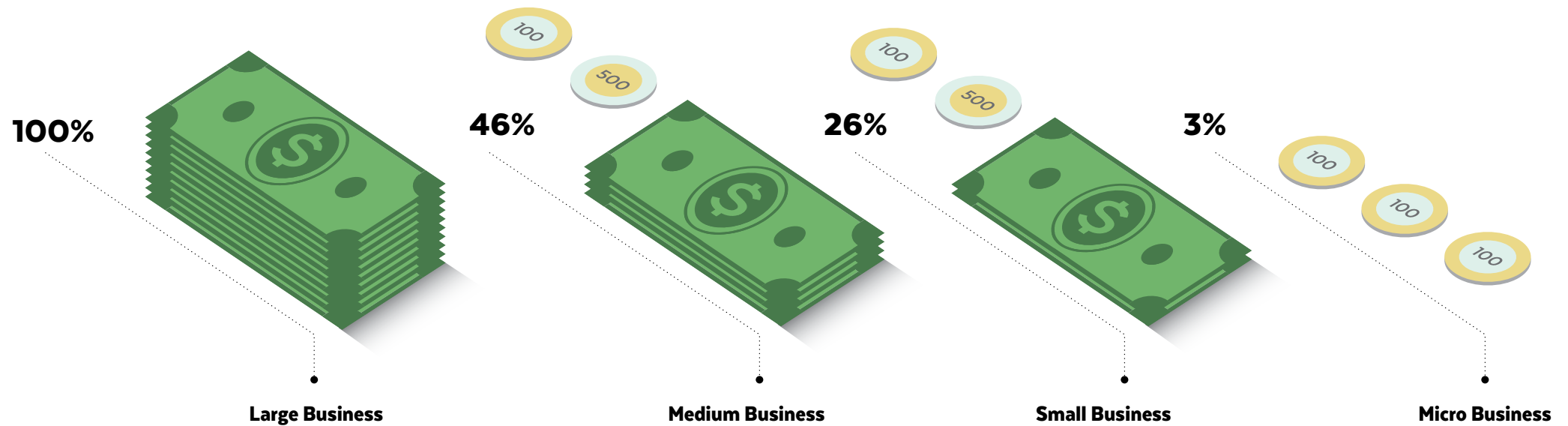
|                                                | <b>Chile</b> | <b>OECD</b> | <b>Germany</b> |
|------------------------------------------------|--------------|-------------|----------------|
| Annual hours worked <sup>1</sup>               | 1,987        | 1,766       | 1,371          |
| US\$ produced in one working hour <sup>1</sup> | US \$23.54   | US \$46.20  | US \$58.97     |

DISTRIBUTION OF AUTONOMOUS INCOME BY DECILE OF AUTONOMOUS HOUSEHOLD INCOME PER CAPITA (2015)<sup>2</sup>



LOW PRODUCTIVITY OF SMALL AND MEDIUM-SIZED ENTERPRISES<sup>3</sup>

In the time frame in which a worker in a large company produces \$10,000, those in smaller companies produce \$300.



## Social spending reduces inequality, but it cannot be the only answer

The contribution of social spending to reduce unequal access to goods and services must be complemented by improving the primary distribution of independent income, which requires narrowing productivity gaps.

The manifestations of inequality, such as income differences, are widening as the market logic expands to more and more spheres of society; in recent decades this has happened in many countries, particularly in Chile.

Notwithstanding the different perceptions of this topic, the truth is, this affects the fact that income inequalities are reflected in life experiences with sharp differences between the different population segments.

Here the State plays a very important role in reducing unequal access to goods and services, which emerges from the distribution of income and wealth in society.

Social spending effectively compensates part of this inequality caused by the distribution of people's independent income, i.e., income from their earnings and jobs. In fact, if we look at the impact of social spending to narrow the gap between the richest ten percent and the poorest ten percent, it is evident the situation is improving significantly:

before social spending, the richest have 27.2 times more income than the poorest; afterwards, we go down to 16 times. The same is true, although less dramatically, for the overall income distribution measured with the Gini coefficient, down from 0.495 to 0.482. However, there are still major differences and we are still far from OECD standards.

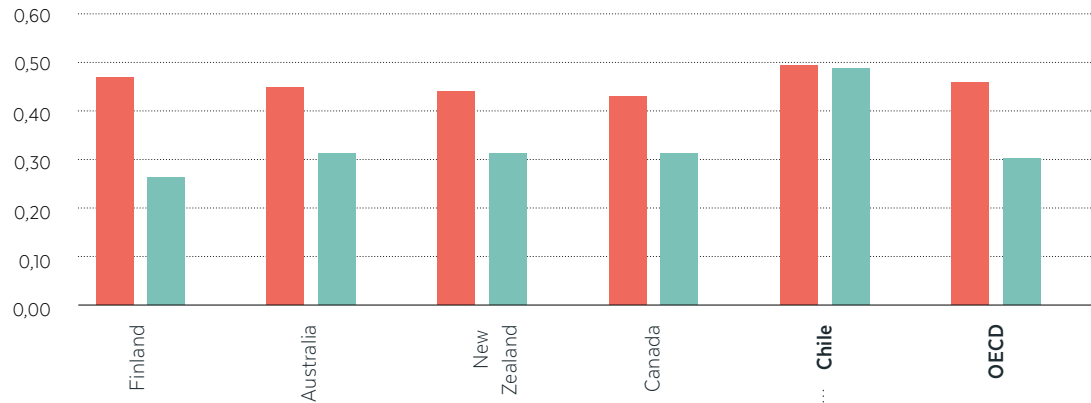
Undeniably the demand for greater equality has real foundations in Chile. The problem is that if we move forward in this direction, we mainly depend on compensatory social policy efforts, the pressure on public spending will not only increase, but it will also make it more difficult to invest in other sectors that are needed to continue our development. This is the case of some sectors that have an enormous impact on our coexistence, for example, public goods intended for public use, such as culture, protection from natural disasters, and environmental conservation and promotion.

The contribution of social spending to reduce unequal access to goods and services must be complemented by improving the primary distribution of income; this can only be achieved if wages and earnings are substantially increased in the sectors that today employ more people.

1. Government at a Glance, 2015, OECD.
2. Ministry of Social Development, 2016.
3. Ministry of Social Development, 2015.

## AUTONOMOUS AND MONETARY GINI IN THE WORLD, 2015<sup>1</sup>

● **Self-employed:** Gini coefficient income before taxes and transfers      ● **Monetary:** Gini coefficient income after taxes and transfers

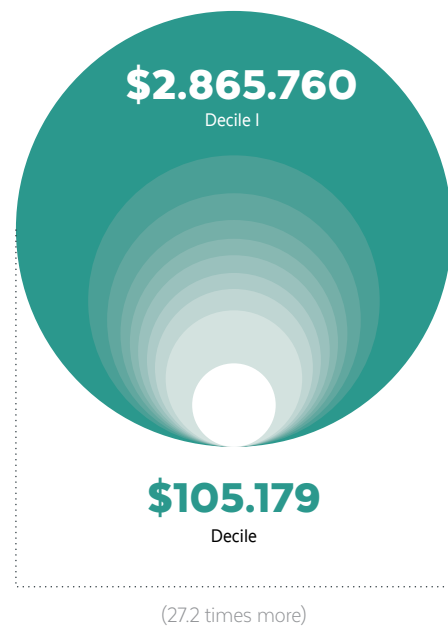


The Gini coefficient is a measure of income inequality. It corresponds to a number between 0 and 1, where 0 equals perfect income equality for all people and where 1 corresponds to total inequality.

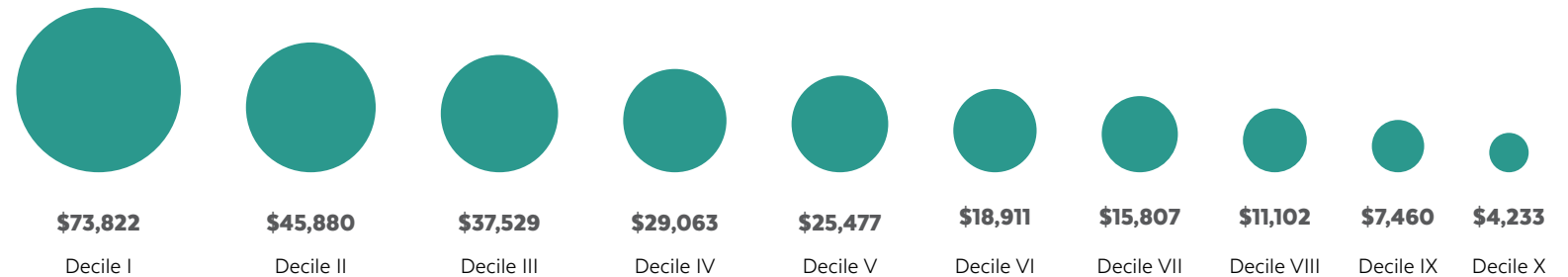


## AUTONOMOUS HOUSEHOLD INCOME PER DECILE<sup>3</sup>

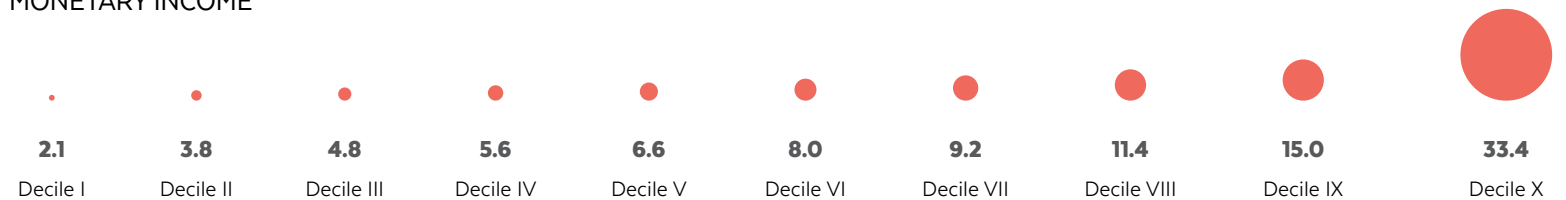
**Decile I:** 10% poorest of the population  
**Decile X:** 10% richest of the population




## MONETARY HOUSEHOLD ALLOWANCE PER DECILE<sup>3</sup>




## DISTRIBUTION OF MONETARY INCOME<sup>3</sup>





## An ageing population is another factor putting pressure on our economy and social policy



Thinking about new job opportunities for older people, new technologies offer more and more alternatives for people to access more productive jobs and stay active over time.

Until a few years ago, we benefited from what is known as the “demographic bonus”. This refers to a situation where a small proportion of the population that does not work is maintained by a relatively high proportion of working-age people.

This condition is changing rapidly, and demographic projections indicate that Chile is heading towards a situation where it will have an increasingly smaller proportion of working-age population in relation to a growing non-working age population (that is also living longer). It should be borne in mind that, beyond the fact that the current pension system is based on individual capital accounts, the State assumes a large proportion of pension spending through its contribution to the solidarity pillar and to welfare pensions, not to

mention the impact of public spending on health and other sectors.

In Chile, the extensive debate over low pensions shows the importance this issue has for the population, and it will become more important in the future. Notwithstanding institutional or regulatory improvements that may be designed and implemented, we cannot turn our backs on the fact that increasing the productivity of our economic activities contributes to improving retirement income. More productive jobs tend to be associated with higher wages, and a growing economy helps support its inactive population.

However, new job opportunities (paid or unpaid) for older people must also be taken seriously. Today, at 65, many people still have the need, and sometimes also the desire, energy and, of course, the experience to continue contributing to society. Without entering the retirement age debate, it is worth noting that more and more retired people are choosing to continue working. And the new information and communication technologies increasingly offer opportunities to contribute to society remotely, provided we take charge of digital literacy.

1. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision.

<https://populationpyramid.net/es/chile/2050>

DEMOGRAPHIC PRESSURE ON SOCIAL SPENDING<sup>1</sup>

2000

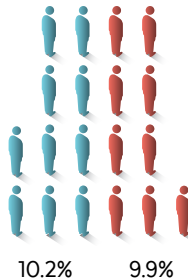
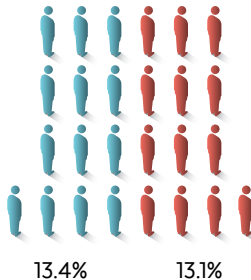
2015

2030

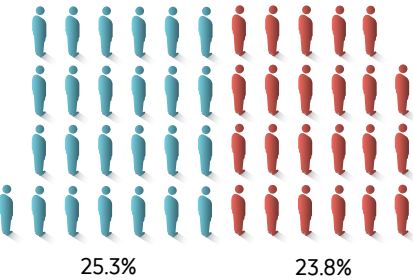
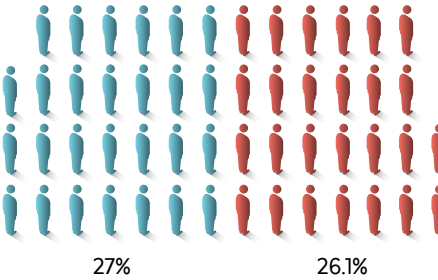
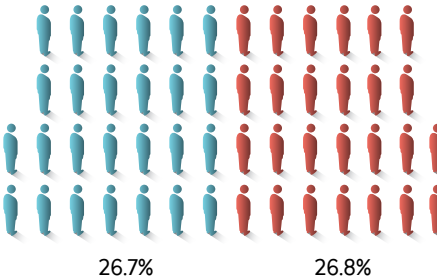
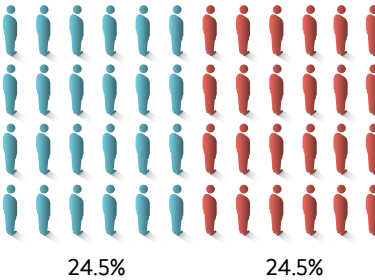
2050



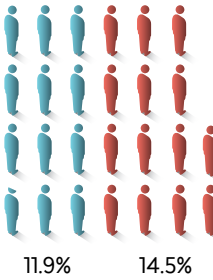
OVER 65 YEARS OF AGE




BETWEEN 26 AND 64 YEARS OLD




CHILDREN UNDER 15



= 1%  
 = Men  
 = Women



## We must take on the challenge of improving productivity



The challenge is twofold: steadily increase productivity over time, but also ensure that these increases are spread across companies of all sizes and their workers.

Chile is one of the few Latin American countries that has managed to raise its productivity in recent decades. However, our progress has slowed down and, in fact, our productivity growth has been declining over the past decade.

A sustained increase in our productive performance is key to economic growth, since it allows us to improve wages even without the compensatory effect of social policy but, at the same time, improved earnings generate higher tax collection, allowing the State to make

more social investments. Thus, the challenge is twofold: steadily increase productivity over time, but also ensure these increases are distributed across the different economic activities, materialising in companies of all sizes and their workers.

However, this improvement does not immediately or automatically raise wages, but it is certainly a condition for this to happen and for it to be maintained.

A better distribution of primary income also means less pressure on social spending as a mechanism to correct inequalities, thus creating space to address other challenges. And our current context is putting new demands on us, in addition to the challenges accompanying us along our difficult path to development.

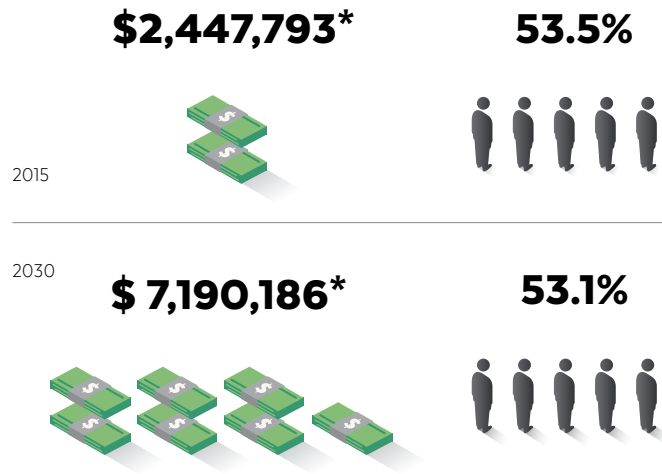
1. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision

<https://populationpyramid.net/es/chile/2050>

2. OECD Compendium of Productivity Indicators 2016 -© OECD 2016.



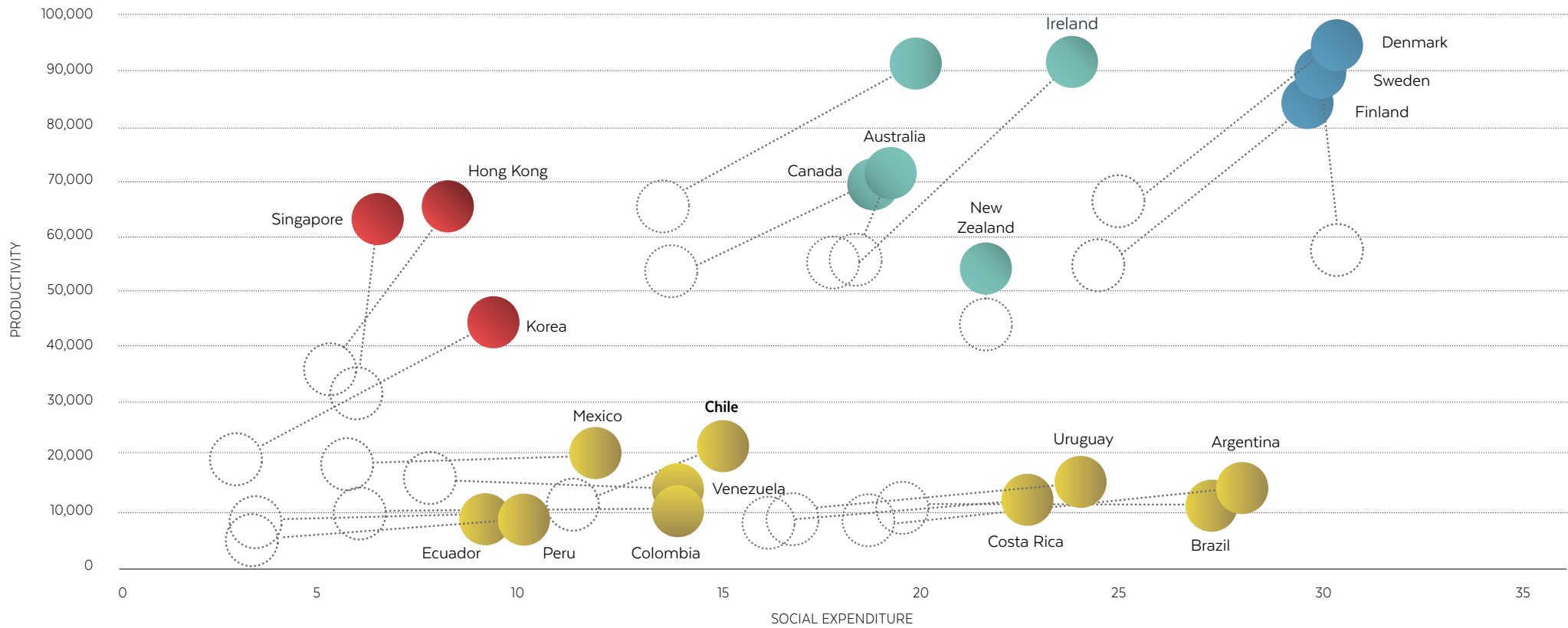
PROJECTION OF SOCIAL EXPENDITURE TO REACH OECD LEVEL AND PROPORTION OF ECONOMICALLY ACTIVE POPULATION<sup>1</sup>



Reaching the OECD average level of social spending means tripling it by 2030, with a similar proportion of the economically active population.

\*Weights per capita, economically active population

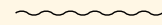
SOCIAL EXPENDITURE AND LABOUR PRODUCTIVITY<sup>2</sup>





**Carlos Álvarez Voullième, Director CNID**

Carlos is a Civil Industrial Engineer from Universidad de Chile, and he has a Master in Economics and Master in Public Administration from Harvard University. He was Undersecretary of Economy, Executive Vice President of the Corporation for the Promotion of Production (Corfo) and Chairman of the Public Corporation System (SEP). Between 2010 and 2013, he was Deputy Director of the OECD Development Centre in Paris. He is currently a Director of InvestChile.



## A strong drive for innovation and productivity

By Carlos Álvarez Voullième



In recent years, Chile has shown a significant decline in its potential growth. Estimates of growth trends prepared by the Central Bank and the Expert Committee of the Budget Department are around 3% per year, well below the figures of around 5% in the 1990s and 2000s.

This deceleration is chiefly explained by the substantial decline in the contribution by the natural-resource export sectors to Chile's growth since the middle of the last decade, when they stopped growing at a higher rate than the average GDP growth rate, because they reached production scales subject to decreasing yields.

A clear example of this phenomenon occurred in copper mining, which being the key driver of growth in the 90s, entered a period of permanent decline in productivity in the 2000s, this was largely caused by the deteriorating quality of mineral resources (ore grade, waste rock-ore ratio, etc.). As a result, based on the Report of the Productivity Commission 2016, because of a declining total factor productivity (TFP) in mining, the country's TFP grew at a meagre rate of 0.1% and not 1.4% like the rest of the economy, largely as a result of the lower quality and availability of mineral resources.

In the near future, Chile will no longer have the revenues from natural resources to drive its growth and it will have to promote new high-productivity activities to return to growth rates of 4% or more, either by modernising existing sectors or by boosting new export sectors. To do so, it will have to innovate its policy mix to support growth, developing new capabilities and taking advantage of the opportunities arising from global technological change. It will no longer be enough to guarantee a stable macroeconomic scenario or a friendly business environment. It will be necessary to give a strong boost to innovation and productivity growth in existing sectors, to have up-to-date technological infrastructure, and to give strong support to new productive activities, combining programmes to develop capacities of high-growth potential sectors, promote innovative entrepreneurship and attract global companies that transfer technology and best practices for innovation and management.

## And take on the employment challenge

A comprehensive approach to STI is an opportunity to face and transform new technological advances into an opportunity for creating more and better jobs in Chile.

A more equal income distribution requires, for example, increasing employee productivity, but it also involves creating and opening new job opportunities in response to technological change.

Our economy has not been creating jobs fast enough and most new jobs are in self-employment, including street vending. Young people, women and older people are excluded or marginalised from the labour market. Likewise, high labour force participation in the service sector does not occur in the knowledge-intensive sectors.

The impact of STI on employment is a matter of debate. Some argue that in certain jobs, as processes change, people will inevitably be replaced by technology<sup>5</sup>. Furthermore, several studies<sup>6</sup> show that the net effect of business innovations creates new jobs, basically through the impact of product innovations, which offsets the reduction in process innovations.

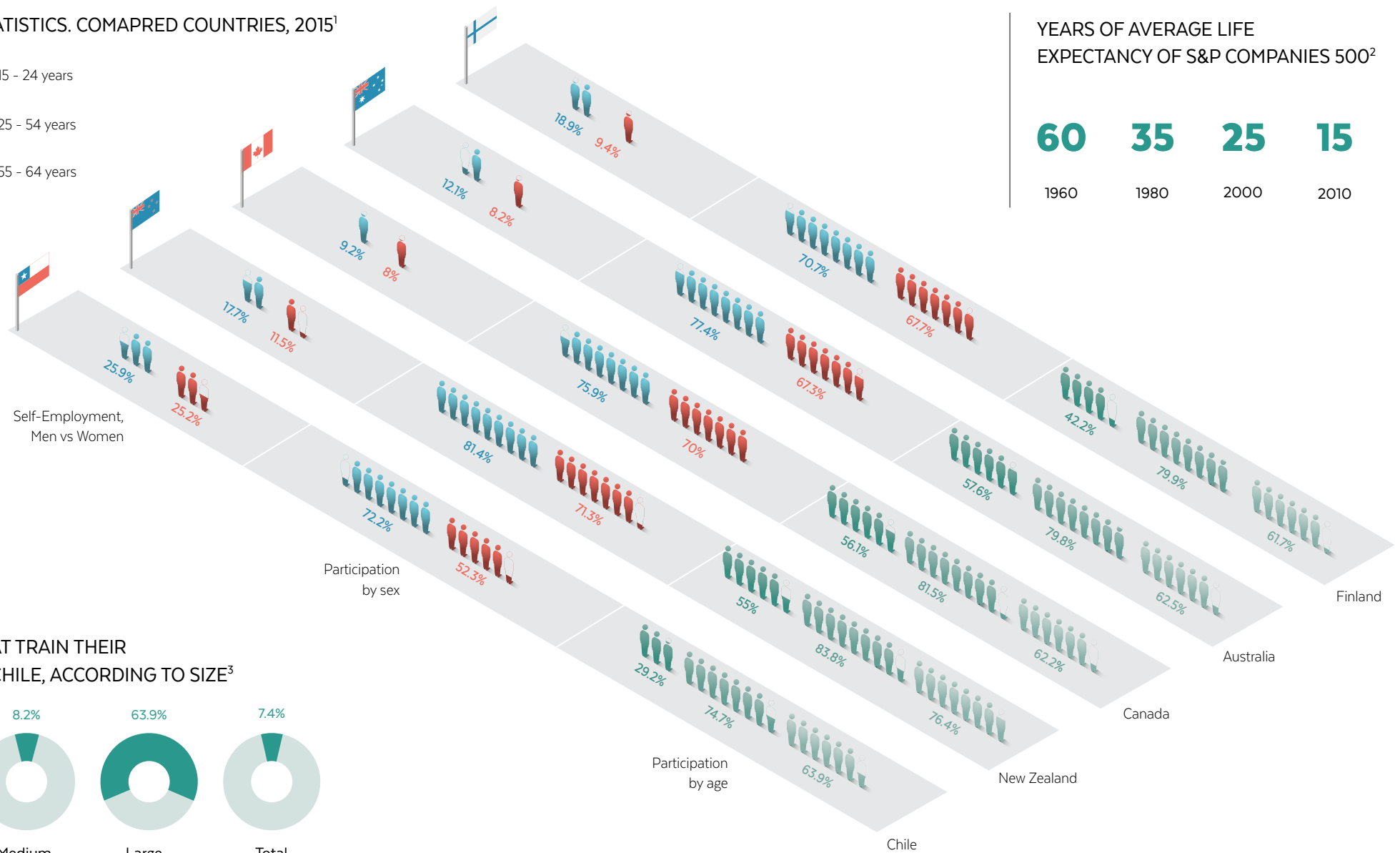
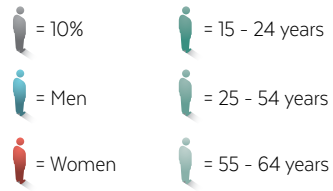
Innovation is key, and so is adapting employee skills to rapid technological change. For this reason, a major concern in Chile is that training activities are mainly concentrated in large companies (63.9% of total), in certain sectors and regions.

New technologies can offer new forms of labour force participation and integration, as well as facilitate labour market integration for young people, women and adult population in technology-based services. However, for this to be effective, the focus and scope of initiatives, to acquire and strengthen employee skills in line with their basic education, age, digital literacy, and opportunity costs, among other variables, must be improved.

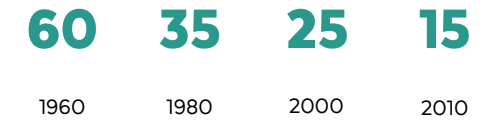
A strategy that is a comprehensive approach to these dimensions is an opportunity to confront and transform new technological advances into an opportunity for creating more and better jobs in Chile.

1. [https:// data.oecd.org/emp/self-employment-rate.htm](https://data.oecd.org/emp/self-employment-rate.htm)  
  
[https://data. OECD. org/emp/employment-rate.htm](https://data.OECD.org/emp/employment-rate.htm)  
  
<https://data.oecd.org/emp/self-employment-rate-by-age-group.htm>
2. Increase Venture Builder with Innosight data.  
  
S&P 500 or Standard & Poor's 500 = stock market index from 500 large companies listed on the NYSE or NASDAQ.
3. Longitudinal Employment Survey, ELE, 2015.
4. Employment Projections Program, U.S. Bureau of Labor Statistics. 2014.
5. See IEEE's approach ([http://theinstitute.ieee.org/ieee-roundup/blogs/ blog/ will-automation-kill-or-create-jobs](http://theinstitute.ieee.org/ieee-roundup/blogs/blog/will-automation-kill-or-create-jobs)). More references on the following pages.
6. Pereira, M., Tacsir, E. (2016). "Generación de empleo e innovación en Argentina. Un abordaje microeconómico para el período 2010-2012 2010-2012." IDB, Working Paper IDB-WP-755.  
  
Crespi, G., Tacsir, E. (2012). "Effects of Innovation on Employment in Latin America." BID TECHNICAL NOTE. IDB-TN-496.

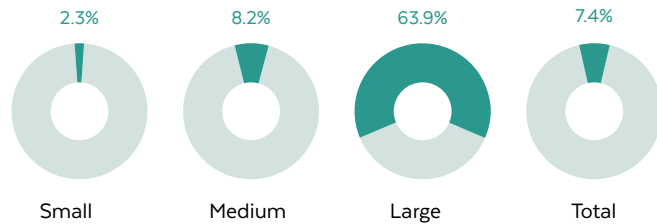
EMPLOYMENT STATISTICS. COMPARED COUNTRIES, 2015<sup>1</sup>



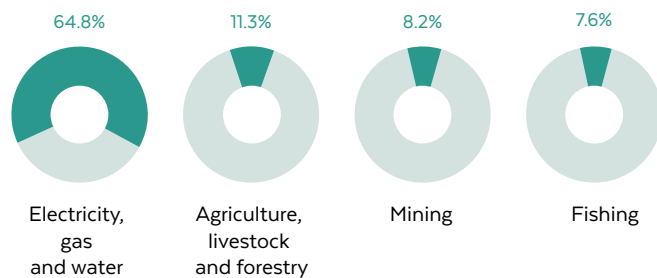
YEARS OF AVERAGE LIFE EXPECTANCY OF S&P COMPANIES 500<sup>2</sup>



COMPANIES THAT TRAIN THEIR EMPLOYEES IN CHILE, ACCORDING TO SIZE<sup>3</sup>



TRAINED WORKERS BY SECTOR<sup>3</sup>



THE PERCENTAGE OF EMPLOYABILITY WILL DECREASE OVER THE NEXT FEW YEARS<sup>4</sup>

- 69.9** Locomotive fuel handlers.
- 50.0** Electronic equipment installers and motor vehicle repairers.
- 42.4** Telephone operators.
- 30.5** Shoe machine operators.

**2016**  
 The Adidas Group announces that it will open fully automated factories in Germany and in Atlanta, USA. In Germany, production will start at the end of 2016, but by 2017 it will be 100% automated. Twenty years ago the company had moved production to Asia, where production costs have increased, so they have decided to return to their home country with fully automated processes.

## III. TODAY WE FACE AN INCREASINGLY DEMANDING AND PRESSING CONTEXT

## An uncertain global economic scenario

We are facing a global economy with less clear directions than a decade ago, requiring us to expand our capacities so that we can continue to seize global opportunities for Chile.

As Chile is a small economy, its best option is to participate in international trade. This path has produced results for this country. But, the economy, in all countries of the world, undergoes cycles of expansion and contraction. As a result, our economic activity will inevitably experience ups and downs. Our growth rate is greatly influenced by what is happening in international markets. In addition to these variations in the global economy, raw material or commodity price cycles especially impact us<sup>3</sup>.

Therefore, we must always pay attention to the trends observed in the global economy. A calm assessment of the international arena shows us a more uncertain context than a decade ago, where mixed signals coexist for our areas of interest.

In fact, a warning sign is that in recent years global economic fluctuations have become more frequent. This increased turbulence affects business planning and, consequently, investments and employment.

Furthermore, international trade has stagnated in recent years, decreasing its share in global activity. This is, of course, a significantly larger share than in previous years and, for a country like Chile, it is still an enormous space in which to prosper. Although we may be affected by the increase in protectionist discourses, particularly in the United States.

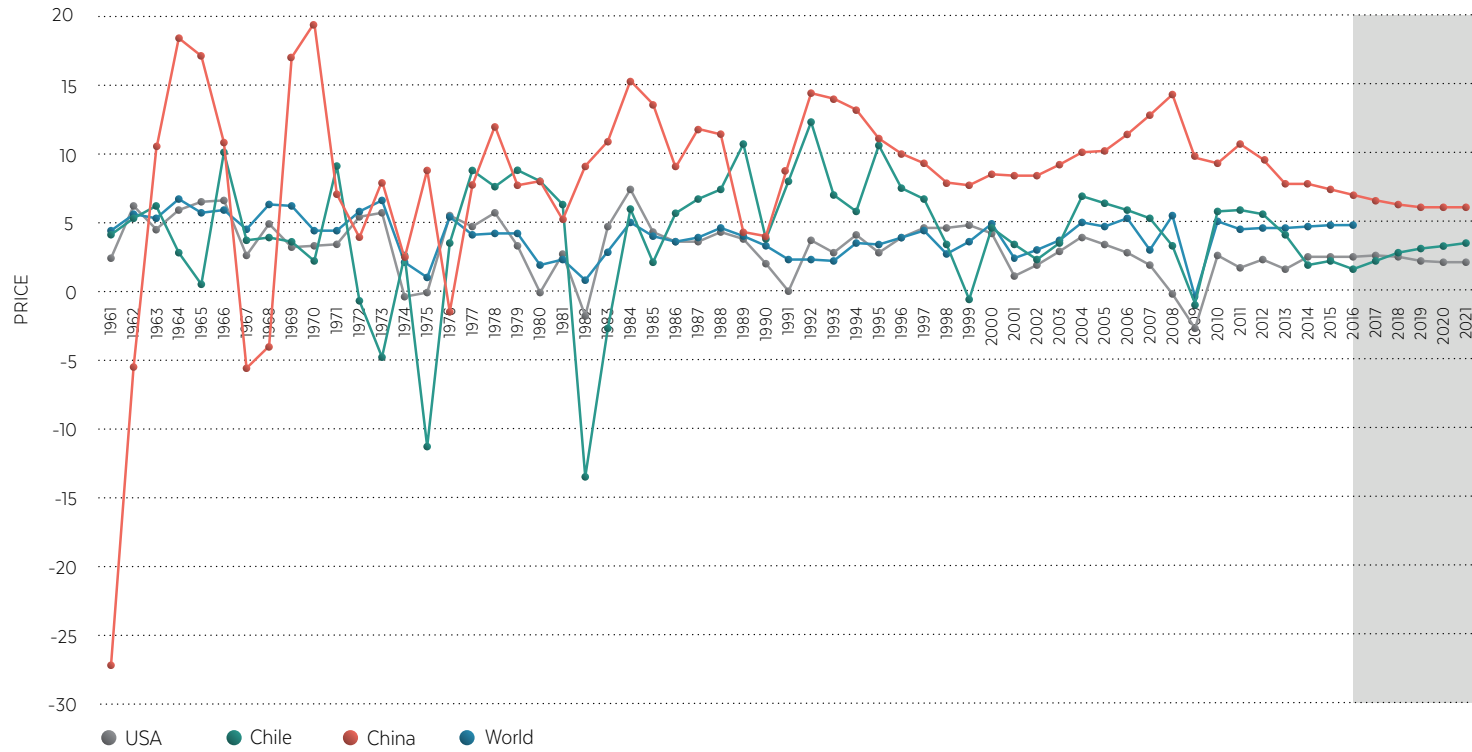
China -our primary target market- has been slowing down its expansion rate and its growth is projected to stabilise at around 6% per year, almost a quarter less than in previous years. However, given the size of its economy, its growing middle class and pace of urbanisation, China's demand for our products, although not just for food, will continue to be significant.

In short, we are facing a global economy with less clear-cut directions than a decade ago, requiring us to expand our capacities to continue to seize global opportunities for Chile.

1. Author's own work based on World Economic Outlook Database, April 2016 for 1980 data, World Bank for 1961-1979 data.
2. Author's own work based on World Bank and WTO data.
3. This phenomenon is evident in the price of copper, where the second "super cycle" of the last fifty years seems to be coming to an end.

### GROSS DEMOGRAPHIC PRODUCT AT CONSTANT PRICES<sup>1</sup>

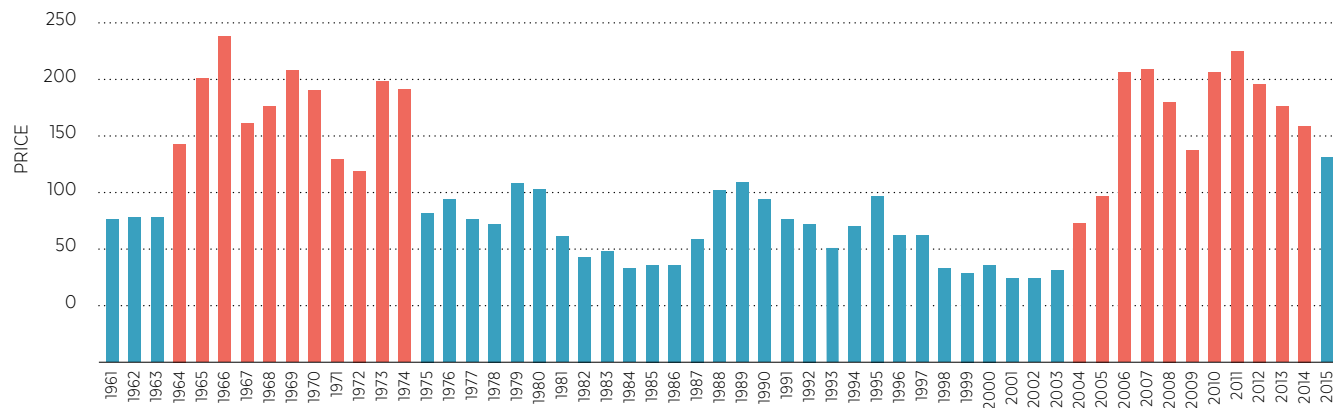
Percentage change 1991-2021



*“The more we know, the less we can predict. Imagine, for example, that one day experts decipher the basic laws of economics. When this happens, banks, governments, investors and customers will start using this knowledge to act in new ways and to gain an advantage over their competitors. We may know how the economy worked in the past, but we no longer know how it works in the present, let alone the future.”*

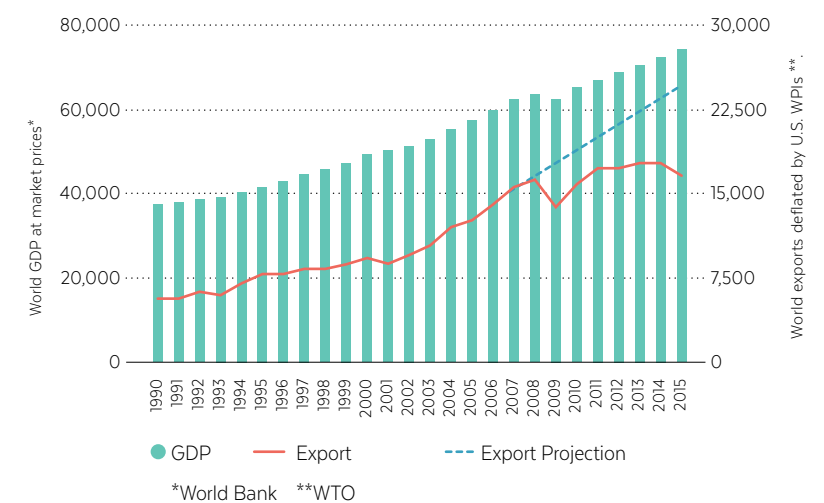
Harari Y., (2015). Homo Deus. Editorial Debate, p. 70.

### EVOLUTION OF DEFLATED COPPER PRICES BY IPM, USA (2003)<sup>2</sup>



WPI: Wholesale Price Index

### EXPORTS AND WORLD GDP AT 2008 PRICES: 1990-2015 (US\$ MM)



\*World Bank \*\*WTO

## Climate change is a critical issue on the path to development

The sustainable exploitation of our resources is an enormous challenge. Producing healthy food for an ever-growing population is a great opportunity.

The world's inhabitants and their governments are increasingly concerned about global change and its effects, particularly climate change. The United Nations Framework Convention on Climate Change and the 2030 Agenda for Sustainable Development not only express this concern, but they also set out a path for countries, with the novelty that the agreement was ratified by the United States and China. As the then French Foreign Minister Laurent Fabius said: "It is indeed the first diplomatic pact in the world and for the world."<sup>1</sup>

How much water is used to produce a certain good, how much carbon is emitted in the process, how waste is disposed of, the impacts of production on ecosystems, these are all questions we ask ourselves at the beginning of this journey, and today countries and industries are voluntarily asking themselves these questions.

It is even more important to understand how to integrate variables associated with natural capital in the development equation, at a national, business and even community level. For a country where the bulk of its exports is based on natural resources, this represents a critical challenge, where there are also unexpected opportunities. Achieving an environmentally sustainable use of the resources of our territory is undoubtedly an enormous pending challenge for Chile.

Some countries have taken the lead in this area. For example, the Federal Council of Germany (Bunderast) announced its proposal to ban manufacturing of internal combustion engine vehicles by 2030 and their road traffic by 2050. China has also started to look towards "greener" growth.

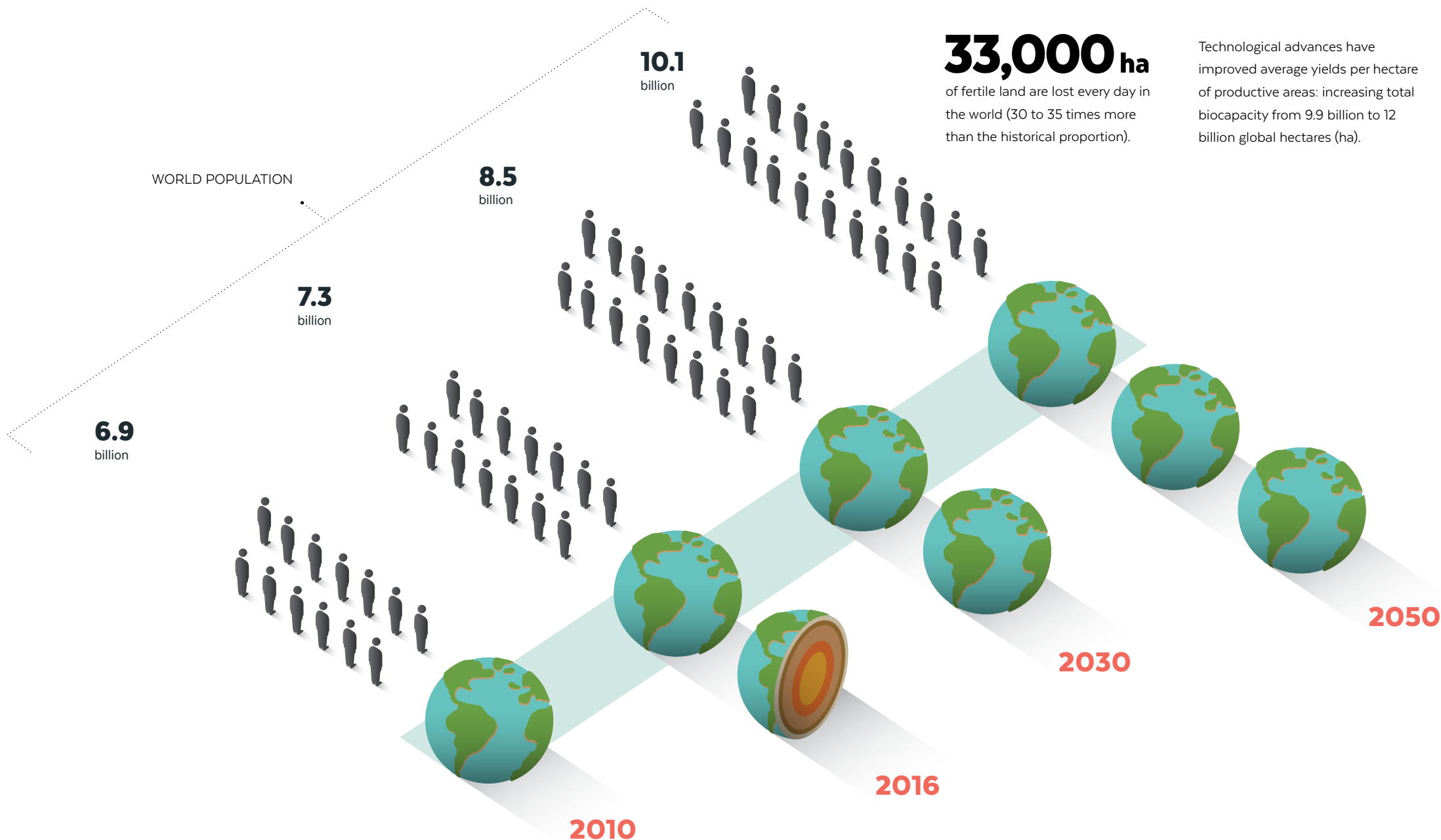
We are faced with a major ethical imperative. Some are not convinced we should quickly join this action. Here we only point out that, as the larger nations begin to move, countries like ours either prepare or simply end up being dragged by the wave of change.

In short, the challenges are enormous, as are the opportunities. An environmentally sustainable exploitation of our resources is undoubtedly a huge pending challenge. Producing healthy food for an ever-growing population is a great opportunity.

Source: Global Footprint Network, 2014

1. Interview with Laurent Fabius in Revista Diplomacia, No 131, April 2016, Santiago.





**33,000 ha**

of fertile land are lost every day in the world (30 to 35 times more than the historical proportion).

Technological advances have improved average yields per hectare of productive areas: increasing total biocapacity from 9.9 billion to 12 billion global hectares (ha).

Currently, to feed the population we require 1.6 planets worldwide, that is, arable land with fertile soil. If we continue at this rate, in 2030 we will need two planets and in 2050, we will need three.



**Bárbara Saavedra Pérez, CNID Advisor**

Bárbara has a degree in Biology and a PhD in Ecology and Evolutionary Biology from Universidad de Chile. She is the director for Wildlife Conservation Society Chile, and is responsible for all its activities in Chile, including the Karukinka project in Tierra del Fuego. She is also the director of the Chilean Ecological Society.



## The sustainability imperative: a quantum leap, urgent, unavoidable

By Bárbara Saavedra Pérez



We now recognise that growth, GDP and traditional economic indicators do not provide the minimum framework needed to shape and support development based on sustainability, inclusion and, above all, on a long-term vision. This is a deep transition that we have just begun, where the only option is to move forward by leaps and bounds.

Natural ecosystems are the basis of human well-being, whether we are individuals, communities, countries or companies. Their degradation impacts and degrades us all, causing global changes, such as climate change, ocean acidification, increased outbreaks and pests, altered biogeochemical patterns, and the disposition and quality of freshwater.

Today we need to accept that the natural order of nature is a hierarchy associated with sustainability (and even more so with development); this requires strengthening, recovering and promoting the fundamental system base that allows life to exist on Earth. And this hierarchy must learn to comprehensively look and act, recognising the multidimensional nature of our socioecological systems.

In this transition, the most significant need we face today is the need to create connections, not transactions, with our environment, whether social, cultural, territorial, ecological or otherwise. Connections

that recognise our identity (at an individual, community, country, company, research centre or other level), and the contexts in which it is embedded. It is here in this double perspective that we can find the seed of the integrated and systemic thinking we must develop. The confluence of science in all its dimensions is a key element in this process, but so is collaboration that enables its integration with other knowledge, because this is the only way integrated views and actions can be accessed and promoted.

With the right approach, the path becomes a key element, expanding transformation opportunities, whenever the process is recognised as a shared learning platform. It is only by viewing it in a designed and attentive manner will we be able to develop capabilities, connections, build trust, learn to work together, including the elite and the poor, embrace uncertainty with the best available knowledge, recognise and capture talent (not only scientific, but all kinds and in all areas) and make it available to jointly build the future.

## In Chile, global change has particularly critical manifestations

This phenomenon is also felt in the degradation of natural ecosystems and associated services; in the conditions they create for agricultural production; in the outbreaks and risk of new pests and diseases; and even in the increased occurrence of natural disasters.

Chile is one of the most vulnerable countries to the impacts of climate change,<sup>4</sup> the best-known manifestation of global change. And this is how people perceive it: 77 percent of the population declares to be concerned about global warming<sup>5</sup>, a much higher figure than the United States, where it is only 57 percent.

The impact of this phenomenon is already being felt in the decreasing trend in rainfall; it is partly responsible for what is referred to as a megadrought between the Coquimbo and Araucanía regions.

But it has also affected southern regions of Chile; it has depleted innumerable rural freshwater sources. A decisive figure for Chile: in

2016, the government has spent nearly US\$80 million on tankers to supply water to affected areas.<sup>6</sup>

This phenomenon is also felt in the degradation of natural ecosystems and their associated services; in the conditions they create for agricultural production; in the outbreaks and risk of new pests, plagues, invasive species and diseases; and even in the increased occurrence of natural disasters such as floods, landslides and wildfires.

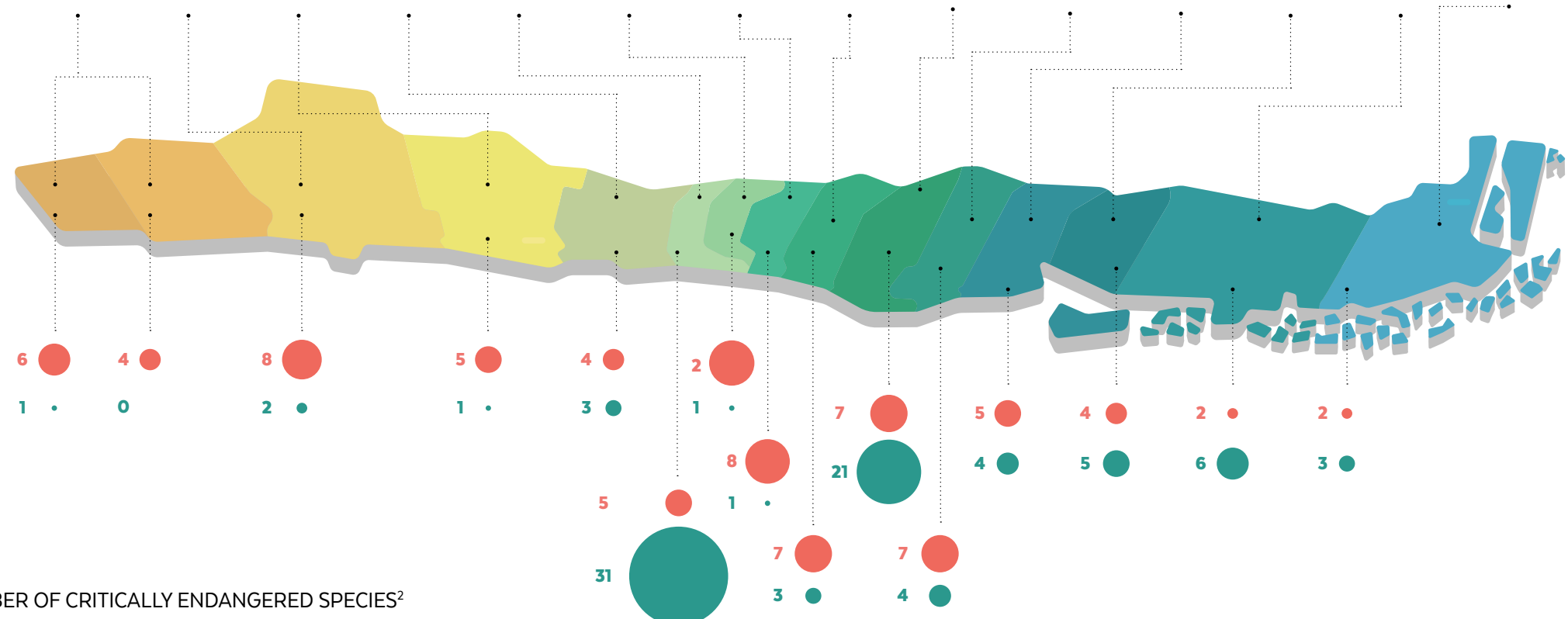
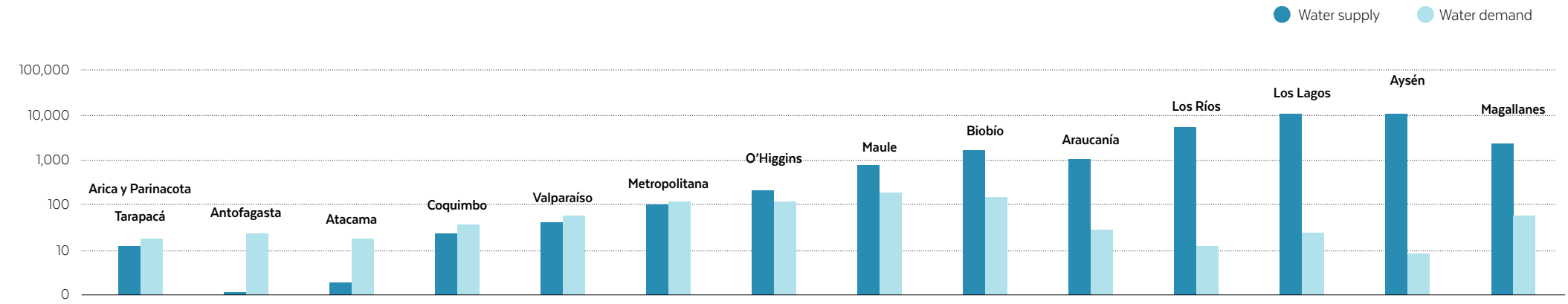
### Climate change and natural disasters in Chile

At the beginning of this year 2017, Chile was first hit by forest fires of a magnitude it had never seen before, and in less than a month, the Metropolitan Region was affected by floods. In both cases, higher temperatures were one of the main reasons, enhanced by poorly designed human interventions that result in loss of native vegetation. Between 1980 and 2011, Chile was the country most affected by natural disasters, particularly earthquakes and tsunamis. Now that the effect of global warming and climate change are much more evident, in addition to earthquakes we should include the increased risk of landslides, flooding and wildfires. Chile has become one of the most resilient nations in the face of earthquakes. We must invest to become resilient in new areas<sup>7</sup>.

1. World Institute Resources, 2015. Ranking the World's Most Water-Stressed Countries in 2040.
2. Ministry of the Environment, 2011. State of the Environment Report.
3. Ministry of the Environment. National Inventory of Species.
4. United Nations Framework Convention on Climate Change (UNFCCC) climate change vulnerability criteria. The available studies (2nd National Communication on Climate Change, 2011).
5. National Survey on Climate Change 2016, Ministry of the Environment
6. Ministry of the Interior
7. R&D&I Committee for Natural Disasters, 2016. "Hacia un Chile resiliente frente a desastres: una oportunidad", CNID.

We will go from an average water stress in 2010 to a very high stress level in 2040, being one of the countries most likely to a decrease in water supply<sup>1</sup>.

HYDRIC STRESS, CHILE (2011)<sup>1</sup>



NUMBER OF CRITICALLY ENDANGERED SPECIES<sup>2</sup>

● Animals ● Plants

## Our current production structure is particularly affected by climate change

Although we have low emissions on a global scale, we have a heavily polluting production structure in relative terms. There is still a lot of progress to be made in incorporating non-conventional renewable energies.

With an energy and water-intensive production structure, we cannot escape the challenges caused by climate change to our production processes. Our exports require large volumes of water. This is the case of agriculture, fruit crops and livestock (which account for 73% of the country's water use), forestry and mining. For example, global water use is distributed as follows: 69% for agriculture, 21% for industry and the rest for human consumption.

Moreover, our growth is almost parallel to increased energy use. Although non-conventional renewable energies (particularly wind power) have increased in electricity generation, we continue to have a heavily polluting power grid. Chile has the highest CO<sub>2</sub> emissions (tons per capita) in Latin America and the Caribbean<sup>2</sup>, apart from the oil powers of Venezuela and Trinidad and Tobago.

Although we have low emissions on a global scale, we have moved towards a more polluting structure in relative terms. Chile has pledged

to reduce its CO<sub>2</sub> emissions per GDP unit by 30% below 2007 levels by 2030. This is an ambitious goal, but it is also an enormous opportunity to add value and emphasize the great potential of our solar energy in northern Chile, to take advantage of the winds in the south, as well as the strong seas along the coast.

There is still much to be done, but we know that with cheap renewable energy, more water availability is also feasible. Chile really has a lot to gain by investing in finding solutions to the technological and non-technological issues hindering the deployment of solar energy.

### Chile's commitments at COP 21 for 2030

- Reduce CO<sub>2</sub> emissions per GDP unit by 30% below 2007 levels. Additionally, and subject to international support, reduce CO<sub>2</sub> emissions per GDP unit to between 35% and 45%.
- Sustainable management and recovery of 100,000 hectares of forest, mainly native species, representing greenhouse gas capture and reduction by about 600,000 tons of CO<sub>2</sub> equivalent per year, from 2030.
- Reforest 100,000 hectares, mostly with native species, capturing between 900,000 and 1,200,000 tons of CO<sub>2</sub> equivalent per year, from 2030<sup>3</sup>.

1. International Energy Agency (IEA), 2015 "IEA World Energy Statistics and Balances".

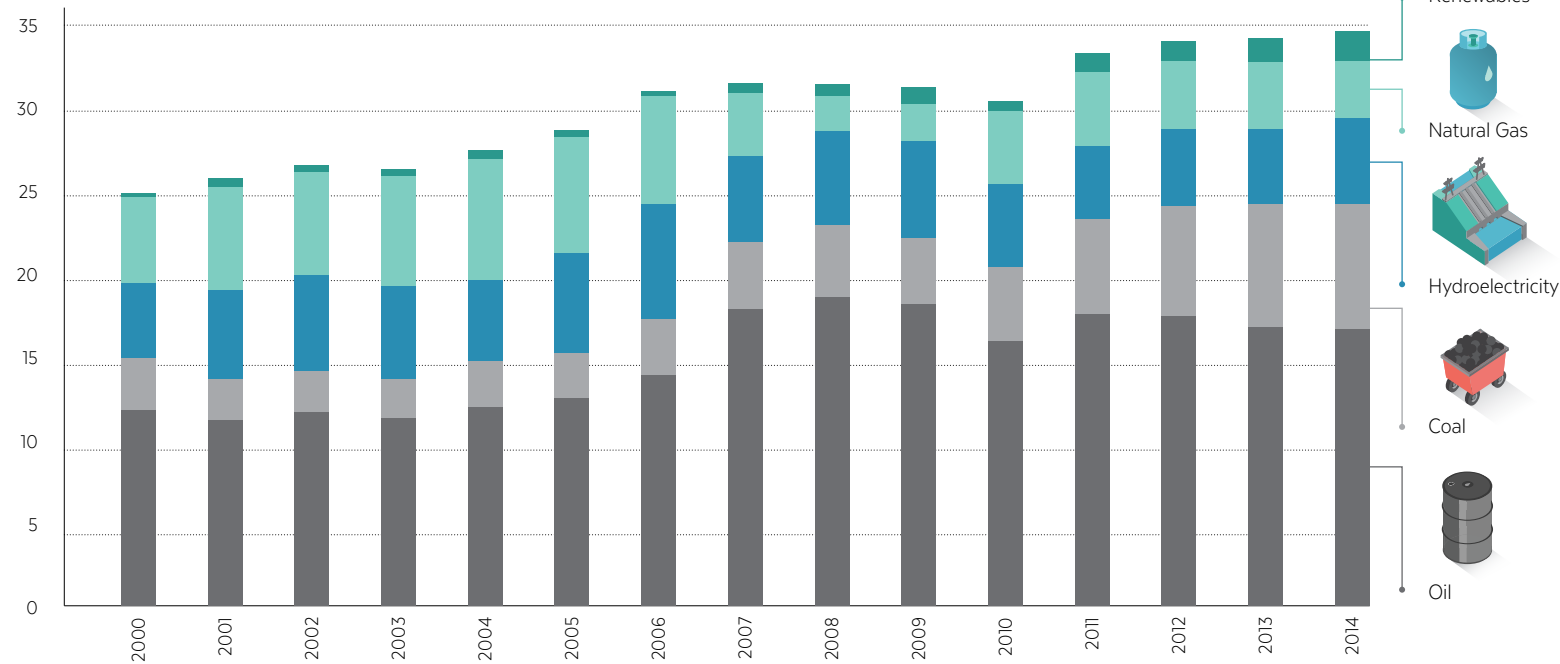
2. <http://datos.bancomundial.org/indicador/EN.ATM.CO2E.PC>. Accessed on 05-09-2016.

3. The Senate Environment Committee unanimously approved the Paris Agreement to address climate change. MMA 4 January 2017.

<http://portal.mma.gob.cl/comision-de-medio-ambiente-del-senado-aprobo-en-forma-unanime-el-acuerdo-de-paris-para-enfrentar-el-cambio-climatico/>

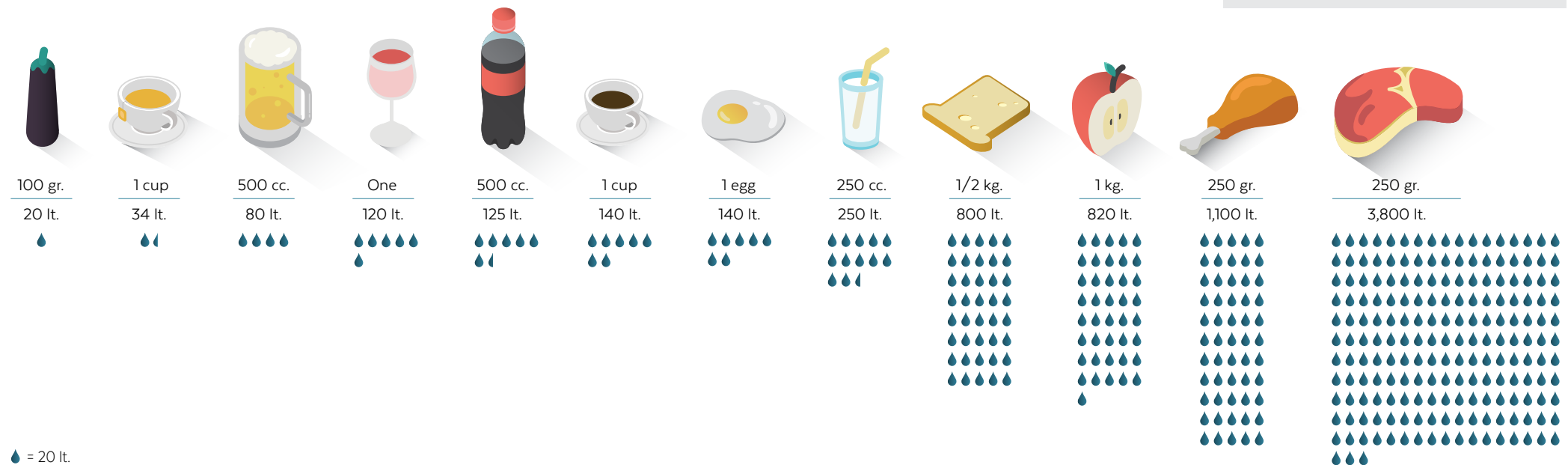
## ENERGY SUPPLY BY SOURCE (2000 - 2014)\* 1

Millions of tonnes of oil equivalent.

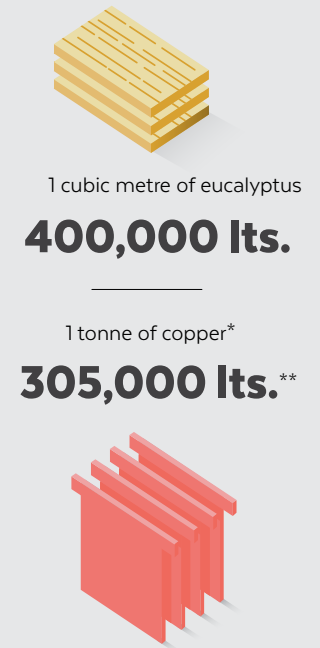


\*Total primary energy supply. Breakdown excludes electricity trading.

## WATER FOOTPRINT OF COMMONLY CONSUMED PRODUCTS<sup>2</sup>



## WATER FOOTPRINT OF EXPORT PRODUCTS<sup>3</sup>



\*In 2015, Chile produced 5.76 million tonnes of copper.

\*\*72.5% is recycled water, 23.5% is inland water and 4.0% is seawater.  
(Source: Cochilco, 2016)

## Rapid and uncertain change affects all spheres of life and poses unprecedented challenges

Knowledge and the development of new technologies open previously unimagined possibilities and radically alter social and cultural practices.

Scientific knowledge creation and new technology development are two capability accumulation processes that recursively enhance each other. Thus, both have undergone remarkable progress and everything seems to indicate that this pace will continue to increase, challenging the structures we take for granted today, such as: legal frameworks, education systems, productive organisation and government.

These changes cause multiple, powerful and, often, unpredictable impacts. They transform our world and challenge a comfortable illusion of “control and certainty”. We are in what Robert Lucky calls “the second part of the board”.<sup>4</sup>

The mastery over life and death, and the ethical questions this implies, the possibility of leaving the hardest work to robots, but also the threat of artificial intelligence to our livelihoods, are some examples of these perplexing times.

The exponential growth that is behind the rapid change that has launched STIs<sup>5</sup> is challenging our linear approach to understanding

various phenomena. And we need to recognise that it is an inherent characteristic of several social, cultural and technological processes, in addition to the myriad of physical, chemical and biological processes that science and engineering have already identified. Among these “new” processes are the transistor density increase per integrated circuit, explosive growth of mobile phones, use of social media and bandwidth availability.

Uncertainty coexists with the desire for quick reactions, often causing anxiety and dissatisfaction among citizens and perplexity among those responsible for public affairs.

The socio-technological dimension of change is not representative of these times; it is only more evident to us now. Something similar to the above examples happened five hundred years ago with the invention of the printing press and the printed book<sup>6</sup>. The surprise is that technologies open previously unimagined possibilities and radically alter practices in many areas, including social and cultural ones.

Time line source: Author's own work.

1. <http://reports.weforum.org/future-ofjobs-2016/shareable-infographics/>
2. [https://www.nytimes.com/2016/12/14/magazine/the-great-ai-awakening.html?\\_r=0](https://www.nytimes.com/2016/12/14/magazine/the-great-ai-awakening.html?_r=0)
3. Class Central ([www.class-central.com/report/mooc-stats-2016/amp/](http://www.class-central.com/report/mooc-stats-2016/amp/)) and Coursera (<https://www.coursera.org>)
4. R. W. Lucky, “Moore's law redux,” IEEE Spectrum, vol. 35, no. 9, pp. 17-17, 1998.
5. And that it became known as Moore's Law.
6. Silver, N. (2012). *The Signal and the Noise: Why So Many Predictions Fail - but Some Don't*. New York: Penguin Press.



## TOP 10 SKILLS OF CHILDREN ENTERING THE SCHOOL SYSTEM<sup>1</sup>

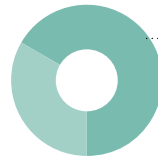
### In 2015

1. Complex problem solving
2. Coordination with others
3. People management
4. Critical thinking
5. Negotiation
6. Quality control
7. Service orientation
8. Analysis (judgement) and decision making
9. Active listening
10. Creativity

### In 2020

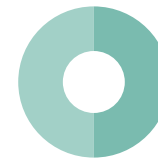
1. Complex Problem Solving
2. Critical thinking
3. Creativity
4. People management
5. Coordination with others
6. Emotional intelligence
7. Analysis (judgement) and decision making
8. Service orientation
9. Negotiation
10. Cognitive flexibility

2016



Two-thirds of the children who enter primary education will probably work in jobs that do not yet exist.<sup>1</sup>

2050



Half of the current occupations will be replaced by machines or algorithms.<sup>1</sup>

We require new skills to cope with uncertainty and rapid change.

## THE GREAT AWAKENING OF ARTIFICIAL INTELLIGENCE<sup>2</sup>

In 2006, translators made their debut and have since become one of the most reliable and popular assets by Google. It has more than 500 million monthly users, at a rate of 140 billion words a day in a different language.

Today we are facing an expansion from the logic of “bit” transmission to “bit to atom” transmission, thanks to the development of 3D printing technology connected to the Internet.

30.000

776

55

A.C  
D.C

1800

1850

1900

1950

2000

2050

## MOOCs<sup>3</sup>

The MOOC (*Massive Open Online Course*) are online courses that, through the Internet, reach a large number of participants, following the principle of open and massive education. In 2016, they registered 58 million students worldwide.

### MOOC courses in 2011

3

### MOOC courses in 2016

6.850

### MOOCs Top 5 by number of users

1. Coursera (23 million)
2. edX (10 million)
3. XuetangX (6 million)
4. Future Learn (5.3 million)
5. Udacity (4 million)

## A change that affects the way we live together

The sciences, arts, philosophy and humanities provide understanding to the new context and scenario of collective action, and enrich social and political dialogue, bringing down the empire of “opinion”.

Without even realising, objects, practices, roles disappear and are replaced by new spaces of identity and relationship. But in many areas, we are swept away and do not have time to realise or we “surrender” to this drift.

Thus, a new scenario for collective action is established. The traditional forms of political order are losing their representativeness. With spaces of rapid coordination and transfer of ideas, social media promote causes linked to specific demands, mobilise people, reconfigure collectives, in search of new forms of impact. Power is no longer what it was. “As we knew it, has come to an end”<sup>5</sup>.

The new voices demand, at the same time, more participation, faster reaction and a strategic vision, and processes of different and often

conflicting paces. It is not a coincidence that all over the world the elites are disoriented and, in many cases, questioned.

Thus, the contribution of the sciences, the arts, philosophy and the humanities is essential in order to understand and enrich social and political dialogue, bringing down the empire of “opinion” and helping to reconfigure ourselves in this new context.

### Can human intelligence be replaced?<sup>6</sup>

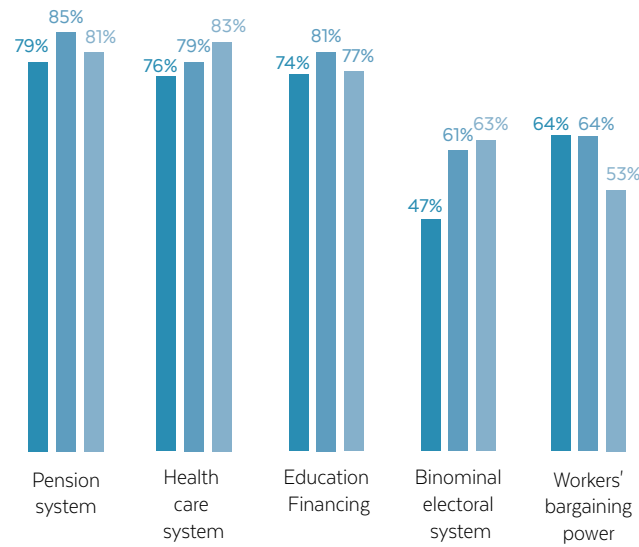
While the ability to analyse large amounts of data to generate “patterns” improves a decades-long path, machine learning generates milestones that change its course. In 2006, Google released a new version of its translator that allows you to read and understand a complex automatically translated text, something almost impossible a year earlier. Microsoft, Baidu and others have made similar advancements, opening a new era of exchange and cultural relations between different countries and regions.<sup>7</sup>

These opportunities also imply threats. According to McKinsey consulting firm<sup>8</sup>, 50% of existing jobs will be replaced by machines or algorithms by 2050. Bill Gates proposes taxing robots to delay this phenomenon and to pay for changes to retrain society to do other jobs<sup>9</sup>.

1. National Public Opinion Study, July- August 2016, CEP.
2. Bicentennial National Survey, 2015. Pontifical Catholic University GFK Adimark.
3. Human Development Reports 2004 and 2013.
4. Excelacom.
5. Naim, M. (2013). The end of power. Ed. Debate.
6. This refers to both the ability to extract insights from large amounts of data and the ability to learn through system training modelled on the nervous system functions.
7. <https://www.technologyreview.com/s/600991/skypes-gone-multilingual/>
8. January 2017 report.
9. <https://qz.com/911968/bill-gates-the-robot-that-takes-your-job-should-pay-taxes/>

## YES, PROFOUND CHANGES ARE NEEDED<sup>1</sup>

● They don't have political opinion ● They have political opinion ● Total

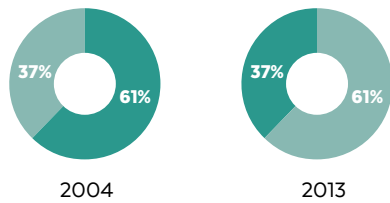


*"Power, like energy, is neither created nor destroyed... but irretrievably dispersed among a multitude of agents, of micro-powers in whose hands it ends up degraded."*

El País, November 13, 2013, about the book *The End of Power* by Moisés Naim.

## CHANGING NATURE OF DEMAND<sup>3</sup>

● Solutions need time ● Solutions must be quick



*"I get a lot of information but I don't vote. I'm in the position that I'm going to vote when..., it's kind of selfish of me to be in that position because maybe my vote can help a lot of people or maybe not. But I want to do it when I really feel like it's going to change something in me."*

Discussion group, middle socio-economic status, Human Development Report, 2015

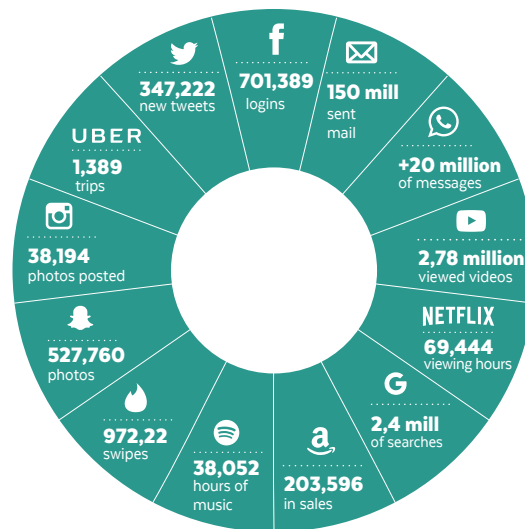
## NEW SOCIAL ORGANIZATION

## DISTRUST



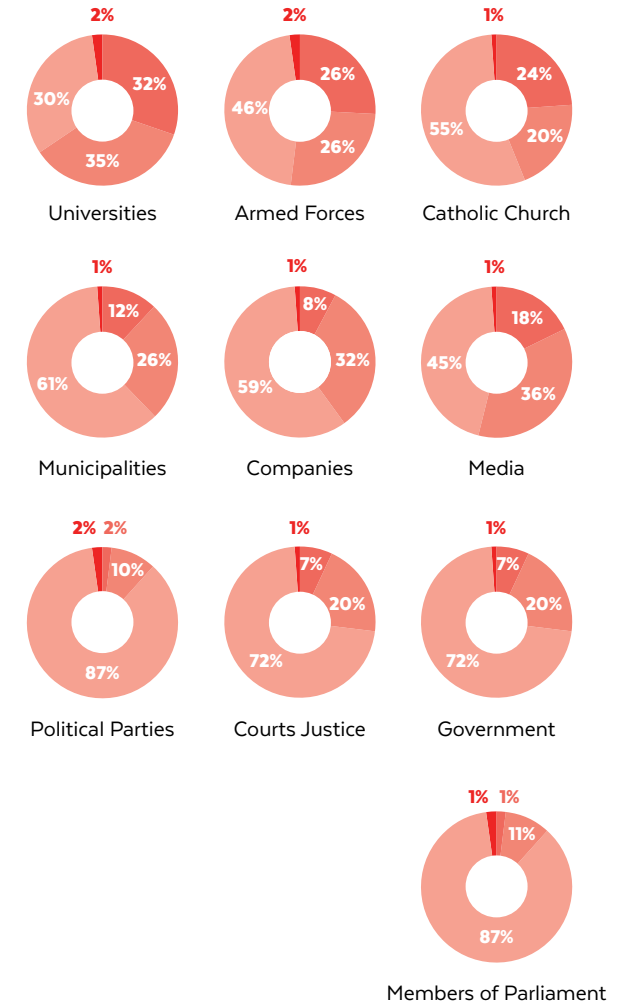
## NEW FORMS ON DEMAND

### WHAT HAPPENS IN A MINUTE ON THE INTERNET (2016)<sup>4</sup>



## HOW MUCH DO YOU TRUST INSTITUTIONS?<sup>2</sup>

● A lot - Quite a lot ● Some ● Nothing - Little ● DK-NO



## MOST PEOPLE CAN BE TRUSTED

● Strongly agree ● Neither agreement nor at odds ● Strongly disagree



## Complexity has become the rule

Having information and knowledge, developing skills to face change, fully understanding emerging concerns, creating new logics of relationships, are all capabilities the State must incorporate.

The tensions inherent in development to achieve growth, inclusion, cohesion and sustainability in a changing, uncertain and accelerating context, make the challenges of “the public services” increasingly complex.

Complexity by nature overcomes us, like a tautology. There are authors who distinguish between two dimensions: a detailed dimension, given the large numbers that multiply the number of potential interactions; and a dynamic dimension, where the cause-effect relationship is subtle and the effects of interventions are not obvious over time. Often, our management and planning systems remain in the field of data and detail, but do not include the processes where this other type of complexity is found.

There are always different sides to every problem, there are multiple and increasingly active actors, making all attempts at simplification futile. In the public sector alone, there are more than 40 water management institutions. All public policies have to consider the large

number of actors and components, but especially the phenomena they are responsible for and the processes they trigger.

The State increasingly needs to be willing to listen, which does not mean giving into specific interests or getting carried away by popular clamour. The challenge is to structure a relationship between the State, organisations and citizens that, through informed dialogue and transparent decisions, will allow to develop a common understanding and join forces to act within this complex context. The impact of tax incentives, the public transport system, new healthcare technologies, is not evident.

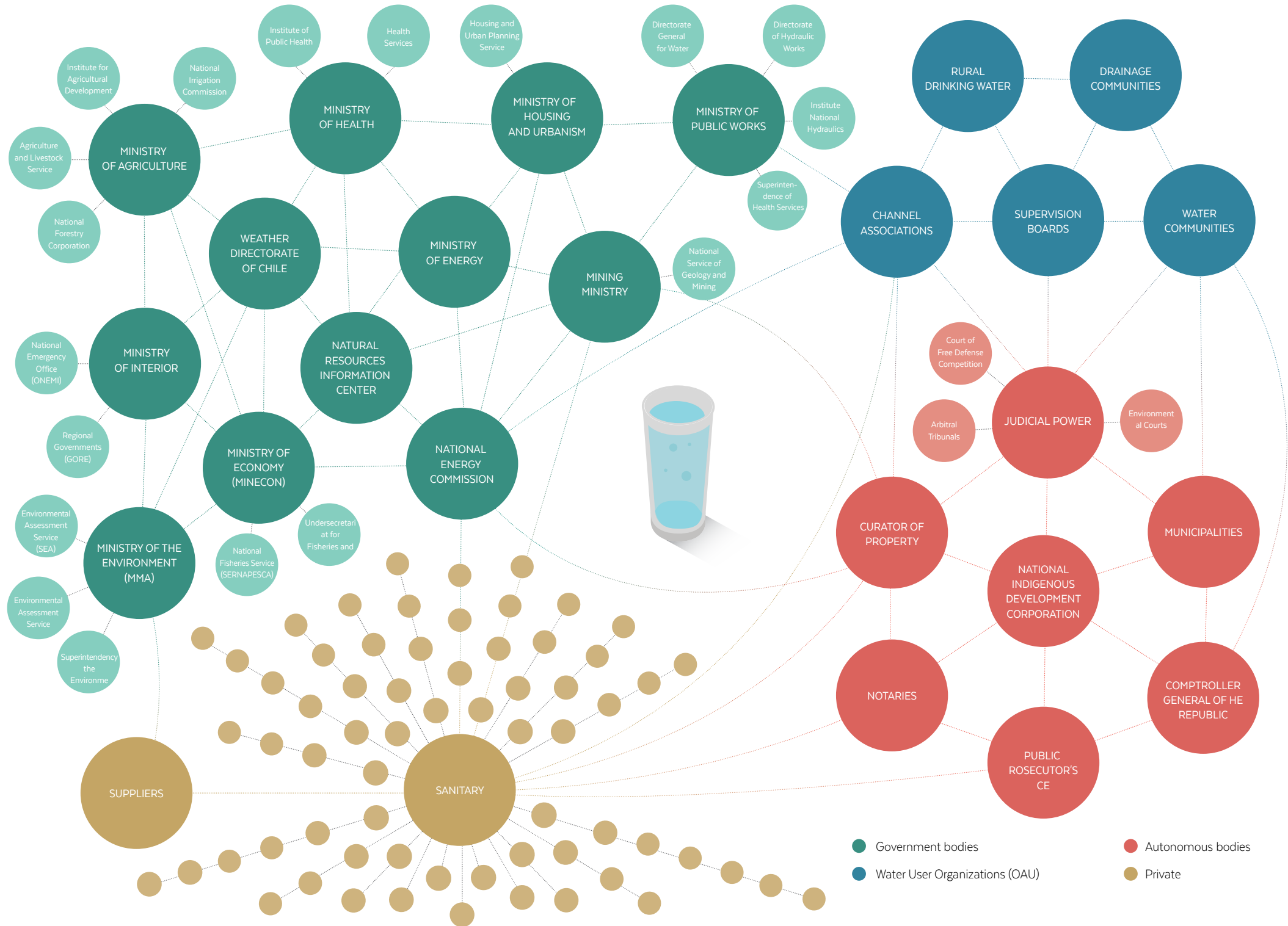
Having information and knowledge in a broad sense, developing skills to face the waves of change, fully understanding emerging concerns, creating new approaches to and logics of relationships, are capabilities the State must incorporate in response to today's public policy challenges.

In 2016, DARPA<sup>3</sup> called to advance the state-of-the-art to understand social phenomena<sup>4</sup>. It seeks clues rather than solutions, asking for everything, from basic principles and conceptual approaches, metrics to assess the reliability of social science research methods, to simulation tools to contrast theoretical predictions with observation. This recognises the need to find new ways of understanding the complexity we face.

1. Source Diagram: Author's own work.
2. Senge, P. M. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York: Doubleday/Currency.
3. Defence Advanced Research Projects Agency, whose forerunner developed the Internet
4. <https://www.fbo.gov/spg/ODA/DARPA/CMO/DARPA-SN-16-70/listing.html>

# MAP OF THE MAIN INSTITUTIONS RELATED TO WATER MANAGEMENT IN CHILE<sup>1</sup>

Note: The connector lines are illustrative, they do not respond to formal institutional relationships



- Government bodies
- Water User Organizations (OAU)
- Autonomous bodies
- Private



**Claudia Bobadilla Ferrer, CNID advisor**

Claudia is a lawyer, founder and director of the Senior Management Network (RAD). She is an advisor to Associated Universities Inc. and director of the ALMA Radio Astronomy Project and non-profit organisations.



## The country where I would like to live

Claudia Bobadilla Ferrer



The recent wildfires in Chile affected a total of 604,473 hectares, burning 6,000 square kilometres of forest, six times the size of New York City. One outbreak was in the Pirque municipality.

From there, Maryanne Muller's invitation "Criticism doesn't put out the Fire" went viral in a matter of hours and mobilised hundreds of volunteers, the media, authorities, and the entire local community. For seven days we worked in the hills doing whatever was necessary and at different camps, encouraging each other and working together to defend the forests that belong to everyone.

The small makeshift camp was transformed into a small country, the country where I would like to live. A generous, kind country, full of myth, good stories and mutual trust. A community "obsessed with the common good", with honest and constructive conversations, with a sense of humour, also with problems and concerns, but with wise and inspiring leadership, and the ability to talk, and not to lose sight of what is essential, the sense of community.

This intense and concrete experience taught me and teaches us lessons that we will all need to learn in these changing times.

**Recognise our permanent and growing fragility and prepare.** Natural disasters are not going to stop, they are part of our lives because of the effects of climate change and they cost the State US\$2.5 trillion a year. An invaluable investment would be to provide us with the technologies, data management and a network of specialised disas-

ter volunteers, to work with brave and courageous young people for Chile, and to provide them with everything they need.

**The urgency of developing local philanthropy. Chile is our country.** Let's mobilise a crusade for philanthropy, to celebrate and spread the joy of giving. We urgently need philanthropists. There is a large space here for innovation.

**The importance of being attentive, attentive to listening empathetically.** To be available to serve in what is needed and not in what I want or believe I can contribute.

**The responsibility we all have to connect, to get to know each other and talk.** What a wonderful incentive, for everyone to go out to connect and talk from our diversities, to discover from where we can contribute by undertaking, innovating to make sense of it, to dignify and make Chile, not only a developed, but also an integrated and happy country.

At the time, I remembered another Chilean hero, Pilot Pardo, who 101 years ago accepted the mission to go and rescue the Antarctic expedition led by the English explorer Ernest Shackleton, who had run aground on Elephant Island where certain death awaited them. Before setting off on the rescue mission, he wrote a letter to his father; the first lines of his letter were:

**"The task is great, but nothing scares me, I'm Chilean..."**



## The new path to development challenges us to mobilise talent



This proposal of science, technology and innovation for a new sustainable and inclusive development agreement for Chile was developed by believing in people's strength.

Understanding, adaptation and anticipation are particularly important skills when we realise that we can no longer continue on this development path.

According to UNDP, until recently, countries were growing and improving their human development indicators, and environmental protection took second place. Today, therefore, the main challenge for countries that have achieved higher wellbeing is to take responsibility for the environmental gaps. In contrast, countries that still have significant welfare challenges, cannot grow today while, at the same time, they try to reduce their ecological footprint; they must grow in an inclusive and sustainable manner.

This is the challenge to our development, and when we propose more efforts in science, technology and innovation, this is because, given these challenging times, we consider essential to provide people with expanded capabilities, in all areas of their work.

Ultimately, it is people in their different roles and positions who make the difference.

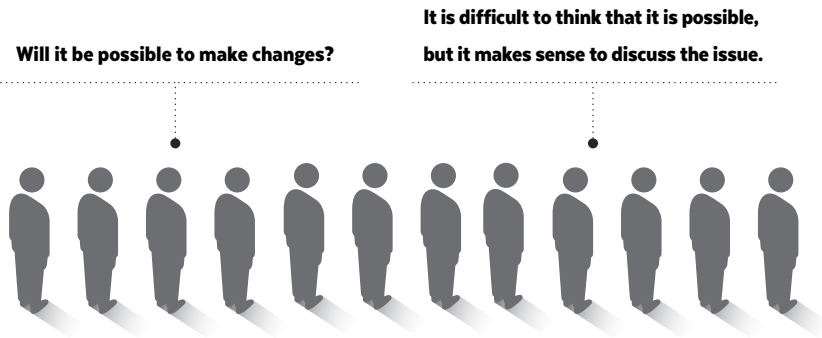
Today, given that a high percentage of our population has access to tertiary and postgraduate education, increasingly more people seek to become entrepreneurs, examples of advancements achieved, such as the use of non-conventional renewable energies, more participation spaces gained in our population, but also the value and hope still placed on science and technology, we can still hope that more people will participate in this world. And for this world to become part of everyone's conversation and concern.

We hope that the "certain pride" we have in being Chilean, as in football or major solidarity campaigns, with the thousands of volunteers who constantly and silently work, and with the Chileans who stand back up again after every natural disaster, also unites us around our potential achievements in science, technology and innovation. They enable us to open connection and realisation spaces, as well as create opportunities for everyone.

This STI proposal for a new sustainable and inclusive development agreement for Chile is based on placing one's trust in people's strength and talent.

1. <http://www.conicyt.cl/explora/2016/06/16/jorge-zuniga-dr-en-fisiologia-mecanica-el-cientifico-inventor-chileno-que-decidió-donar-su-creacion-al-mundo/>  
Consulted in March 2017.

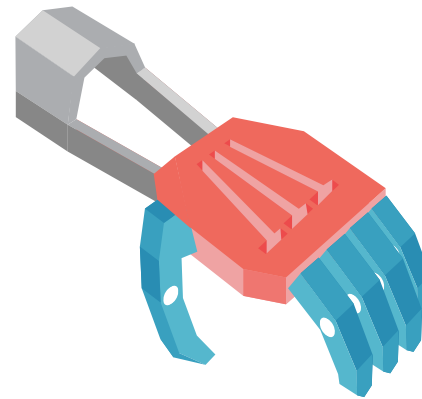




HUMAN DEVELOPMENT REPORT

*"(...) change is possible, but it is also desirable, and despite the difficulties it makes sense to keep looking for it."*

UNDP (2014). Human Development Report. The Times of Politicization. Santiago de Chile, page 24.



*"The best way for science to get close to people and their needs is for the scientific community to have compassion and a social vocation."*

Jorge Zúñiga

CYBORG BEAST, OPEN-SOURCE PROSTHETIC HAND<sup>1</sup>

Biomechanical hand for children by Chilean scientist Jorge Zúñiga. His 3D-printer designs are available at a low cost (50 dollars), allowing more than 2 thousand families around the world to access this prosthesis for their children in less than three hours.

**32,277**

Design downloads

**15**

Medical and educational institutions have used and modified his designs

**+2,000**

Families around the world have printed a hand for their children



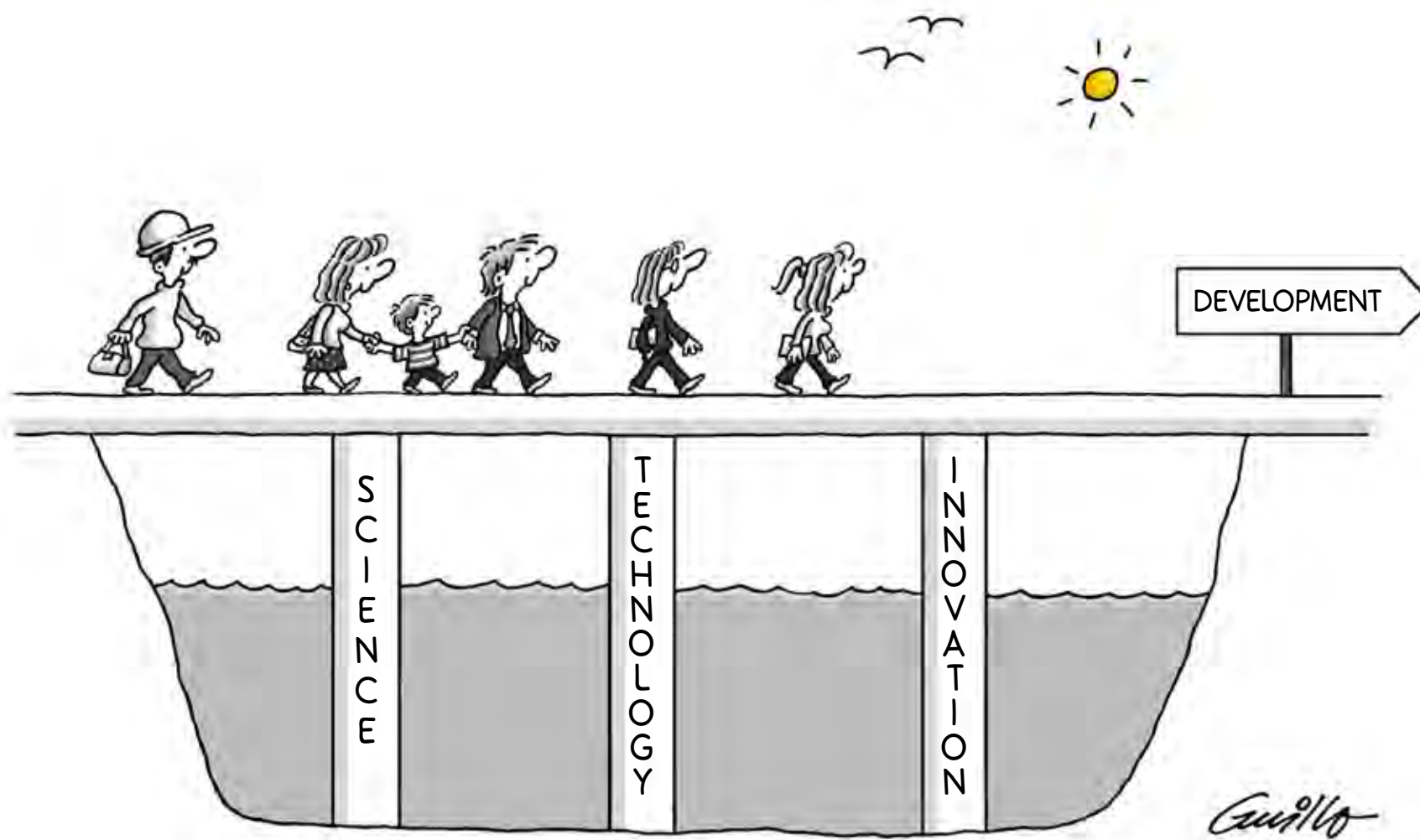
Report highlights the country's resilience after suffering earthquakes, tsunamis, fires and floods: What makes Chileans so resilient in the face of tragedy

A GENERATION COMMITTED TO DEVELOPMENT

*"In this group we wanted to represent part of the young faces of Chile, who operate with different logics, who are full of energy and want to contribute. This group has made important achievements in spite of its youth, overcoming obstacles and taking advantage of the opportunities that exist today for science, technology and innovation in our country. They have rolled up their sleeves to go and play on that field, leading disruptive initiatives, and in many cases, being an example that fills us with pride and proves that if we believe in ourselves, we can play in the big leagues."*

Emerging Agents for Innovation Commission (2016). "Soñando futuro. Una generación comprometida con el futuro".

CNID, Santiago, 2016, page 3.



## A Manifesto of Emerging Innovation Agents.

### A generation committed to development



As a player in the 2030 STI world, today I commit to the following principles and values to contribute to Chile's development:

#### **Connected to concerns and problems in society**

Today's Chile needs a generation committed to its pains and shortcomings, to its needs and dreams. We are willing to be a generation committed to this.

#### **Recognise and value cultural, ecosystem, territorial and social diversity**

Chile is a uniquely diverse country. This makes us stronger; it gives us unparalleled territorial beauty and on which the creativity of our people, our best tool for the future, lies.

#### **Promote and work for sustainable development**

Our efforts must be planned to ensure the next generation can enjoy this world. We need to be aware of our planet and take care of it.

#### **Believe in people**

People are the mainstay. We believe in respect and dignity of all people, as well as their unlimited capacity to create, dream and think.

#### **Open knowledge**

Only when knowledge is accessible to everyone can we dream of a better future, where we can all participate. Open knowledge, in the hands of citizens, offers us enormous potential.

#### **Empower citizens and territories**

We yearn to actively participate in Chile's development, to define its future with our own hands. Empowering citizens and incorporating our territories is a fundamental pillar of any development strategy for the future.

#### **Collaborate, collaborate, collaborate**

We believe in a shared future, where collaboration is the key element to successfully move forward. This is the way we value; competition or transaction logics do not represent us.

*This manifesto was based on a survey of more than one hundred young people involved in science, technology and innovation connected through the participants of the Emerging Innovation Agents Committee, in October 2016.<sup>1</sup>*

1. Emerging Innovation Agents Committee (2016). "Soñando el future. Una generación comprometida con el desarrollo". CNID, Santiago, 2016.



*Guillo*

## CHAPTER 2



## The opportunities provided by science, technology and innovation



### Presentation

STI offer multiple opportunities, but they do not unfold in a vacuum nor are they a miraculous path. It requires broad agreements and common goals, enabling people and institutions to develop their capabilities to face today's challenges.

Development is a complex process, that cannot be reduced to one dimension, the role of science, technology and innovation in this transition is multidimensional. STI have undeniably transformed and influenced all the dimensions of human life and the planet in general. It is also clear that, depending on the time or place from where STI are observed, certain contributions are more valued.

Without denying or undermining the fact that the promotion of science and humanities is important, consistent with the broader approach we need to adopt to move forward on the path to sustainable development, we propose to observe and assess the various ways STI help to meet material prosperity, environmental sustainability, and social inclusion and cohesion goals. In this approach, we should also point out that the path towards technological development and innovation is getting wider, and is now being used to address human concerns that were not previously addressed by this approach. This is where design innovation, social innovation and public innovation increasingly find their place.

As a Council, we are convinced that advances in STI, in their various expressions, is a prerequisite to address the challenges and opportunities in the current context. Here we highlight several ways STI are an essential ally to move towards sustainable development: STI i) contribute to economic growth; ii) enable us to address national challenges no one else will address for us; iii) help to improve well-being and inclusion by adapting technologies; iv) create knowledge to understand different phenomena and anticipate their implications, to guide and support

decision-making; v) help us to take advantage of Chile's distinctive characteristics; and vi) encourage creative skills of people and communities.

National and international examples demonstrate each of these contributions. They reveal a scenario where unprecedented opportunities are emerging, but at the same time, they also threaten several traditional roles and jobs. This ambivalent condition of scientific and technological progress cannot be minimised by fascination or by fear of change. Above all, it is a warning not to "naturalise" processes that are ultimately guided and defined by human decisions. This is also true when we take advantage of advances in STI on our path towards sustainable development. In fact, in many cases knowledge or technological solutions are available, but they are not used because of lack of coordination, vested interests or even simple idleness.

STI offer multiple opportunities, but they do not unfold in a vacuum, nor constitute a miraculous path that will enable us to overcome the barriers we ourselves create, from other spheres, that hinder our own development. It requires broad agreements and common goals enabling people and institutions to develop their capabilities to face today's challenges.

## I. AID FOR ECONOMIC GROWTH

## Innovation helps countries to perform

R&D investment has been shown to increase innovation and productivity levels in countries.

A classical prediction by economists was that, naturally, countries would tend to converge in terms of their per capita income. Poorer countries would grow faster than higher-income ones, and in the long term, they would finally catch up. With few exceptions, this has not been the case.

At the end of the 1980s, while searching for explanations, some economists emphasised the role of innovation. The hypothesis was clear: it allows greater return on investment in infrastructure and equipment (capital) and in human talent (work). In other words, they could continuously increase productivity of their factors. Furthermore, it was found that least developed countries did not easily absorb technology developed by frontier countries unless they implemented policies aimed at technology transfer, training and investment, and had adequate support institutions.

Thus, from an economic perspective, evidence has accumulated in favour of the impact R&D investment has on growth. This has led to

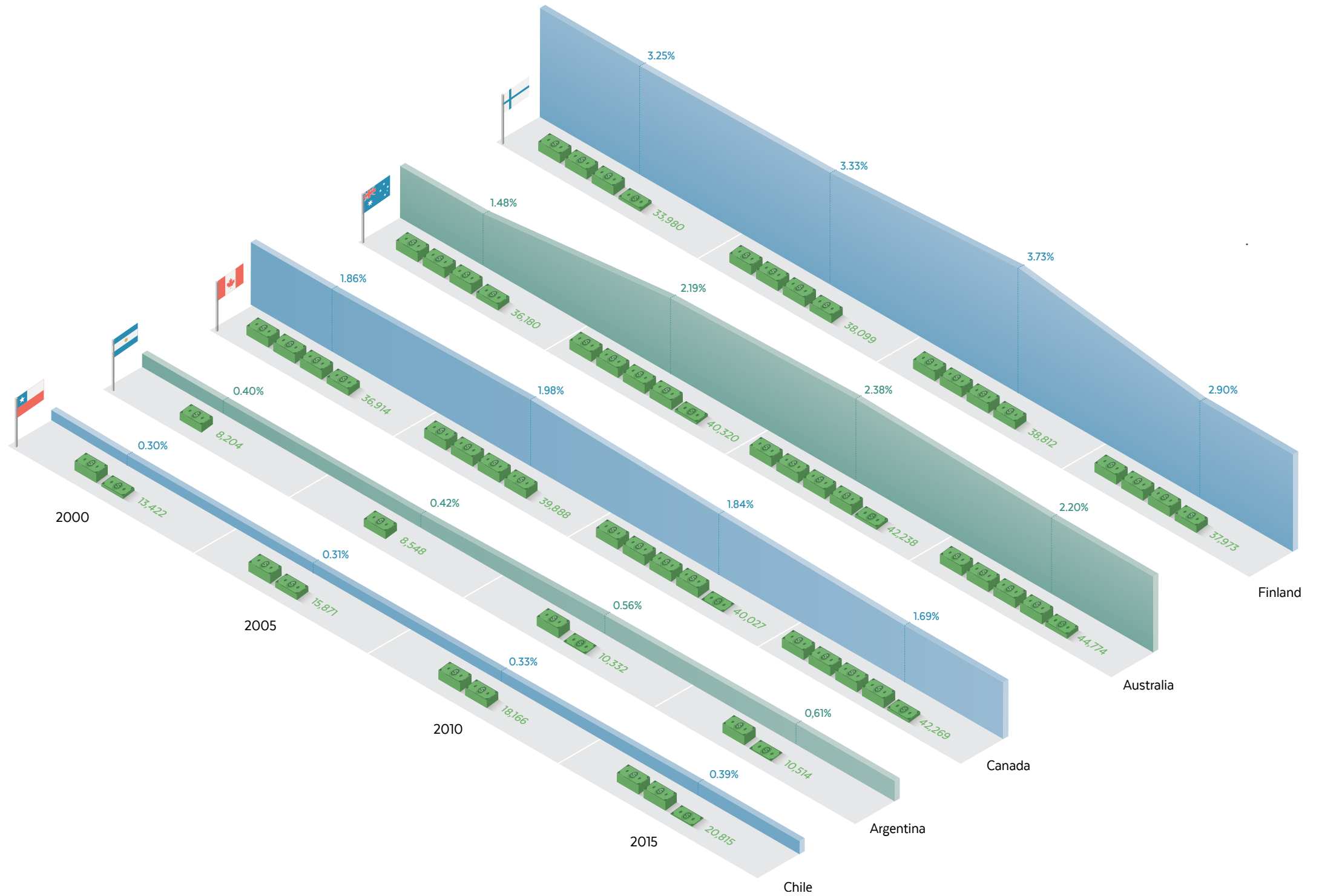
the incorporation of an indicator to measure innovation activities in countries: R&D expenditure. The use of this variable at an aggregate level of the economy has had positive results which have been documented by numerous econometric studies.

However, today, models and data quality are more sophisticated. The relationship between R&D efforts and growth is measured through an econometric model that assesses two correlations with company data: the relationship between R&D expenditure and innovation and then, from innovation to increased productivity<sup>2</sup>. The results show that the differences in R&D investment explain the differences in innovation and help to understand productivity differences between companies, which affects a country's performance.

While most of the analyses using this model have been applied to advanced or newly industrialised countries, studies for Latin American countries, including Chile<sup>3</sup>, also show a positive relationship between investment in R&D, innovation and productivity.

1. Source Diagram: Author's own work based on OECD stats and UNESCO Institute for Statistics data, collected in March 2017.
2. Crepon, B. Duguet E., Mairesse J. (1998). "Research, Innovation and Productivity: An Econometric Analysis at the Firm Level." *Economics of Innovation and New Technology* 7(2): p. 115-158.
3. Crespi, G. y Zúñiga, P. (2012). "Innovation and Productivity: Evidence from Six Latin American Countries." *World development* 40.2 (2012): p. 273-290. Their work is particularly significant, among other things, because of the data refinement work they do.

R&D EXPENDITURE AS % OF GDP AND GDP PER CAPITA (US\$ PPP 2010)<sup>1</sup>



## II. FACILITATOR TO ADDRESS THE CHALLENGES NO ONE ELSE WILL FACE FOR US

## Denmark decides to transform its power grid

By incorporating knowledge that gives us understanding and technological capabilities, we can address our concerns and create opportunities to move towards sustainable and inclusive development.

We face our own inevitable challenges, present in our specific conditions and which only matter to us. This includes, for example, the technological, environmental and social challenges of our mining industry, the sustainability of our water resources and the opportunities we have in terms of non-conventional renewable energies. By incorporating knowledge that gives us understanding and technological capabilities, we can address our concerns and create opportunities to move towards sustainable and inclusive development.

The development of clean energy in Denmark is a clear example. With exports exceeding ten billion euros, today it is a world leader in clean energy equipment and technology. How did it become a market leader? Certainly, thanks to a major public-private R&D&I effort. But to do so, it had to create the conditions to drive and guide the players in this direction.

At the beginning, there was a costly political decision: in the early '70s, after being severely hit by the rise in oil prices, Denmark decided to

reduce its dependence on oil and move towards renewable and non-polluting energy sources<sup>1</sup>. This resulted in legal and regulatory changes that provided a new incentive framework for the different actors.

Furthermore, despite lower oil prices, they upheld this decision. This created a horizon of certainty that gave security to research institutions, companies and universities in relation to their decision to direct efforts towards developing knowledge and technologies that would allow them to achieve this goal.

Denmark had a natural advantage to build on: its strong winds that average 7.6 metres per second. Denmark was able to use this advantage and were the first to build offshore wind farms.

There have also been ongoing efforts to engage local communities. There is also a compensation scheme and direct benefits for people affected by an investment. It is no coincidence, then, that several locations have set more ambitious goals for their power grid than national ones.

The Danish case shows us how to propose a radical transformative goal, approaching it from a unique condition, building a broad and lasting national agreement, and decisively incorporating science, technology and innovation.

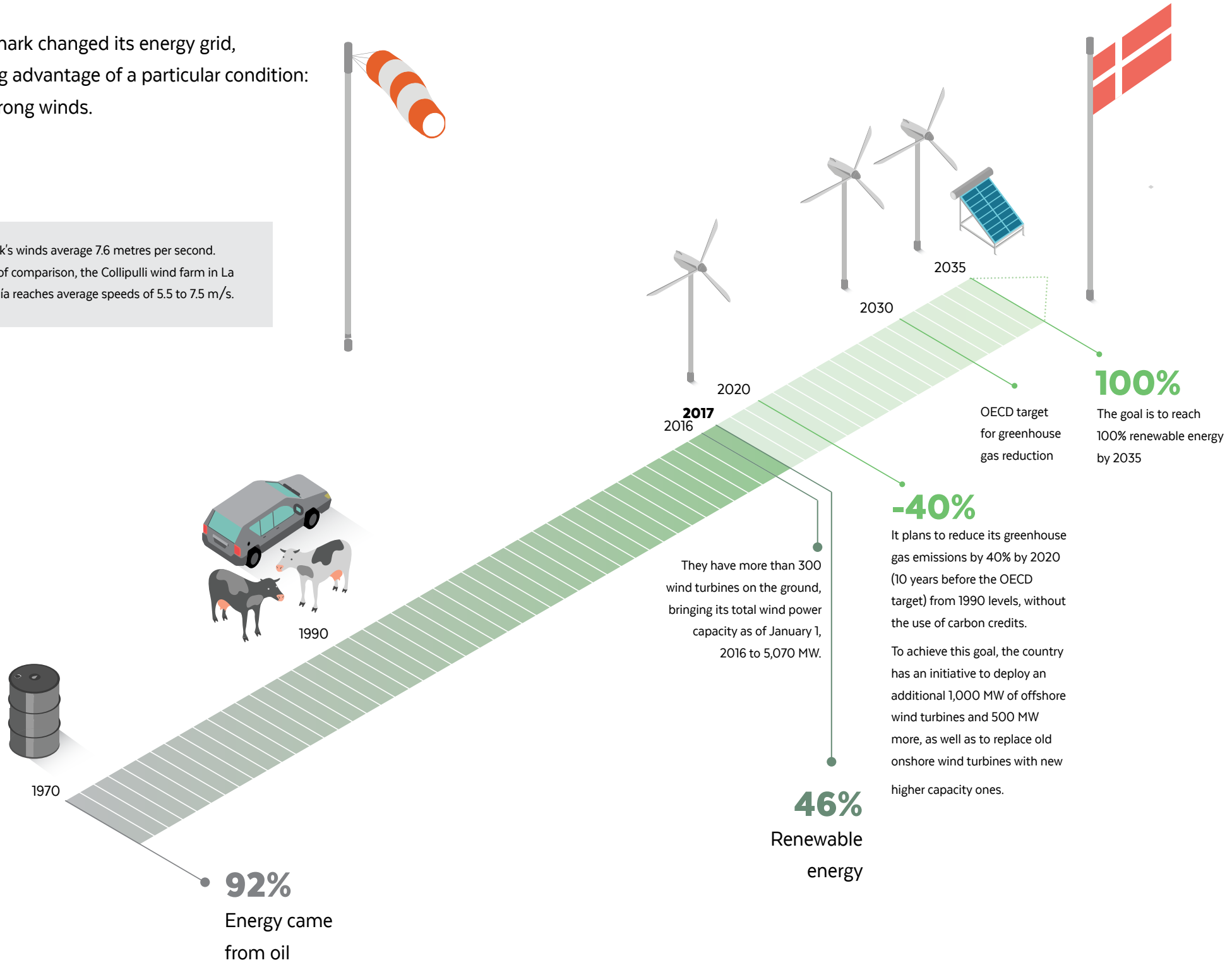
Source: Author's own work based on data from <https://stateofgreen.com/en/pages/denmark-becoming-the-state-of-green>

1. <https://stateofgreen.com/en/pages/denmark-becoming-the-state-of-green>



Denmark changed its energy grid, taking advantage of a particular condition: its strong winds.

Denmark's winds average 7.6 metres per second. By way of comparison, the Collipulli wind farm in La Araucanía reaches average speeds of 5.5 to 7.5 m/s.



## We can make mining a virtuous industry

Falling resource revenues and future challenges in mining are forcing mining companies to drive innovation and improve their technological processes and management practices.

Chile is known for its large-scale copper mining industry. And we can continue to mine, if we use innovation and technological development to control costs, and improve sustainability and inclusion in a society increasingly concerned about the environment and quality of life.

In the last 25 years, copper production has grown 3.5 times, producing 30% of the world's copper. Mining will undoubtedly continue to be important, but how important? In order to maintain a high level of dynamism, the mining industry needs to overcome the natural challenges it faces: lower ore content by volume, deeper deposits, environmental sustainability, and harmonious and inclusive relationships with the environment and communities. Even more so if we consider that half of our reserves are in the headwaters between Los Vilos and Rancagua, which supply water to the most populated and agriculturally active region in Chile.

We have some outstanding cases, companies that have developed innovative and highly technological development solutions for mi-

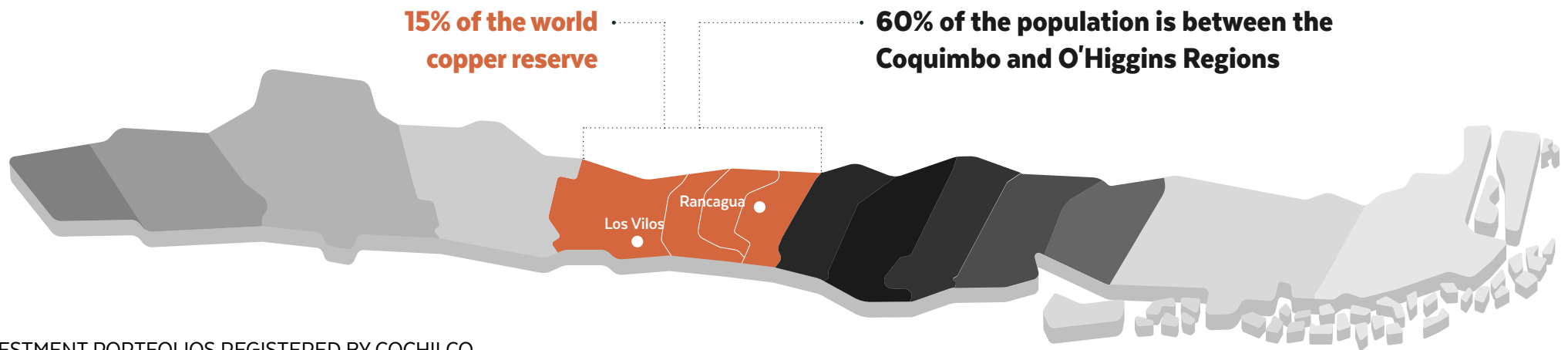
ning, which are now present in other parts of the world. And we could multiply them. In Australia, its mining industry is three times as big as the Chilean industry, technology suppliers in the industry export 20 times more than ours.

We cannot escape the challenge: mining represented 45 percent of Chile's GDP growth between 1990 and 2010, and more than 20 percent of our GDP in the second half of the 2000s; our scale of operations is unparalleled; and water resources sustainability is under threat.

Moving forward and solving technological difficulties adds value in Chile and the world. And we have shown signs of progress. Following the call by the CNID<sup>3</sup>, the Alianza Valor Minero group will be created in 2015, in addition to Corfo's Alta Ley programme. While Alta Ley is focused on coordinating advances in tailings technology, Alianza Valor Minero, a public-private organisation, monitors progress towards the agenda and the setting up of a continuous dialogue system.

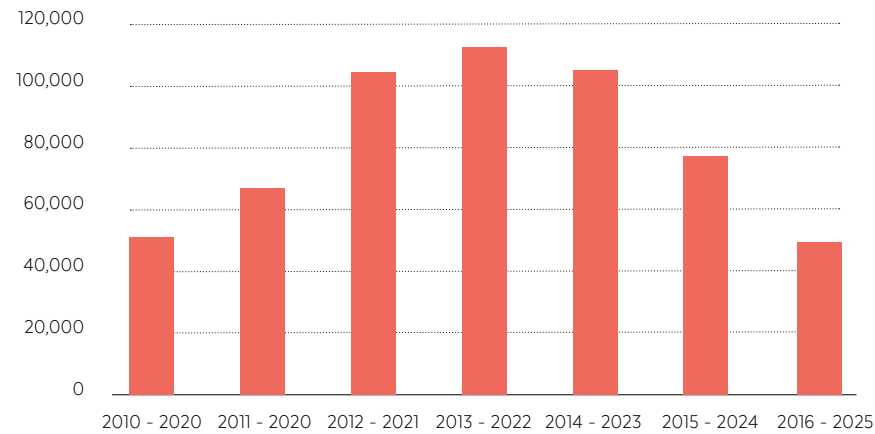
As never before in the history of mining, falling resource revenues and future challenges, mining companies are forced to improve the productivity of their operations through innovation and also make significant changes to certain management practices.

1. Cochilco.
2. Cochilco.
3. The Presidential Advisory Committee on Mining for the Development of Chile and its "Una plataforma de futuro" agenda, in 2014



### INVESTMENT PORTFOLIOS REGISTERED BY COCHILCO

Copper, gold and metallurgical plants, iron and industrial minerals MM US\$ (1996 - 2016)

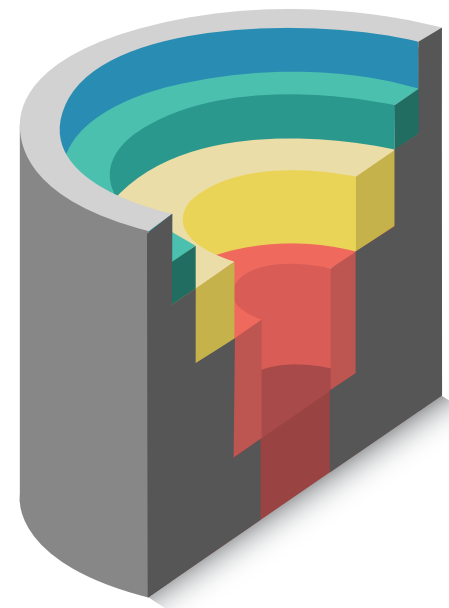


### ORE GRADE REDUCTION<sup>1</sup>

Copper concentration in the soil



In 2016, the investment project Codelco-Andina 244 is withdrawn.



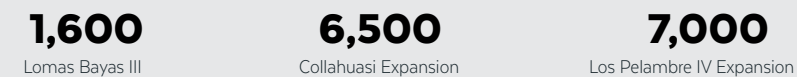
### CHALLENGES THAT CAN AND SHOULD BE ADDRESSED BY MINING

- Size and depth of operations
- Ore grade reduction
- Stricter environmental requirements
- Increasing community empowerment

The depth of the ore forces us to develop engineering and technology for underground operation.

### LARGE COPPER PROJECTS WITHDRAWN FROM THE PORTFOLIO CHILE 2015 (IN MM US\$)<sup>2</sup>

They are undergoing a restructuring process and have no investment or start-up date



In proportional terms, Australian mining technology suppliers export around 20 times more than Chilean suppliers.

## Ensuring availability of water is another challenge that no one else will take up for us

Ensuring the availability of water for the population, for our key productive activities and for the sustainability of our ecosystems, is a priority for sustainable and inclusive development.

Water is a unique, finite and irreplaceable natural resource essential to life. But above all, it is a vulnerable resource. Despite its apparent abundance, only 0.74% of the world's water is fresh.

In a global context, Chile is privileged in terms of water resources. Its total average runoff<sup>5</sup> is worth an average of 53,000 m<sup>3</sup>/person/year<sup>6</sup>, which is considerably higher than the world average of 6,600 m<sup>3</sup>/person/year. However, when the average is broken down by region, it is a completely different situation: arid conditions prevail from Santiago to the north; the average water availability is below 800 m<sup>3</sup>/person/year.

Water scarcity in the northern and central part of Chile, where most of the population lives and where the main economic activities are clustered, is growing. In these areas, most of the surface water has

already been allocated and there are issues associated with overuse of groundwater. At the same time, water availability is also limited by declining water levels in some basins.

However, the south also has problems caused by the increasing intensity and frequency of droughts. In recent years, many of the sources that used to supply water to rural areas have been depleted, so now water is frequently delivered by tankers. In 2016, about US\$80 million was spent on providing freshwater to rural municipalities, delivering 50 litres per person per day (equivalent to a five-minute shower).

The main objective is to ensure the availability of water for the population, but we must consider that our main productive activities have a very high water footprint and that the sustainability of our ecosystems also depends on their water availability. The ecosystem services provided by water are often overlooked, but they are essential to ensure the sustainable development of territories.

“Having basic information and knowledge about our water resources is an essential condition to develop and direct R&D&I efforts, ensuring their excellence and supporting good water management at local, regional and national levels. Therefore, this condition is a priority for our research efforts.”<sup>7</sup>

1. World Bank, 2010.
2. DGA, 2016.
3. Ministry of the Interior.
4. World Bank, 2011.
5. Volume of water from rainfall that runs off in surface and underground watercourses.
6. World Bank, 2010.
7. R&D&I Committee for the Sustainability of Water Resources (2016). “*Ciencia e innovación para los desafíos del agua en Chile*”, CNID, page 25.

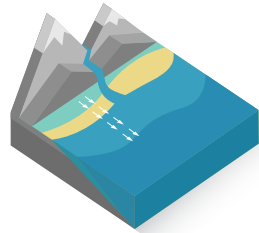
In Chile there is more water per person by year than the world average.<sup>1</sup>

**53,000 m<sup>3</sup>** Chile

**6,600 m<sup>3</sup>** World

But from the Metropolitan Region to the north, we have 800 m<sup>3</sup> per person per year, in contrast to the south, where it exceeds 10,000 m<sup>3</sup>.

River slides: The worldwide uniqueness of Chilean rivers is because of the high slope they reach in short stretches



In Chile, there is a greater variety of basins than the average country in the world.<sup>2</sup>

**101** Chile    **16** Spain  
**8** Australia    **5** Canada

**13 of 15 regions**

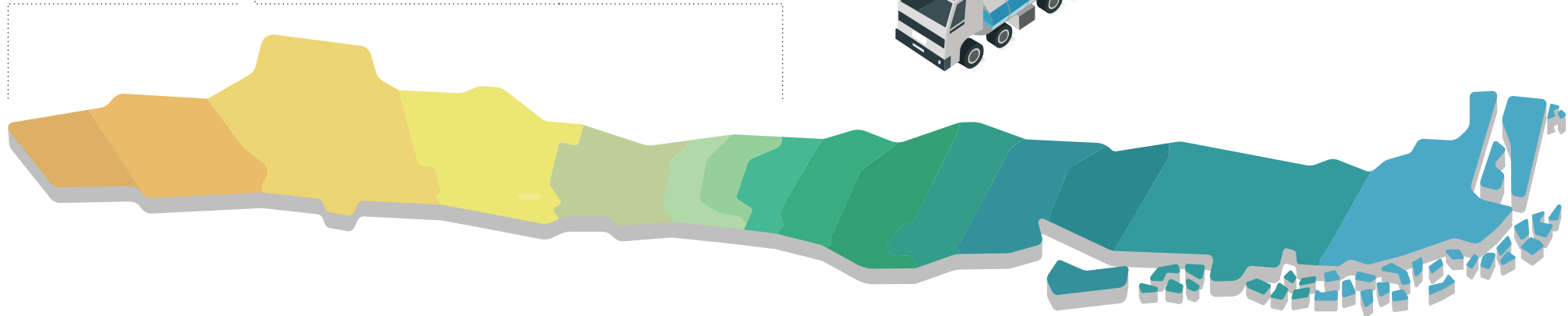
Have communities that don't have water.

**US\$ 80 MM**

Was spent 2016 on tank trucks.<sup>3</sup>



It is estimated that by 2040 we will be in the top 10 to 25 water-stressed countries.



**70%**

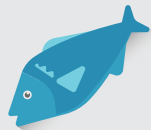
National production structure depends on water.<sup>4</sup>



Mining industry



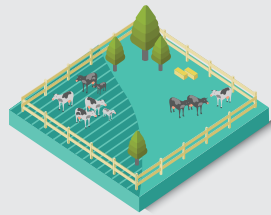
Forestry industry



Fishing industry



Agricultural industry



Livestock industry

#### WATER RESOURCES RESEARCH NETWORK

This network was created under the auspices of the R&D&I Committee For Water Resources Sustainability organized by the CNID, bringing together more than 25 research centres, universities and research groups. It is organized in four macro-areas and will allow the exchange of knowledge, the promotion of joint actions, as well as the improvement of quality and relevance of the efforts.

#### RESOLUTION ADOPTED BY THE UNITED NATIONS GENERAL ASSEMBLY

*"Recognizes that the right to drinking water and sanitation is a human right essential to the full enjoyment of life and all human rights."*

July 28th, 2010



**Margarita D’Etigny Lira, CNID advisor**

Margarita is an agricultural engineer from Universidad de Chile, and a founding partner and director of IdeaConsultora. She was executive director of the Foundation for Agricultural Innovation (FIA) and, for example, she has been a member of the PDIT Steering Committee of the Ministry of Economy, the Advisory Council of CONICYT, the Steering Committee of FONDEF and the Steering Council of INNOVA.



## Sustainable water resources management: an urgent and collective task

By Margarita D'Etigny Lira



The concern about the sustainability of water resources today reaches a global dimension from which we are not absent. The sustainability of water is under threat, a systematic decline in water supply and a sustained and inorganic increase in demand.

The sustainable management of water resources has become an extremely important and urgent issue for Chile, as water is vital to human survival, to maintain the balance in our ecosystems and to support our productive base. For this reason, we need a long-term systemic viewpoint, with policies that ensure environmentally sustainable, economically efficient and socially harmonious development. Making progress in sustainable management requires the integration of multiple and diverse factors, where the need to have solid scientific information on our hydrological systems and ecosystems, to use available technological advances, to have representative organisations to carry out comprehensive management, as well as to attain the community's commitment and understanding of the importance of protecting our water resources.

In 2015, the CNID started designing an R&D&I agenda to support water sustainability, calling on multiple actors (from public-private sectors and connected to STI) to join a committee that worked rigo-

rously and participatively for more than a year and directly involved more than 300 people.

In 2016, the CNID submitted to the President of the Republic the "Science and Innovation for Water Challenges" Agenda, and it set up the support mechanisms required to implement, monitor and update the agenda. In this area, it is important to point out that the Water Resources Research Network, consisting of 25 research centres, universities and researchers, has put national scientific capabilities to collaboratively work on the priorities set out in the Agenda; the Committee on Strategic Water Research Orientations, led by the DGA and it consists of public R&D&I institutions, and is counterparty to the Network; and the active maintenance of the R&D&I Committee for the Sustainability of Water Resources to regularly update the Agenda.

We are convinced that these coordination initiatives are essential to implement the proposal, because it is only through collaborative work and coordinated efforts, that we will be able to decisively move forward and protect this vital resource. Through coordinated efforts, we will be able to protect this vital resource.

## III. PLATFORM TO LEVERAGE TECHNOLOGICAL ADVANCES TO IMPROVE OUR WELL-BEING AND INCLUSION

## Adapting technologies developed by others can lead to major improvements

Technological adaptation brings significant benefits, but it requires its own abilities to understand and adapt it to our local conditions.

Not all challenges necessarily require original technological advances. We are citizens of the world and, in many cases, we can make important improvements to our well-being and inclusion, adapting technologies developed by others in the world to our specific characteristics.

For example, the case of power supply stability solutions. The FDA's White Oak Laboratory<sup>1</sup> located in Maryland, USA, given the nature of its activities requires an uninterrupted power supply. Therefore, it not only relies on its own emergency system, which is normal for this type of service, but it also has a hybrid energy supply system: one part is provided by a local microgrid with a parallel supply from the city's central system.

Thus, between 2010 and 2013 alone, this lab has entered "island mode" (when it is 100 percent offline from the central system) more than 70 times, avoiding blackouts caused by earthquakes, storms and hurricanes, such as "Sandy".

This development was adapted for a different purpose in Chile; in the northern town of Huatacondo it became our first smart microgrid

based on non-conventional renewable energies. From having access to electricity ten hours per day and under high intermittent conditions, today it has an unrestricted power supply 24 hours per day, achieving a penetration of about 75% of its energy consumption is based on renewable sources, thanks to these technologies.

Technological adaptation can lead to major benefits, but technologies sometimes need to be adjusted to use them in new situations. Therefore, an R&D base is always required to understand and adapt technologies. In the case of Huatacondo, it was the Energy Centre at the Faculty of Physical and Mathematical Sciences of Universidad de Chile.

Furthermore, we should bear in mind that most of the time the challenges to successfully implement existing technological solutions, are more in organisational or cultural aspects, or in the barriers set up to protect vested interests. For this reason, in the case of the Huatacondo, a key element of the project was that we worked with the local community from the very beginning, and today its own inhabitants do the microgrid maintenance work.

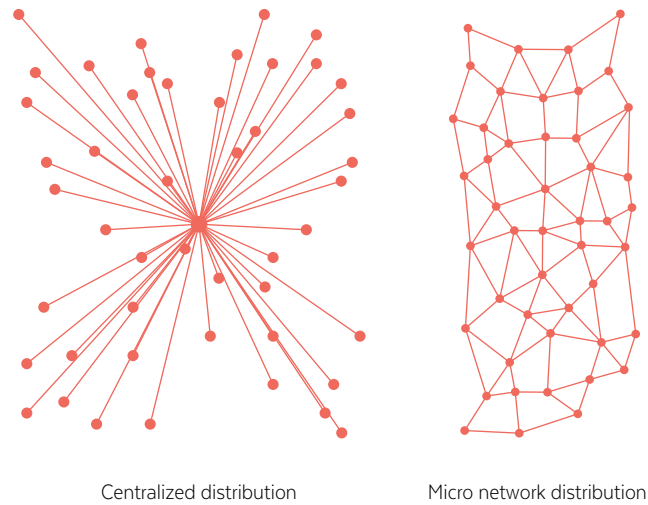
Source Diagram: Author's own work.

1. U.S. Food and Drug Administration



## MICROGRIDS

Microgrids are small electrical distribution systems, based on various renewable sources of energy generation, which can operate autonomously and/or be complemented by centralized distribution systems.



## RESILIENCE - FDA CASE

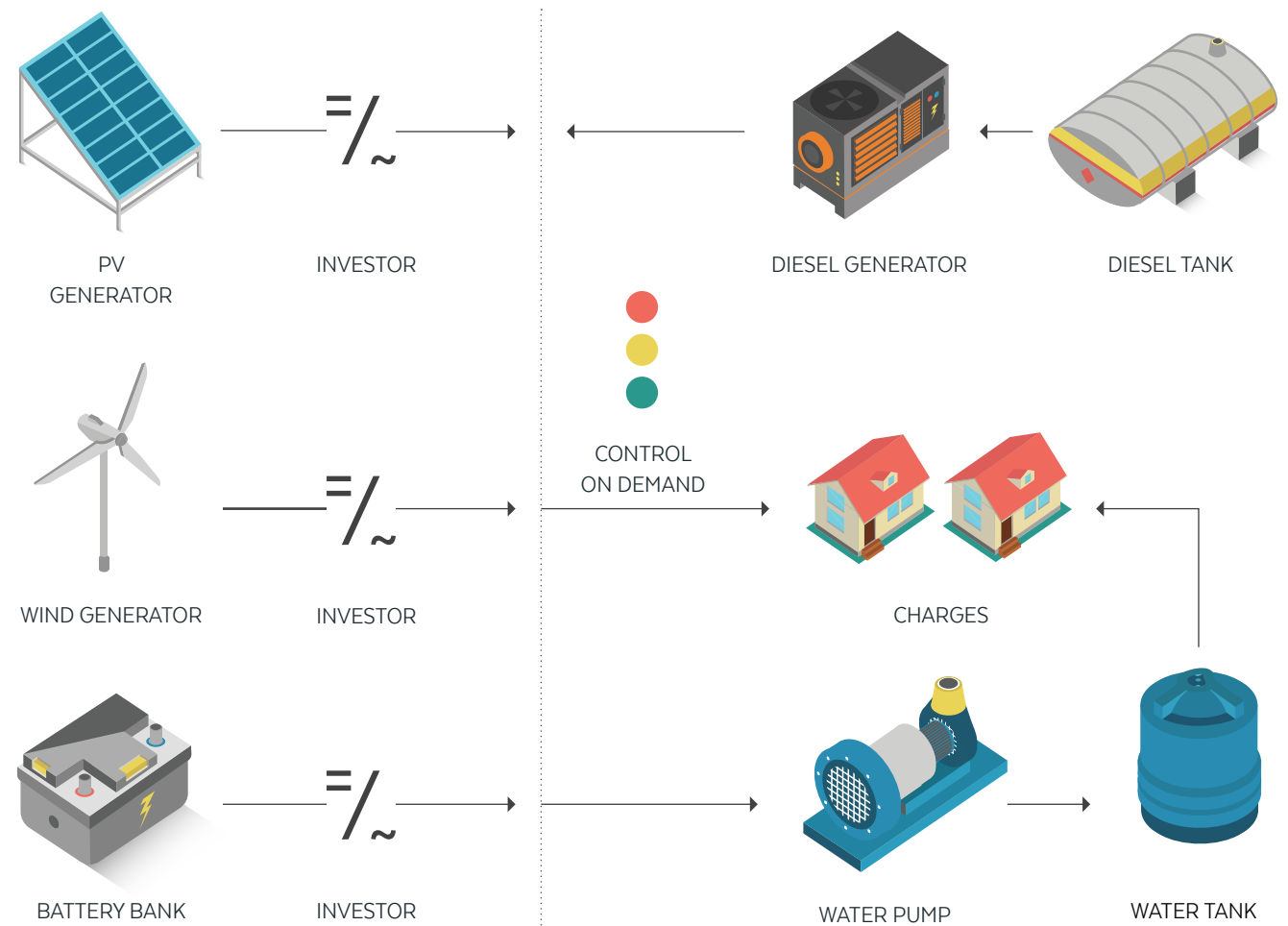
Due to the nature of its investigations, the FDA requires an uninterrupted power supply. That is why White Oak has a hybrid system in its laboratory: a local microgrid connected to the city's macrogrid.



## ADAPTATION FOR TERRITORIALLY ISOLATED COMMUNITIES

**Huatacondo, located 240 kilometres south of Iquique, has the first intelligent micro-network based on NCRE in Chile.**

It went from having access to 10 hours a day of oil-based electricity, at unrestricted consumption, achieving a penetration of about 75% of energy from renewable resources.



## Construction and health, two sectors where technological adaptation would allow us to take a giant leap

Adaptation not only incorporates technological development, but it is also a new way of addressing social concerns that challenge practices, regulations, protocols and bureaucracies.

Technological adaptation can benefit public policies in sensitive sectors such as construction and health.

Building Information Modelling (BIM) is a process for creating and managing data during the life cycle of a building, it is a technological development that originated in the aerospace industry, migrated to manufacturing and then to construction. The United Kingdom was the first country to use public procurement to encourage the use of these systems to optimise the efficiency and quality of construction projects.

Between 2013 and 2014, the UK saved 12-20% on the cost of public building projects. After this experience and since 2016, all UK public sector projects are required to use BIM.

In Chile, the use of this modelling tool is growing and specific applications have already been developed for different construction projects, such as healthcare facilities and the new Santiago airport. In addition, a Corfo programme with the Ministry of Public Works, the Ministry of Housing and Urban Development and the Chilean Chamber of Construction, has replicated the English experience and is helping to install these capabilities in local bidders so that future government tenders can be conducted with this system. An additional benefit of BIM implementation is that it speeds up the permit process time and facilitates work inspections.

Furthermore, telemedicine systems allow medical data to be distributed via electronic systems, so that the time between tests and results, or between the specialist's examination and diagnosis, is reduced. In many cases, face-to-face contact is no longer necessary, reducing functional isolation, allowing for complementary medical services and opinions, as well as facilitating educational and chronic patient management programmes.

Telemedicine is not only a technological development, it is also a new way of approaching healthcare; it challenges practices, provisions, protocols and bureaucracies.

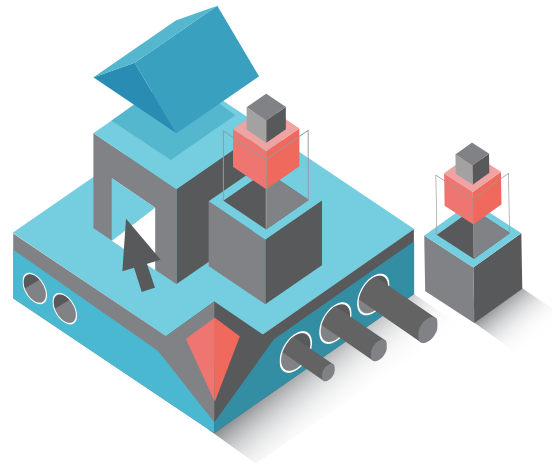
In Chile, Las Higueras de Talcahuano hospital is a pioneer in this field: it managed to reduce neurology waiting lists by 20% between March and December 2015, with nearly 25,000 telemedicine transactions, including tele-appointments, examinations and telecare in different specialties: cardiology, child psychiatry, nephrology and neurology, all in the same year.

In 2016, the programme was expanded to primary and secondary care patients in the Arauco and Ñuble-Healthcare Services. This specialty healthcare does not require patient transfer, and only the patients who really need treatment, go to the hospital.

Both examples show the enormous progress that can be made in sensitive sectors such as the construction and health sectors, thanks to careful technological adaptations.

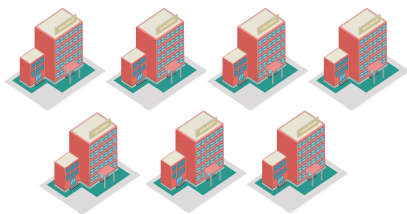
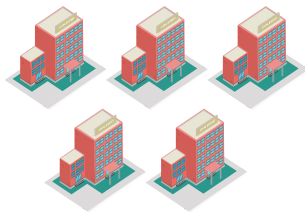
1. HM Government, Construction 2025, (2013).
2. The Whole System Demonstrator (WSD), a programme that began in 2008 in the United Kingdom to identify the scope of telehealth and telecare, by controlling more than 6,000 patients with chronic diseases in three different geographical contexts.
3. <http://web.minsal.cl/disminucion-de-listas-de-espera-logra-programa-de-telemedicina-del-hospital-las-higueras/>
4. From English version *Building Information Modelling*.

# SECTORS THAT HAVE BENEFITED FROM TECHNOLOGIES AND PLATFORMS



## BIM

UNITED KINGDOM



Allows the construction of 7 schools for the value of 5<sup>1</sup>

CHILE

### Construction 2025 Programme

It is a national strategy that aims to transform construction in Chile, to improve the productivity of the construction industry throughout its value chain and generate a cultural change around the value of sustainability, considering the impact of the life cycle of the property and welfare of the people.



## TELEMEDICINE

UNITED KINGDOM

Telemedicine has reduced the mortality rate of chronic patients by up to 45%<sup>2</sup>

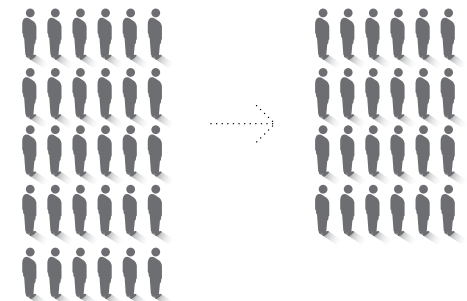
During 2015, the Telemedicine Programme at Las Higueras Hospital in Talcahuano municipality, managed to reduce the number of patient waiting time by 20% in the Neurology specialty, from 3,000 to 2,400, between March and December.

Patricia Sánchez, Deputy Director of the Higueras Hospital, highlighted the decongestion of the system by over-consultation in the hospital.

“We are solving health problems in the patient’s place of origin and with that we filter that at our level only the patient who requires it”.<sup>3</sup>

CHILE

### Las Higueras Hospital in Talcahuano



**3,085**  
March 2015

**2,400**  
December 2015

**-20%**  
Patient waiting time

## IV. IMPROVING OUR COMPREHENSION SKILLS TO FACE THE NEW SCENARIOS

## Integrate and take advantage of the impacts of scientific and technological progress on society

Create knowledge and have the skills to use this knowledge are key aspects to strengthen our ability to understand, adapt and anticipate in new scenarios.

A series of new phenomena are challenging our certainties and normal lifestyle in the world, and creating unprecedented ethical dilemmas. History is full of these moments, however, what is typical of this era is the dizzying pace of the changes that are rapidly spreading as a result of the communications revolution.

The structure and size of cities changed radically a hundred years ago after the telephone and car were invented. Physical and psychological distances shrank, basically broadening the definition of living “close by” and reducing the uncertainty of travelling for hours to ask about a product or service that might not be available.

Today it is not clear whether the alleged algorithms objectivity on which many of our decisions are based, such as what we post, bank offers and even the likelihood of criminal recidivism, is actually true. It is information prioritised and provided to us by a small group of people; however, we are not aware of this process<sup>4</sup>.

Similarly, the arrival of autonomous cars confronts us with a case that challenges our understanding. Cars can in fact bring major

benefits. But they also affect city structures, labour dynamics, regulations, and even modify the logic of civil and criminal liability in the event of an accident.

Creating knowledge and having the skills to use this knowledge are key aspects in strengthening our ability to understand, adapt and anticipate the opportunities and difficulties that arise. Developing and maintaining these skills is particularly critical in the public sector, since the State must lead the discussion on how to adjust regulations and institutions to the new realities. It is also the space with more responsibility in terms of managing the consequences of change, including arbitration between losing and winning sectors.

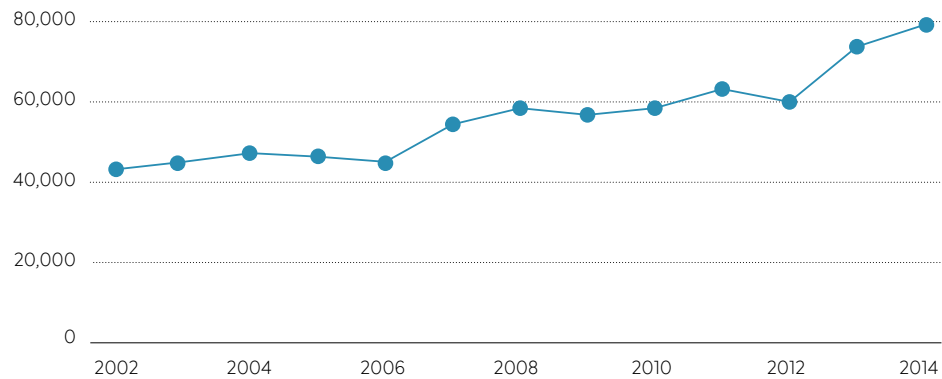
Fruitful reflection and dialogue are possible if citizens have the ability to process the information and knowledge available, and if we learn to discriminate the importance of what is read or heard. Today, all positions can find an Internet site that “backs” them (with more or less validity), therefore, we have the opportunity to move forward with conversations that allow us to think and build together, instead of defend and claim positions.

1. Accident data observatory. Ministry of Transport and Telecommunications.
2. Unit of Studies of the Automobile Club of Chile.
3. <http://uk.businessinsider.com/mercedes-benz-self-driving-cars-programmed-save-driver-2016-10>
4. <https://www.propublica.org/article/how-we-analyzed-the-compass-recidivism-algorithm>

## INTEGRATION OF AUTONOMOUS CARS AND THEIR POTENTIAL BENEFITS.

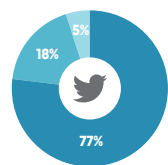
1. Faciliate the mobility of people with physical disabilities.
2. Give greater autonomy to dependent persons in matters of displacement.
3. Reduce traffic accidents, especially due to lack of attention to traffic conditions.

CAR ACCIDENTS 2002 - 2014, CHILE<sup>1</sup>

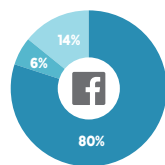


FREQUENCY OF ACTIVITY WHEN DRIVING, CHILE<sup>2</sup>

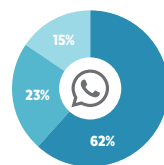
● Always / frequently    ● Sometimes    ● Never / almost never



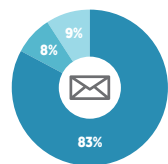
Twitter



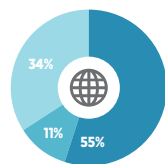
Facebook



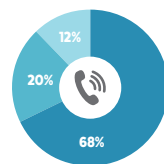
WhatsApp



Email



Internet



Calls

The emergence of autonomous cars, at the same time, challenges our capacities of understanding and anticipation abilities

### NORMAL DRIVER'S DILEMMA

You are driving your car at about 100 km/h on an intercity highway, when you pass a ten- year-old boy running after his ball.

Would you maneuver to avoid running over the child even if it meant risking a high- speed rollover?

### WHAT IF THE VEHICLE WAS A SELF-DRIVING CAR?<sup>3</sup>

A prestigious brand declared that its self-driving cars will have an algorithm that will prioritize the driver's safety above any other circumstance.

Should a company be able to make such decisions a priori?

Are you willing to let an algorithm make the decision to run over the child?



## V. OPTIONS TO TAKE ADVANTAGE OF OUR SPECIFIC CHARACTERISTICS

## Many countries have taken advantage of their distinctive characteristics as an opportunity for development

What could be viewed as an unfavourable condition, the Dutch were able to transform into an important area of development.

There are many cases of countries that have taken advantage of their distinctive natural characteristics to turn them into an opportunity for development and to create a powerful identity in the world. A clear example is the Netherlands.

Two-thirds of the Netherlands is below sea level. Tackling this situation by creating reliable and efficient solutions has been a challenge that has continually tested the ingenuity of its population. They have successfully overcome it throughout their history, otherwise they would not have prospered.

In order to keep the sea and two large rivers that run through its territory at bay, the Netherlands had to develop first-class engineering, particularly hydraulic engineering. From very early on, its universities have excelled at training of specialists in this field and the government has invested heavily on creating different water management institutes and research centres.

Today, the Netherlands is the world leader in water management. For example, after Hurricane Katrina, the United States asked Dutch com-

panies and professionals for assistance to create a system to prevent future disasters, as they are the world experts in this field.

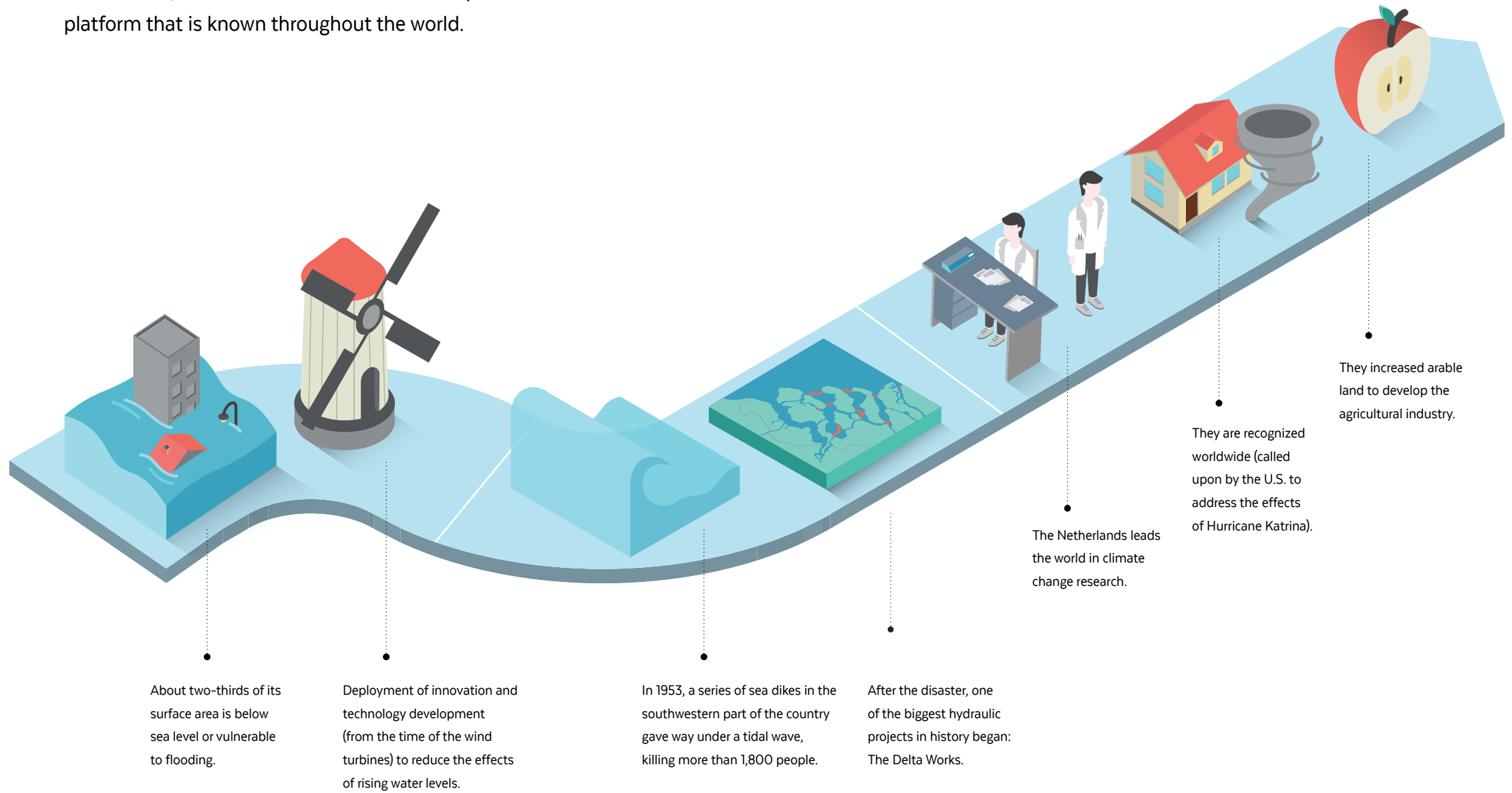
What could be considered an unfavourable condition became a major field of development over time. Today, the Dutch are making inroads and create knowledge and state-of-the-art technologies in practically all areas related to this subject matter. This includes, for example, hydraulic engineering, water treatment and management (99.9% of the population has access to chlorine-free drinking water), to water pumping, transport and recycling. As a result, they have more than 1,500 technology companies in this sector, that export more than 7 billion euros per year.

This activity is supported by a large ecosystem, with nearly fifty universities, technology development centres, technology demonstration and testing spaces, incubators, and a vibrant business community. The government has defined it as a strategic development area and, as such, it is an area of strong public-private collaboration.

However, the Netherlands, aware of its fragile geographical situation, also conducts research about the future and it is already a leader in research on the effects of climate change on the sea.

Source: Author's own work.

The Netherlands, as a result of its endless battle with the sea, has been able to create a development platform that is known throughout the world.



~~~~~

We have an opportunity in the knowledge and experience we have accumulated from natural disasters

~~~~~

By just being in Chile, we have access to a natural laboratory where we can develop solutions and applications practically impossible anywhere else.

Except for major storms, such as hurricanes and monsoons, we regularly experience large natural events such as earthquakes, tsunamis, volcanic eruptions, landslides, droughts, tidal waves, floods and forest fires. These events are on the rise and urban growth increases the number of people exposed to their effects.

Thus, a scenario takes shape where resilience emerges as a fundamental dimension for the future of Chile and the world. We cannot prevent natural disasters, nor eliminate their, sometimes, dramatic consequences. But we can learn to live with them and mitigate their impact, while at the same time create a value offer for the world<sup>1</sup>.

In Chile, these events have a major impact. Although there have been few fatalities compared to other countries, for the victims, the process of restarting is a great social burden and –if we look at it in economic terms– an important financial burden for the country. In the 2010 earthquake alone, the government spent US\$ 30 billion. Between 1980 and 2011, different disasters are

estimated to have cost an annual average of 1.2 percent of GDP, the highest in the world.

While the funds invested in prevention have a very high return: in the case of earthquakes the estimated return is 140%, while in the case of floods, it is 510%.

The natural disaster prevention and response processes help us save lives, recover jobs, services, infrastructure, daily life and create opportunities to develop goods and services in multiple dimensions. The events affect all of society, for example, causing production losses, deepening social vulnerability and disrupt connectivity. Therefore, technologies that help to improve response to their consequences may cross a wide spectrum of possibilities for Chile and the world.

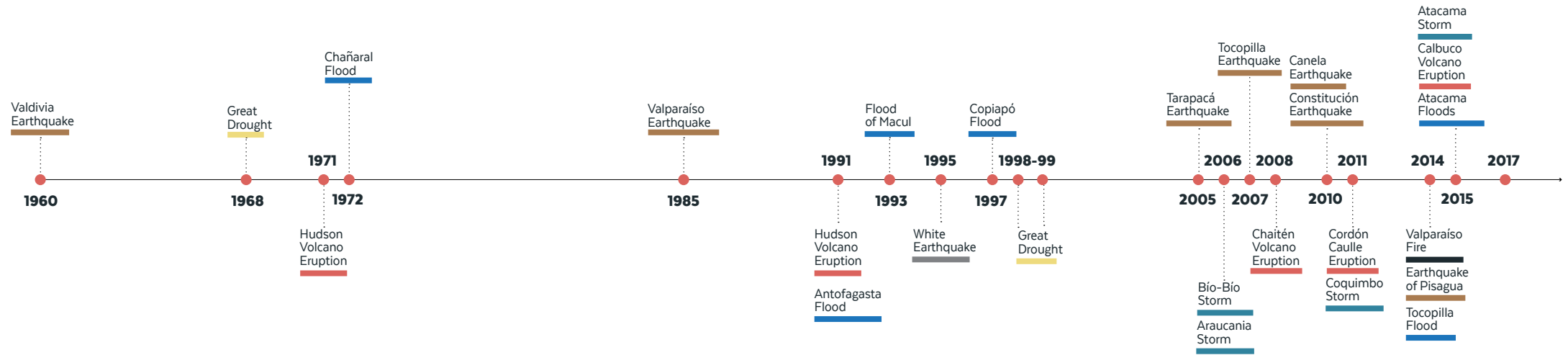
By just being in this territory, we have access to a laboratory where we can create solutions and applications, from social disciplines to engineering, that would be practically impossible to carry out anywhere else. Anti-seismic engineering, social technologies for resilience, infrastructure monitoring systems, basic services and communication assurance are some examples of these possibilities.

Source Diagram: R&D&I Committee on Resilience to Natural Disasters (2016). “*Hacia un Chile Resiliente frente a Desastres: una Oportunidad*”, CNID, Santiago, Chile.

1. Committee on R&D&I for Natural Disasters, 2016. “*Hacia un Chile Resiliente frente a Desastres: una Oportunidad*”. CNID, Santiago, Chile.



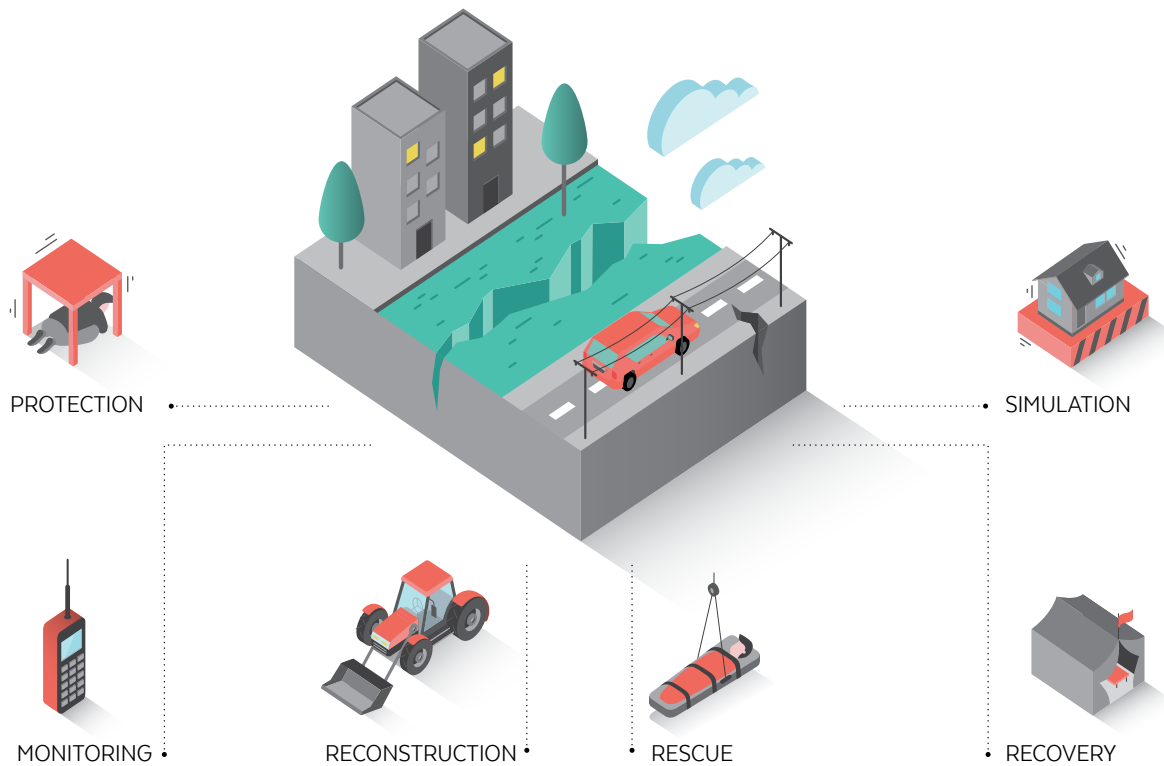
SOME OF THE MAIN NATURAL DISASTERS IN CHILE  
IN THE LAST 60 YEARS



“Deploying an R&D&I strategy for resilience to natural disasters in the territory is a moral imperative that, at the same time, brings with it a great opportunity for the development of our society”.

Source: Resilience to Natural Disasters R&D&i Commission (2016). “Hacia un Chile Resiliente frente a Desastres: una Oportunidad”, CNID, Santiago, Chile.

POTENTIAL R&D&I AREAS AROUND RESILIENCE TO NATURAL DISASTERS





**Juan Carlos De La Llera, CNID Advisor**

Juan Carlos is a Civil Engineer from Universidad de Chile and he has a PhD in, structural dynamics modelling, and vibration reduction systems from the University of California, Berkeley, USA. He is Dean of the Faculty of Engineering at Universidad Católica and founder of SIRVE, a company that designs, produces and implements devices that protect structures from damage caused by earthquakes.



## A country that stands up to care for its people and the world

By Juan Carlos De La Llera



My academic and professional life has been linked to Chile's most devastating natural disasters, earthquakes. For decades I have researched, followed and participated in the developments that aim to improve our ability to deal with these events. I believe that the most effective solutions do not only involve new knowledge in hard science and engineering, but also a more comprehensive understanding of the physical and social environment.

The same event triggers and spreads differently over an environment with different levels of physical and social vulnerability. For this reason, the concept of risk always implies, on the one hand, the composition between a natural hazard and, on the other, the exposure and vulnerability of all the systems present in the affected geographical area.

Building and urban development regulations have evolved a lot over the last fifty years. However, the fact that the majority of those killed by the tsunami in 2010 were foreign tourists on the coast shows the importance of having a comprehensive approach to disasters. We, who live in this territory, are constantly changing the way we live in it. And so, a natural event that before was an anecdote, today can cause a tragedy.

Chile, almost without realising it, has become a world leader in earthquake resilience. The opportunity today is to apply this capacity to other types of natural hazards and disasters. Disaster prevention, response and recovery technologies, as well as how we organise and respond at a community and institutional level, have tremendous potential to create innovation and value for the world.

We are a true natural laboratory that calls to develop cross-cutting capabilities needed in a wide range of situations. Phenomena that are alien to our reality, such as hurricanes and monsoons and even terrorist attacks, can be confronted by using technologies and institutional arrangements conceived and designed in Chile.

Presiding over the committee to develop an R&D&I agenda on natural disasters (called CREDEN), under the auspices CNID, has given me great satisfaction in my professional life, as I have coordinated more than one hundred very talented and diverse people around the dream of its leitmotif: "A resilient Chile is a Chile that loves its land and its people" (CREDEN 2016).

## Magellan Natural Laboratory: participating in world conversations, anchored in this territory

By opening spaces for our STI, attracting scientists from around the world and engaging in interdisciplinary dialogue, this region can address some of the fundamental questions facing the planet today.

A natural laboratory is a unique location on a global scale, that can cover a territory or a geographical or geophysical landmark, and, as such, it can provide comparative advantages for research, in the broad sense of the word.

Why is the Magallanes region a unique territory and why does it have a great potential? There is a long list of reasons. First, Patagonia is the only mainland on the planet located south of the 50th parallel, it has the world's purest waters and it is home to an enormous biodiversity of lichens and mosses. All these characteristics make it a unique environmental reserve, in addition to being the closest gateway to Antarctica.

The region's scientific attraction has drawn increasing attention from the international research community. Thus, every year more than a hundred foreign scientists come to work in the region, and the number is growing.

The Magallanes Regional Government, together with several other actors, including the CNID, has embarked on a strategy that could turn the entire region into a large Natural Laboratory, making Punta Arenas the capital of Antarctica. Other initiatives, include the construction of an Antarctic research centre in Punta Arenas and a laboratory in Puerto Williams which will have facilities for researchers to stay for longer periods of time.

The objective is to establish a science and technology development hub based on the natural resources and special characteristics of this territory. By opening spaces for STI development in Chile, attracting hundreds of scientists from all over the world and interdisciplinary dialogue, this Chilean region can help to tackle some of the key issues facing our planet today. For example, a key issue for our countries is the effect of global change on the southern hemisphere, where there is very little research; however, it is also important because it complements research on its impact on the northern hemisphere.

"(...) Therefore, developing a territorial innovation system focused on the sub-Antarctic natural laboratory in the Magallanes Region represents a unique opportunity to improve our society's knowledge about some of the major global challenges we face today, and to promote a sustainable development model for the territory."<sup>1</sup>

Source: CNID and the Regional Government of Magallanes and Chilean Antarctica

1. Technopolis Group and Cameron Partners. "Región Subantártica: impulsora de Desarrollo e innovación". CNID. 2015. Page 3.

SOME REASONS WHY WE HAVE IN THE SUBANTARCTIC ZONE  
A GREAT NATURAL LABORATORY UNIQUE IN THE WORLD



From the 50° parallel to the south there is no other land surface on the planet. It is a privileged place to understand global change, particularly climatic change.

Antarctica

Magallanes Region



Construction of the International Antarctic Centre



More than 14,000 m<sup>2</sup> with laboratories, aquariums and educational spaces



International Scientific Dissemination Cruise Organization (2017)

**58.7%**

of its territory are protected areas



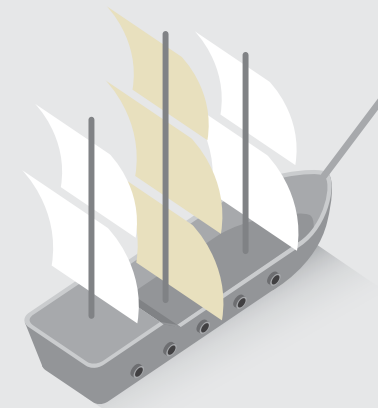
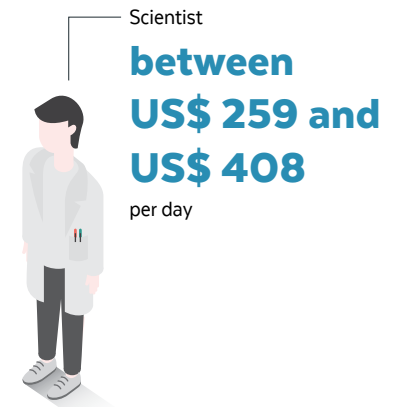
University of North Texas certifies that the region has the purest waters in the world.

**More than 800**

types of mosses, lichens and liverworts

The Regional Government of the Magallanes Region, together with various actors, is working to carry out a strategy that can turn the whole area into a great natural laboratory and to Punta Arenas in the capital of Antarctica.

HOW MUCH DOES IT LEAVES IN ITS WAKE FOR MAGALLANES?



*“The voyage on the Beagle was by far the most important event of my life and determined my entire career.”*

Charles Darwin



**Álvaro Fischer Abeliuk, CNID Director**

Álvaro is a Mathematical Engineer from Universidad de Chile, a founding partner of the Resiter companies and chairman of the Science and Evolution Foundation. He was chairman of the Institute of Engineers and Fundación Chile and he is a member of the New York Academy of Sciences and of the Human Behaviour and Evolution Society.



## Unique natural laboratories

By Álvaro Fischer Abeliuk



Chile is home to two unique Natural Laboratories at both ends of its territory, capable of attracting world-class science to drive national development and that of all mankind.

In the far north are the world's best skies for astronomy. From the beginning of the next decade, this region will concentrate two thirds of the world's capacity to collect astronomical data. In addition, the Atacama Desert has the best capacity on Earth to generate solar energy, the adaptations of organisms able to survive the extreme environmental conditions provide valuable scientific information.

In the far south, the Sub-Antarctic Region is home to the world's southernmost forests, most of the planet's lichens, mosses and liverworts, a rich marine life, plus a complex variety of marine and land ecosystems attract world-class science. This region is also the gateway to Antarctica, a continent where mankind is conducting a bold social experiment; 14 million km<sup>2</sup> are dedicated to scientific research and the land is not officially owned by any country.

Due to its excellent geographical location, Punta Arenas is naturally called to become the scientific capital of this experiment.

Chile and the Magallanes Region are taking steps in this direction. And there are two important scientific research centres connected to the rest of the world (the Cabo de Hornos Sub-Antarctic Centre and the Centre of Excellence in Biomedicine). Furthermore, the fibre optic cable between Puerto Montt and Puerto Williams, the future construction of the Antarctic Centre, an iconic building on the shores of the Strait of Magellan that will mark Punta Arenas' vocation for the white continent, and the Cabo de Hornos Sub-Antarctic Centre in Puerto Williams, are just a sample of Chile's commitment to this idea.

Additionally, if we consider that both extremes have already become world-class tourist attractions (such as San Pedro de Atacama and the Torres del Paine National Park), Chile has opportunities in multiple dimensions: its two extreme Natural Laboratories only depend on the political decision of its authorities.

## VI. CONDITIONS TO DEPLOY PEOPLE'S CREATIVITY

## The knowledge created by STI can be appropriated and multiplied by people and citizens

Making digital infrastructure available and moving towards the appropriation of science and technology will enable us to connect to and add the creativity of the many, to face challenges and take advantage of opportunities of our time.

We know that innovation does not always respond to a linear sequential model of research-development-innovation. Neither is knowledge creation and technological development an exclusive area for those who are dedicated to R&D&I.

There are many examples to show what has been accumulated in these worlds, it is appropriated and multiplied, and it is the basis for deploying people's creative skills, even in extreme situations.

This is what happened at the Fukushima Daiichi nuclear power plant in Japan after the earthquake in March 2011, where members of the Tokyo Hackerspace met to design and develop projects to help the affected areas. As a result of this process, the Kimono Lantern Kit, a rechargeable solar lamp, was the first free, designed, built and mass-produced hardware.

Soon after, authorities gave the order not to publish the radiation levels recorded by the Japan Meteorological Society, which caused widespread panic and global concern. Faced with this situation, Tokyo Hackerspace members in collaboration with foreign experts built the first DIY radiation detector<sup>1</sup>, to provide alternative monitoring data to official sources. This monitoring is decentralised and the data is collected by the users themselves.

Through community workshops (citizens and farmers), instructions were shared to assemble a series of electronic components into a functional tool. Thus, a public, open-access citizen database was built using radiation data.

Making digital infrastructure available, as well as moving towards the appropriation of science and technology can help us connect, overcoming the geographical distances of our territory, and add the creativity of the many, to face challenges and take advantage of opportunities of our time.

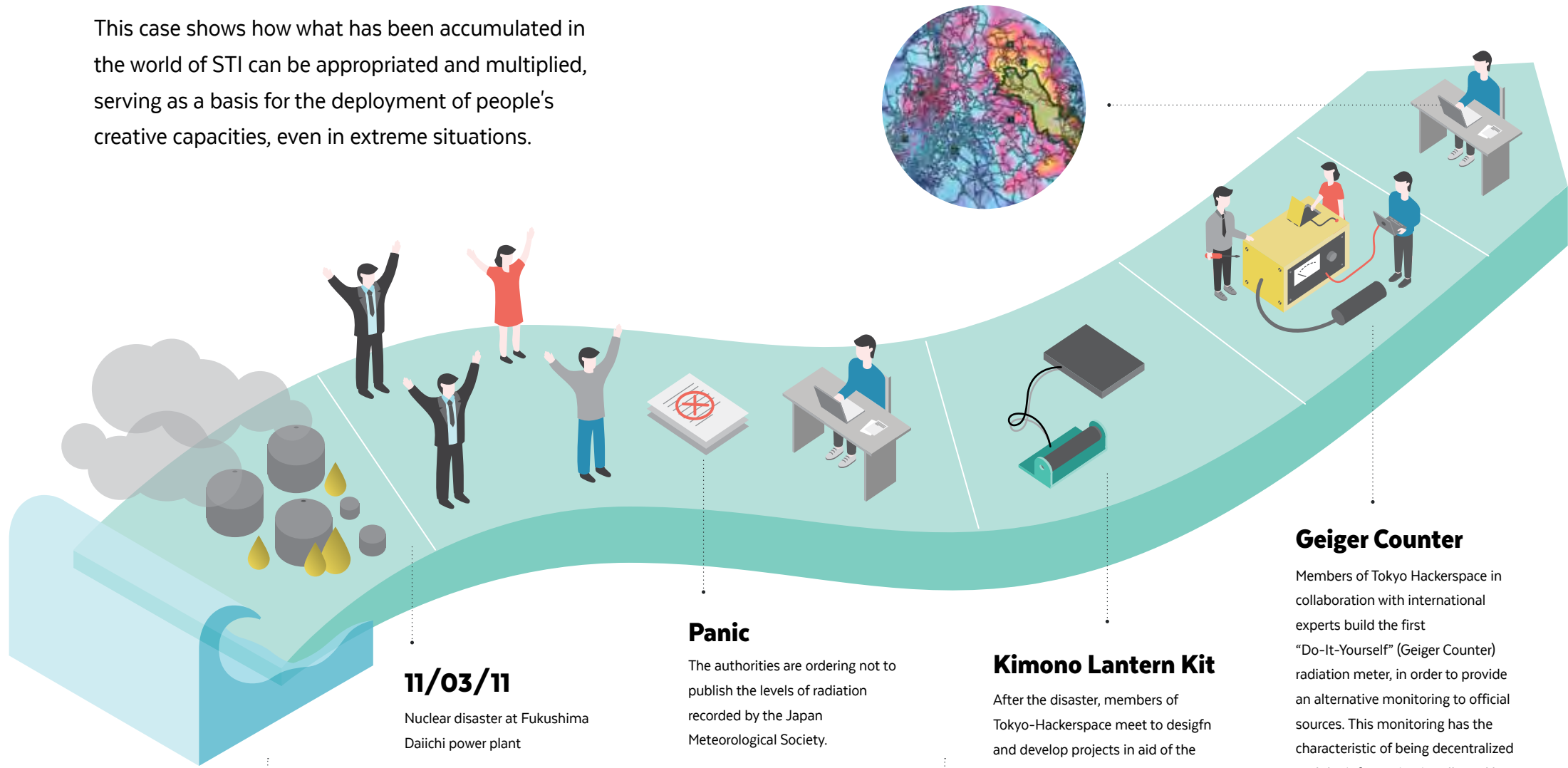
Source: Author's own work.

1. Geiger counter.



## CITIZEN EMPOWERMENT FROM STI, AFTER THE EARTHQUAKE AND NUCLEAR EMERGENCY IN JAPAN IN 2011

This case shows how what has been accumulated in the world of STI can be appropriated and multiplied, serving as a basis for the deployment of people's creative capacities, even in extreme situations.



**11/03/11**

Nuclear disaster at Fukushima Daiichi power plant

### Panic

The authorities are ordering not to publish the levels of radiation recorded by the Japan Meteorological Society.

### Kimono Lantern Kit

After the disaster, members of Tokyo-Hackerspace meet to design and develop projects in aid of the affected areas. Kimono Lantern Kit, a solar rechargeable lamp, was the first free hardware designed, built and mass-produced.

### Geiger Counter

Members of Tokyo Hackerspace in collaboration with international experts build the first "Do-It-Yourself" (Geiger Counter) radiation meter, in order to provide an alternative monitoring to official sources. This monitoring has the characteristic of being decentralized and the information is collected by the same users.

### Citizen Empowerment

After partnering with the Safecast organization, a citizen science movement based on crowdsourcing and free (hardcore) hardware began..

*"The comments caused the financial markets to sink and hit Japan's economy as it struggled to cope with a devastating earthquake."*

The Telegraph

*"There is talk of an apocalypse and I think the word is particularly well chosen. Practically everything is out of control. I cannot leave out the worst in the hours and days to come."*

Gunther Oettinger

*"The basic principle behind anti-disaster measures is to allow people to act on reliable unified information... if the forecasts were announced, there would be a risk that ordinary people would panic."*

Hiroshi Nino

## VI. CONDITIONS TO DEPLOY PEOPLE'S CREATIVITY

## Social innovation has earned its space

These spaces combine entrepreneurship and creativity with technological opportunities at the service of social and environmental concerns.

The opportunities created by innovation and entrepreneurship, especially by the younger generation, have led to new solutions to tackle social and environmental problems. This has created the so-called social innovation ecosystem; it provides a path for young people from different socioeconomic backgrounds to find spaces to unleash their creativity and commitment, contributing to solve Chile's problems.

The term social innovation was coined around 2006 to identify the spaces where actors combine their entrepreneurial and creative skills with their social and environmental concerns and the public and private technological and budgeting opportunities available to them.

Today, we have had different experiences heading in this direction. Since 2015, Corfo has been creating specific innovation and social entrepreneurship support schemes; however, contributions by government agencies linked to this area are still less than 0.4% of the total budget, similar to the percentage observed in the private sector.

This Council is convinced that Social Innovation and its various expressions offer multiple possibilities to complement the State's pu-

blic policies on development challenges. For this reason, in an alliance based on what today is called the fivefold helix<sup>5</sup>, a programme has been designed with Corfo, based on innovative methodologies, to propose a series of initiatives in response to a complex issue felt by our citizens: persistent poverty in several regions of Chile, due to different causes and manifestations in multiple development dimensions.

To this end, we will dedicate one year to promote the inclusion of actors and build alliances, creating governance, ensuring participation and political adaptability. The goal is to learn from this experience, creating a series of technical backgrounds to ensure efficient, effective and innovative management, as well as a monitoring, assessment and shared institutional learning system to complement the programme implementation.

Therefore, we can move forward by identifying environmental conditions that help develop locations stuck in a poverty trap, where not even public policies, economic activity or social organisations have been able improve their conditions.

1. [www.antofoemprende.cl](http://www.antofoemprende.cl)
2. [www.lachimbaantofagasta.cl/web/](http://www.lachimbaantofagasta.cl/web/)
3. <http://www.iadb.org/es/temas/competitividad-tecnologia-e-innovacion/innovation-lab-un-mundo-de-soluciones,1370.html>
4. [www.fiis.org](http://www.fiis.org)
5. Public and private sectors, the scientific and academic world, civil society and the world of entrepreneurship.

UNITED KINGDOM

**£ 24,000,000,000**

The UK has generated an estimated £24 billion social enterprise industry, making it a world leader, in a 15-year process of joint support between the state, the private sector and civil society.

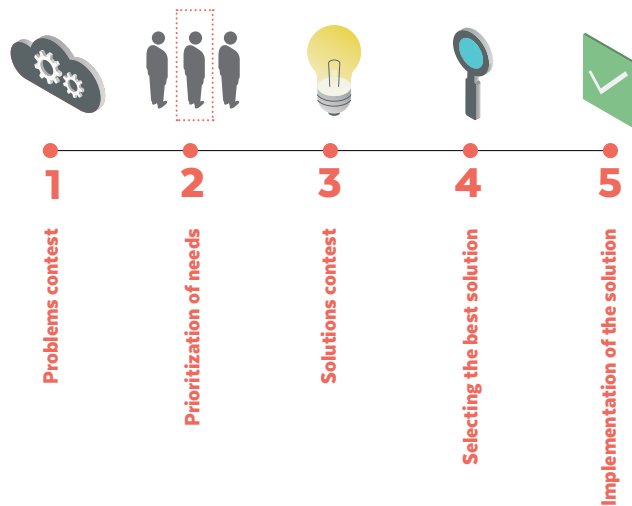
INTER-AMERICAN DEVELOPMENT BANK

**All-terrain wheelchair**

MIT has developed a wheelchair that allows the user to move easily on unpaved terrain. The wheelchair is built with high technology and has the advantage of being very low cost. The IDB's financing is aimed at implementing its production in Guatemala.

**Contest A World of Solutions**

Innovations for people with disabilities, to foster inclusion in the educational system and the labour market through the development of new technologies.<sup>3</sup>



CHILE

**From 2015, Corfo creates specific support mechanisms for innovation and social entrepreneurship**



**Antofaemprende**

Contest promoted by CREO Antofagasta and Fundación Minera Escondida with the objective of "raising solutions that improve the quality of life in Antofagasta and the municipalities of the Region, with an integral vision and the active participation of all the sectors involved: public, private and civil society."<sup>1</sup>

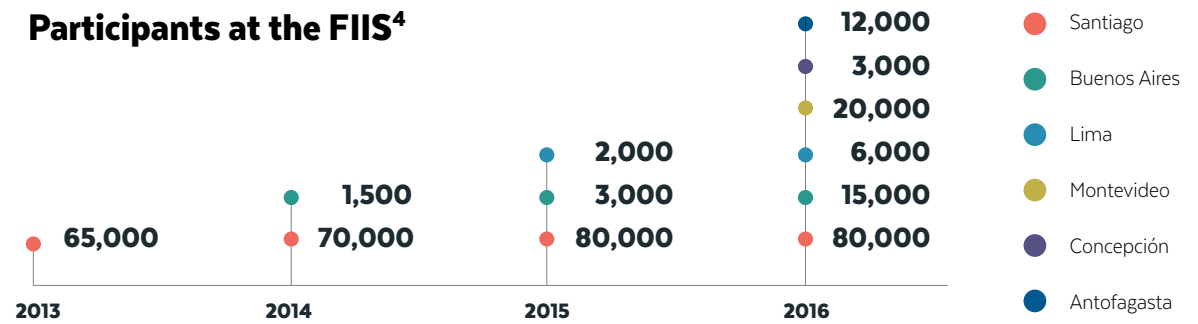
**The Kitchen as an Agent of Social Change<sup>2</sup>**

"La Chimba, cuisine with senses, is a venture that enhances Antofagasta's identity from the perspective of gastronomy. For this we function as a work table, where all those who are part of the food chain participate with the objective of promoting the production of the local offer."

Pablo Godoy



**Participants at the FIIS<sup>4</sup>**





**Rodrigo Jordán Fuchs, CNID Advisor**

Rodrigo is a Civil Engineer from Universidad Católica de Chile, and he has PhD in Economics from the University of Oxford. He is a mountaineer and a founding partner of Vertical S.A. and Vice President of the National Foundation for the Overcoming of Poverty. Previously, he was Director of the TV Corporation of Universidad Católica.



## STI can help to even the playing field faster, more effectively and, above all, with more dignity

By Rodrigo Jordán Fuchs



The invitation was irresistible. Very little could be more urgent than to reflect on the future of our country. Thinking about politics, the economy, society, or the role of the State is very important, but the invitation to join the National Innovation Council for Development involved reanalysing all these dimensions, from a common and uncommon perspective, to rethink our country's development.

I say common and uncommon because the intention was to use what had already been developed and learned, and from there think about what is new. And here is what makes it attractive. The invitation included innovation related to science and technology, but also as a question and willpower to find new ways of interaction, reaching agreements, designing and implementing public policies. How can science, technology and innovation help build a more supportive, fairer, more inclusive and more welcoming society?

Countries that have improved their Gini coefficient not only have worked on their Research and Development and Innovation (R&D&I) capabilities, but it is also where R&DI have been appropriated by the most vulnerable citizens. I believe it is imperative to continue on this path to create facilitating conditions towards a more inclusive deve-

lopment. Certain technologies have had this facilitating dimension. A good example is mobile telephony.

Therefore, the State's digital agenda must tend towards facilitation platforms to help level the playing field. We must get to work and get our hands on the cables. This does, however, require a strategy to set significant and challenging goals for Chile. Even if they seem unachievable. Who said we cannot create a state-of-the-art digital broadband network with easy access for everyone?

The most important thing: whatever the goal of the digital agenda, and to ensure it really is innovation for development, it is essential to look at the process and not just the result.

From the beginning the process must involve the people who will use and benefit from the technology. Their dignity is undermined when they are not included in the development agendas. One of the most profound inequalities in Chile is unequal treatment. Today, it is imperative that we are all included in development and we must look for new ways to ensure this occurs. This upholds dignity.

## New dynamics of science-based entrepreneurship are being developed and installed

In the search for flexible and interdisciplinary spaces, many young scientists are building their own paths to create their contribution to Chile.

The complexity and speed of the 21st century requires the confluence of various disciplines to understand it better, and thus develop capacities to adapt, anticipate and transform.

In this context, interdisciplinary work and the challenges of transdisciplinary research often require spaces to exercise their potential. The characteristics that make these spaces ideal vary based on the nature of the disciplines that they bring together, but what these spaces have in common is that they provide tools and equipment for in situ deployment of capabilities and locations where different views and ideas can be discussed.

In this logic, everyday solutions emerge from outside the norm in search of a space sufficiently agile and flexible to be able to respond to contemporary challenges.

This is the case of a group of university graduates from different scientific courses who want to develop functional products based on their research. Not having a scientific publication in mind, they

faced several obstacles within their own university, which forced them to look for (and design) a new space. This is how the Santiago LabSpace was founded.

The first challenge was to find funding to purchase the specialised equipment required to develop their products. The next challenge became an opportunity when they realised, they were not alone.

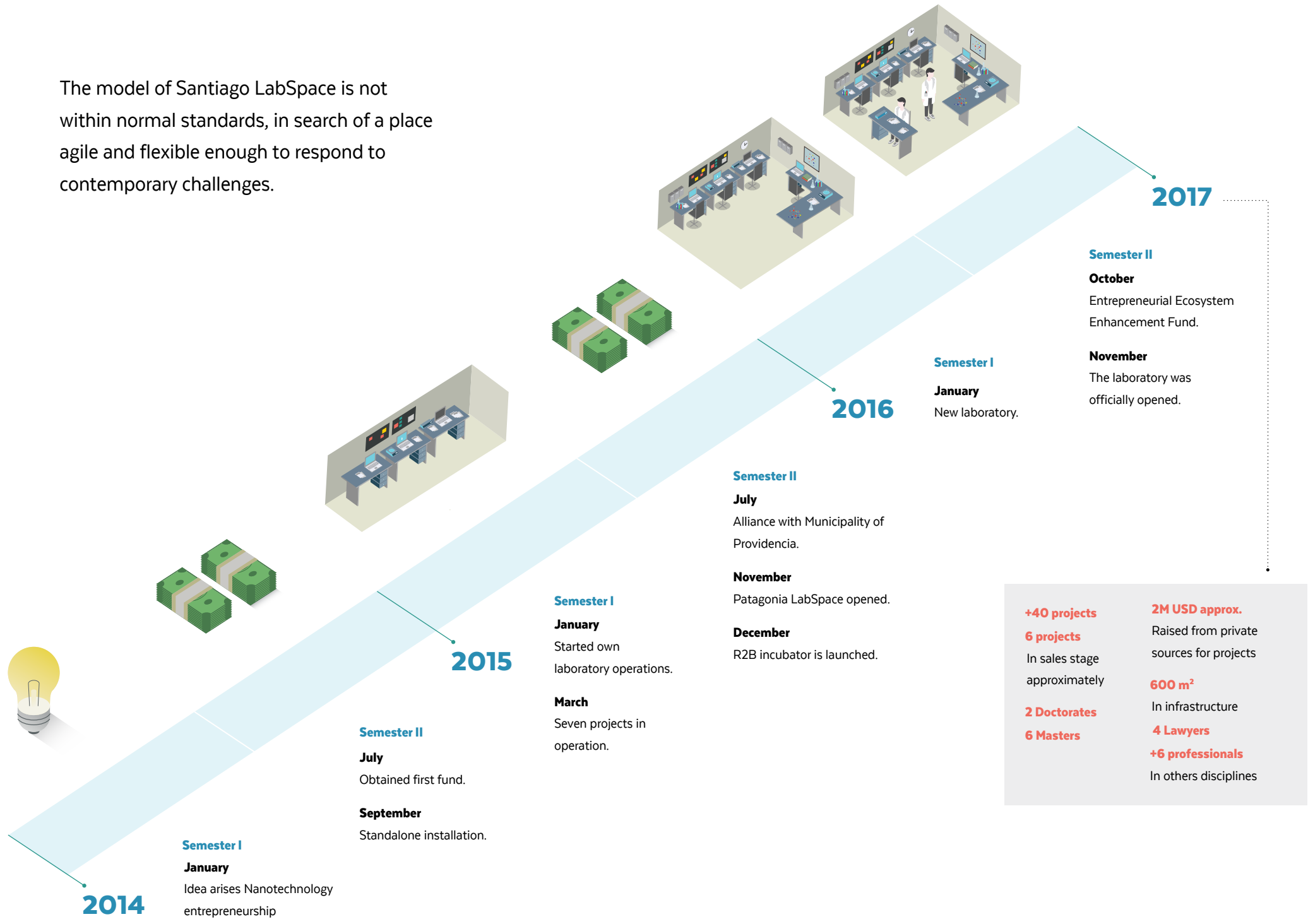
Thus, began the project that today has laboratories in different parts of Chile, alliances with international institutions and that, based on their experience, provides specialised services to support the development of scientific and technological products and their effective positioning in the market.

Today, its facilities provide spaces with equipment and tools where the different disciplines can experiment and prototype; it is also a place where the different teams and projects can share ideas and dialogue.

This is one of many notable cases; it demonstrates how a growing number of young scientists want to build their own research path and contribute to society, in the spaces they build, in addition to traditional places.

Source: Author's own work based on Stgo LabSpace data.

The model of Santiago LabSpace is not within normal standards, in search of a place agile and flexible enough to respond to contemporary challenges.



**2014**

**Semester I**  
**January**  
 Idea arises Nanotechnology entrepreneurship

**2015**

**Semester II**  
**July**  
 Obtained first fund.  
**September**  
 Standalone installation.

**Semester I**  
**January**  
 Started own laboratory operations.  
**March**  
 Seven projects in operation.

**2016**

**Semester II**  
**July**  
 Alliance with Municipality of Providencia.  
**November**  
 Patagonia LabSpace opened.  
**December**  
 R2B incubator is launched.

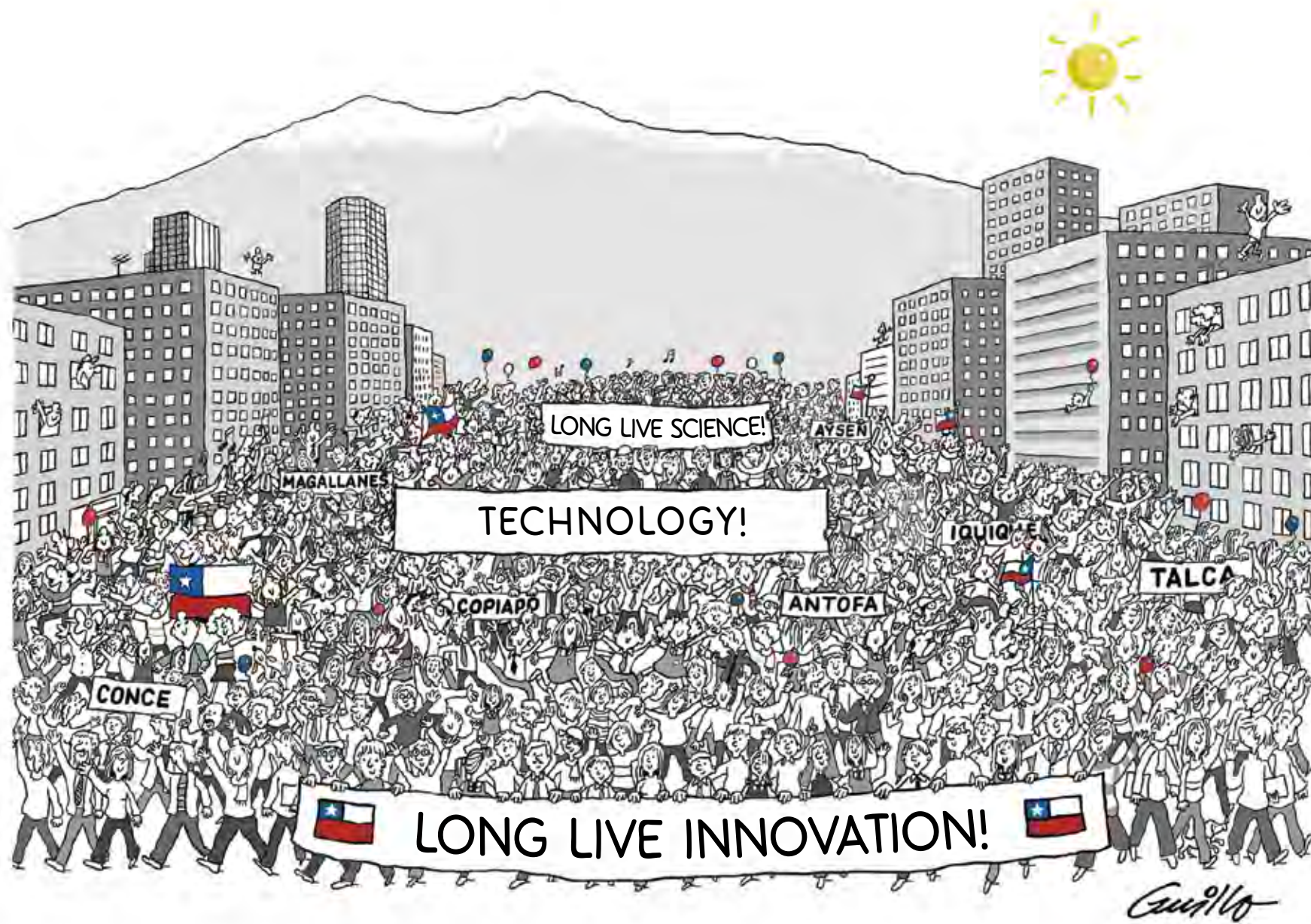
**Semester I**  
**January**  
 New laboratory.

**2017**

**Semester II**  
**October**  
 Entrepreneurial Ecosystem Enhancement Fund.  
**November**  
 The laboratory was officially opened.

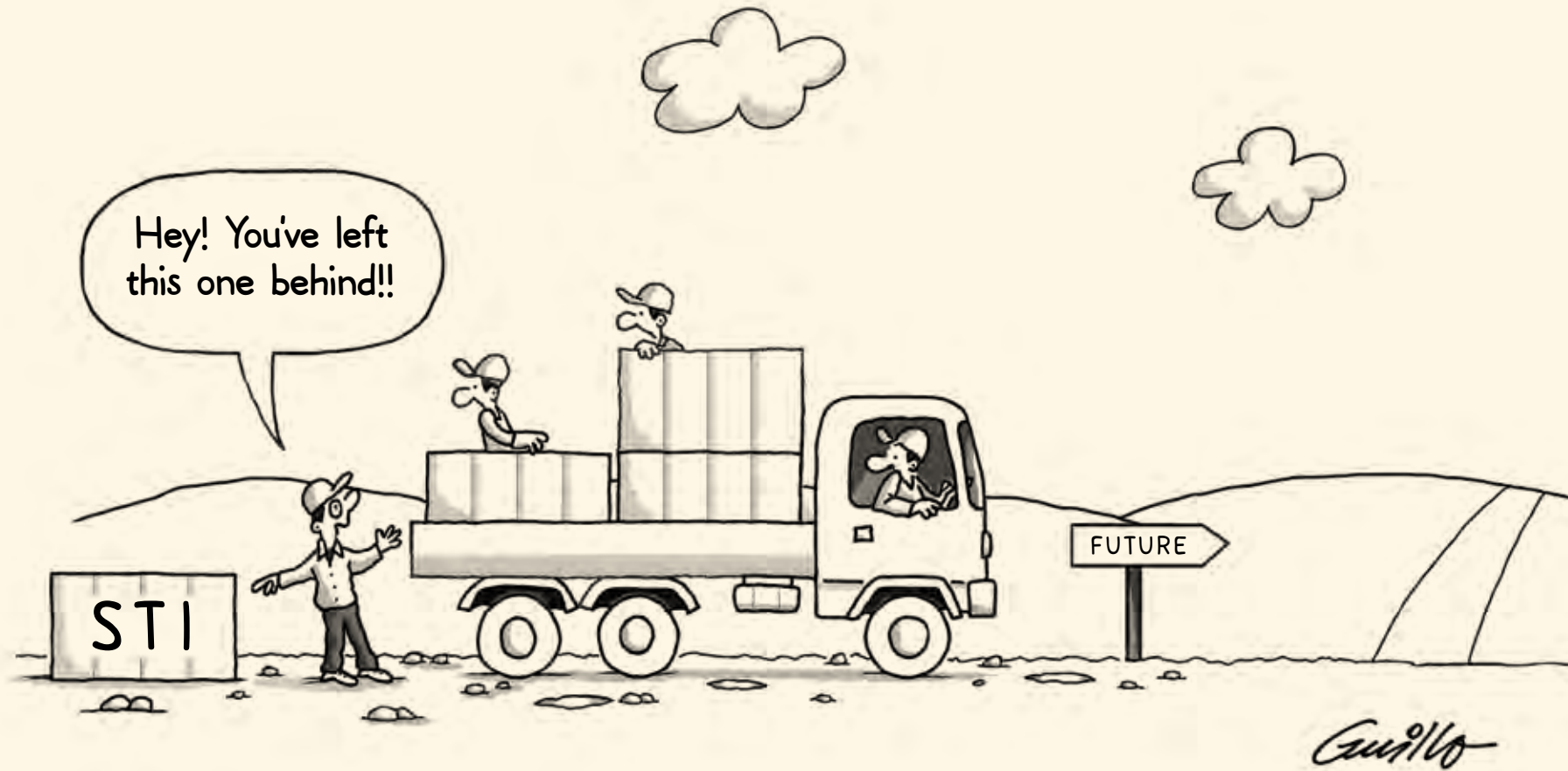
|                                                   |                                                  |
|---------------------------------------------------|--------------------------------------------------|
| <b>+40 projects</b>                               | <b>2M USD approx.</b>                            |
| <b>6 projects</b><br>In sales stage approximately | Raised from private sources for projects         |
| <b>2 Doctorates</b>                               | <b>600 m<sup>2</sup></b><br>In infrastructure    |
| <b>6 Masters</b>                                  | <b>4 Lawyers</b>                                 |
|                                                   | <b>+6 professionals</b><br>In others disciplines |











## CHAPTER 3



## Our science, technology and innovation in the last decade: we have done so much with so little, but we need so much more



### **Presentation**

Today, we can develop more R&D&I capabilities, in an ecosystem that encourages fruitful connections.

We want to make progress guided by our dreams and aspirations, but starting from what we are and what we have done, acknowledging the Chile we have. The last ten years can be viewed as a period of learning, where new creation spaces and dynamics have emerged, and new collaboration frameworks between different actors have been established. However, given the scale of the challenges we are facing, we need to take longer steps and make more decisive commitments.

It is well-known fact that although we do not do much science, we do quality science. A new characteristic in this period is that collaboration between disciplines, connection between research and problems, and opportunities in our society are increasing. Therefore, the work conducted by universities and collaborative research centres has been significant.

The expansion of the entrepreneurial spirit and the deployment of new spaces to develop creativity, illustrated by the rise of coworking spaces and the growth of innovation and social entrepreneurship, is probably the most attractive characteristic of our innovation system in recent years. However, this effervescence has not had a significant impact and it certainly has not spread to our companies, which continue to innovate very little. Moreover, the little innovation reported is more directed at business models than technological development, which means that technological innovation is still pending in Chile, both for established and emerging companies.

In the case of smaller companies, the biggest weakness is adopting and using available technologies. This is undoubtedly the main path to improvement for these

companies and yet it is scarcely used. For example, they hardly use the opportunities provided by information and communication technologies.

Most of these shortcomings arise from an essential component we tend to disregard: the connection between the different actors. Far from being obvious or automatic, the creation of collaborative relationships is an arduous task that must be explicitly considered a policy goal. Dedicated agents with specific skill sets are required to perform this task to produce fruitful relationships and to have spaces where people from different backgrounds can meet.

For many years, this area was neglected, but recently this situation has started to change thanks to initiatives, such as Engineering 2030, research centres that incorporate technology creation and transfer into their daily work, or open creation and design spaces. Today we can fill in the major gaps that continue to exist in the role of connection, particularly in terms of having more agencies whose function is to promote technology adoption in smaller companies. We must continue to move forward in this direction.

## I. TODAY WE CAN GIVE A MUCH MORE DECISIVE BOOST TO OUR STI

## Our innovation ecosystem is beginning to take shape

The country has been progressively interacting and, in different ways, with science, technology and innovation, strengthening an ecosystem joined by more and more actors.

Since the beginning of the new century, Chile has been deploying various initiatives to strengthen and improve our STI efforts. Both public and private actors have been active, and enthusiastic, drivers of several actions. Undoubtedly today, both the number of initiatives underway and the interest of people and institutions is significantly higher than just a decade ago. The media coverage of these issues is a clear sign of this. Practically all publications include a section on science, innovation or entrepreneurship. But we should mention how technology has reached households in recent years. Smart phones, renewable energy, health breakthroughs, have all done their part in raising awareness.

However, we still have a long way to go in this field. Announcements have not been accompanied by actions on a scale similar to the sense of urgency that often permeates words. We can be proud, for example, of the increase in patent applications by residents; however, we do acknowledge that there are major gaps compared to OECD countries and that other countries in the region are moving faster than we are.

In order to analyse the evolution of our STI activity, we have chosen to approach it from a systemic perspective that focuses on the evolution of knowledge and innovation demands, the capabilities available to meet these demands, as well as the interaction process between them.

### Advances in Industrial Property

Advances in trade and technology have made industrial property (IP) an increasingly relevant issue in the development strategies of a country. In recent years, Chile has had significant achievements in this field:

- 2014: INAPI begins operating as one of the twenty PCT<sup>3</sup> international search authorities.
- 2015: Pablo Valenzuela awarded WIPO gold medal for inventors.
- 2017: Alexis Kalergis awarded WIPO gold medal for inventors.
- 2017: INAPI is chosen as one of the world's ten most innovative industrial property offices, according to the World Trademark Magazine.

1. Innovation Division (2016); Best Colleges.com study "Highest Research & Development Funding" (2016).
2. MINECON (2009); OECD (2016); RICYT (2016); CONICYT (2016).
3. Patent Cooperation Treaty (PCT)

R&D EXPENDITURE AS % OF GDP

0.22%

2005

0.39%

2015

In **2016**, our spending on science, technology, innovation and entrepreneurship was equivalent to half that of Johns Hopkins University in the USA.<sup>1</sup>

Note: R&D expenditure executed by the establishments: corresponds to R&D carried out within the establishment and financed both by the actual company and by the government, international funds or other sources, in accordance with the definitions of the OECD in the Frascati Manual (2015).

NUMBER OF RESEARCHERS (FTE\*)<sup>2</sup>



\*Full-Time Equivalent

2004

The Innovation Club was founded

2007

Avonni Awards created

2009

First Innovation section appears in communication media

2010

First Port of Ideas

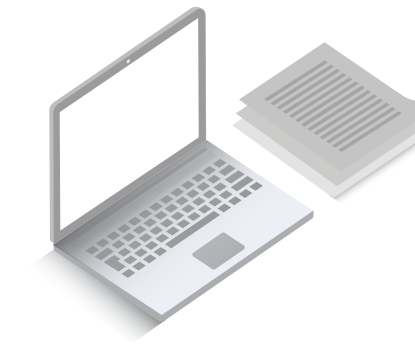
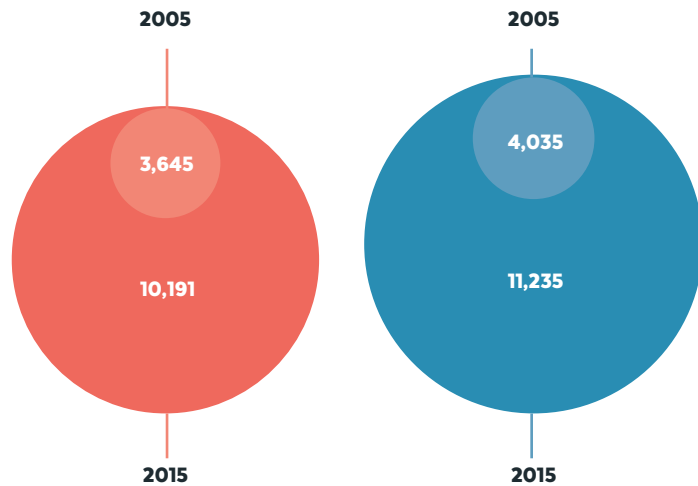
2010

Association of Entrepreneurs (ASECH) was founded  
B Corporation arrives to Chile

2013

First International Festival of Social Innovation (IFIS)

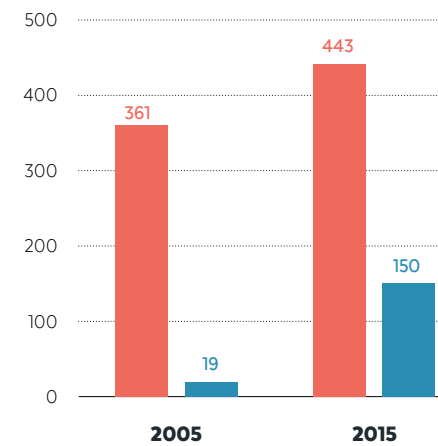
PUBLICATIONS<sup>2</sup>



● WOS  
● SCOPUS

WOS: corresponds to the scientific productivity indexed in Web of Science (WOS)  
SCOPUS: corresponds to the scientific productivity indexed in SCOPUS

PATENTS



Between 2004 and 2014, Chileans have registered 710 patents in USA, 252 in Canada and 222 in Australia.

## We have made great efforts to train people

In a world of rapid technological change, a challenge for our educational system is not only to produce and master technologies, but also to understand their ethical dilemmas and implications for our coexistence.

Undoubtedly, one of the most fundamental changes Chile has experienced is the enormous expansion of higher education, both technical and university education. In fact, Chile today has a much higher graduation rate than other OECD countries had when they had our current GDP per capita.

Although a lot of consideration is given to the increasing number of university graduates, the fact is that since 2010, enrolment in first-year technical education<sup>4</sup> has exceeded university enrolment. This fact alone should be an incentive to focus on this education area, because it is very important for innovation and productivity skills.

At a university level, social sciences courses have led this expansion; however, the number of qualified engineers and technologists has dropped from 25% in the early 1990s to 20% today<sup>5</sup>.

It is not clear whether this evolution has been influenced by the

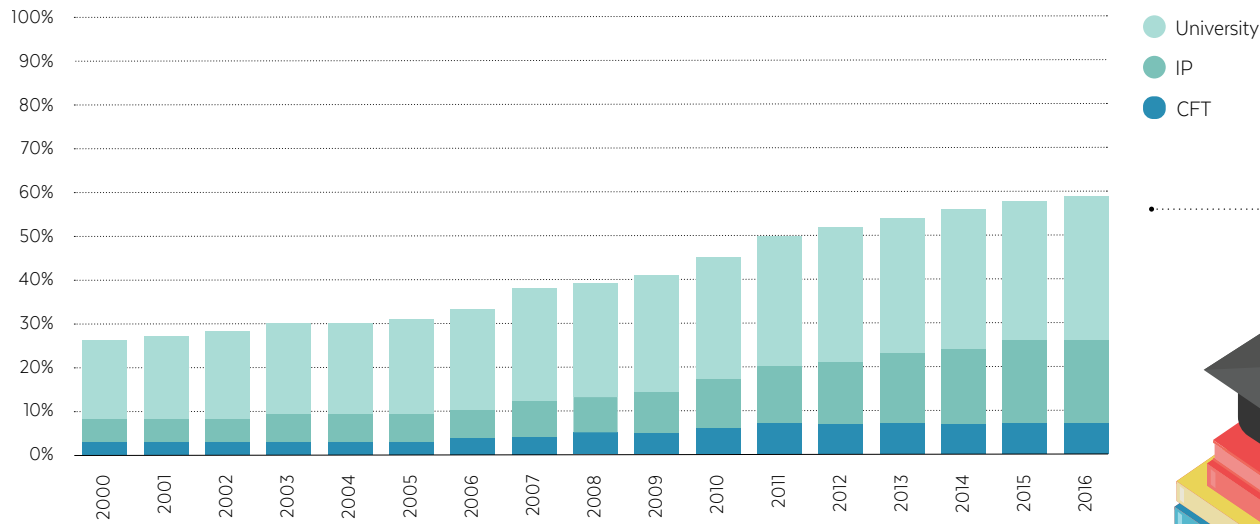
students' motivations or by the university courses offered. However, an important fact is that engineering and technology education is essential to achieve higher levels of innovation.

However, this does not detract from the social sciences or humanities. On the contrary. First, they should not be underestimated as a result of an inorganic expansion of the jobs and vacancies on offer. And second, today more importance is given to developing soft skills and comprehensive training as key aspects of successful professional performance.

Rather than a clash between traditional ways of dividing training and education, the path should point towards putting more effort into integrating different disciplines into the process. After all, as international assessment results show, one of our main weaknesses continues to be reading comprehension skills. And in a world of rapid technological change, being able to produce and master technologies is as important as being able to understand the ethical dilemmas and the coexistence implications involved. We should not view them as separate tasks.

1. Author's own work based on SIES and INE data.
2. SIES, Mineduc.
3. Author's own work based on OECD data.
4. Professional Institutes and Technical Training Centres.
5. See [www.ricyt.org](http://www.ricyt.org)

## EVOLUTION OF GROSS UNDERGRADUATE COVERAGE BY GENERAL TYPE OF INSTITUTION (2000 - 2016)<sup>1</sup>



• Most higher education graduates in the period 2007- 2014 are in social sciences, business education and law, with 28.3% (373,994 professionals).<sup>2</sup>



## PIAAC

OECD, International Assessment of Adult Competencies

### Reading and writing

- 1.6% reaches the highest levels (4 and 5) | OECD average is 10.6%
- 12.9% reaches level 3 | OECD average is 35.4%

### Mathematical reasoning

- 1.9% reaches the highest levels (4 and 5) | OECD average is 11.2%
- 10% reaches level 3 | OECD average is 31.8%

### Troubleshooting in computer contexts

- 2.1% reaches the highest level (3) | OECD average is 5.4%
- 12.4% reaches level 2 | OECD average is 25.7%

Young people between the ages of 16 and 24, perform significantly better than adults over 34.

## STUDENTS IN TERTIARY EDUCATION PER 100,000 INHABITANTS<sup>3</sup>

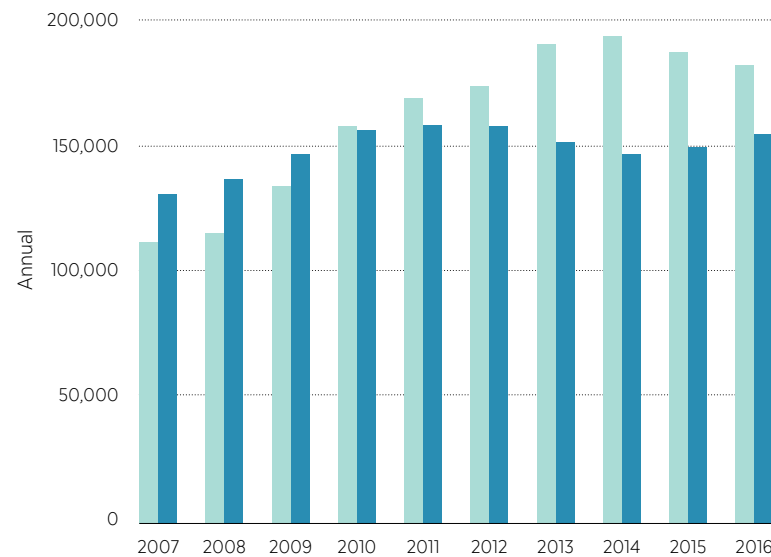
When countries had the same GDP per capita as Chile (US\$ PPP 2011)

1 icon = 100 students

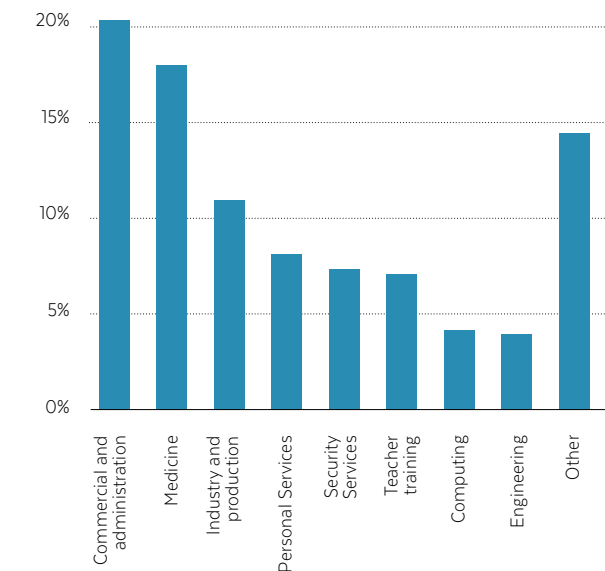


## ANNUAL ENROLMENT IN TECHNICAL-VOCATIONAL EDUCATION (2007 - 2016)<sup>2</sup>

Higher education TP (light blue), University Ed. TP (dark blue)



## ENROLLED IN HIGHER TECHNICAL EDUCATION, 2016<sup>2</sup>





**Gonzalo Vargas Otte, CNID Advisor**

Gonzalo is an Agricultural Engineer from Universidad Católica de Chile and he has a Master in Science from the University of California Davis, USA. He was an academic and director of the Department of Agricultural Economics at Universidad Católica de Chile and General Manager of Fundación Paz Ciudadana. He is currently the Rector of Inacap and Director of Vertebral.





## Educate to innovate

By Gonzalo Vargas Otte



What makes a country developed is the ability of its people to continuously innovate. Different studies confirm that innovation rates in Chile are substantially lower than in developed countries and new policies and instruments are continually sought to encourage innovation.

But do we really know how to manage innovation, what attitudes, knowledge and skills do people need to make successful innovations? The literature is very clear on this: for an organisation, company or institution to foster continuous innovation, it requires people and teams with state-of-the-art technical knowledge and with a set of behavioural competencies (mistakenly called “soft skills”). We also know that innovative individuals are not enough; it requires a well-established innovative culture in the different organisational strategies, policies, processes and systems. In short, more and better knowledge per se is not enough, nor is the existence of a highly trained professional or scientific elite. On the contrary, all the people involved in the different aspects need to be trained, lead and contribute to innovation processes.

Currently in Chile, more than 40 percent of secondary education graduates, and most of those who enter higher education, choose a technical-professional course, in secondary education institutions, technical training centres, professional institutes and universities.

Unfortunately, in Chile and Latin America, society and public policy have historically considered this education sector has a very secondary role, tacitly thinking that these future technicians and professionals are going to have a rather passive role. In contrast, this sector is traditionally important in developed countries; this is why they are developed!

If we really want to become a more innovative country, we need to change the paradigm: to stop thinking that only the elite are capable of innovation, or that innovation is based on the latest scientific findings only. Much of the innovation in the world is incremental and comes from the recombination of existing knowledge and technologies. Investment in research and development is certainly necessary, but it is not enough. We must think of a country where everyone has the capacity to innovate, and this requires the entire education system, and particularly the technical-professional education, to ensure that their future graduates have the skills required to do so.

## We still have spaces to connect more researchers with our challenges as a society

Postgraduate and specialisation education has increased sharply. But few are dedicated to the country's major challenges and the different types of knowledge do not tend to integrate well. A more associative interdisciplinary approach is needed.

Postgraduate and specialisation education has grown considerably in recent years: the number of PhD graduates has more than doubled between 2007 and 2015, and it is expected to double again in the next seven years. This increase can be seen in all areas of knowledge, although natural sciences continue to predominate. However, in absolute terms we are still below other countries.

In 2015, 82% of the PhD students surveyed said they were working in R&D<sup>5</sup> and the figures show their participation in academia has clearly increased. The question that arises, then, is how to make the most of the pool of talent that graduate every year, and to integrate this talent into society in an interdisciplinary manner to achieve higher levels of knowledge and well-being.

In this regard, CNID studies on technological and scientific capabilities, the logic associated with water sustainability and

resilience to natural disasters<sup>6</sup> show that there are few specialists in these key areas for Chile.

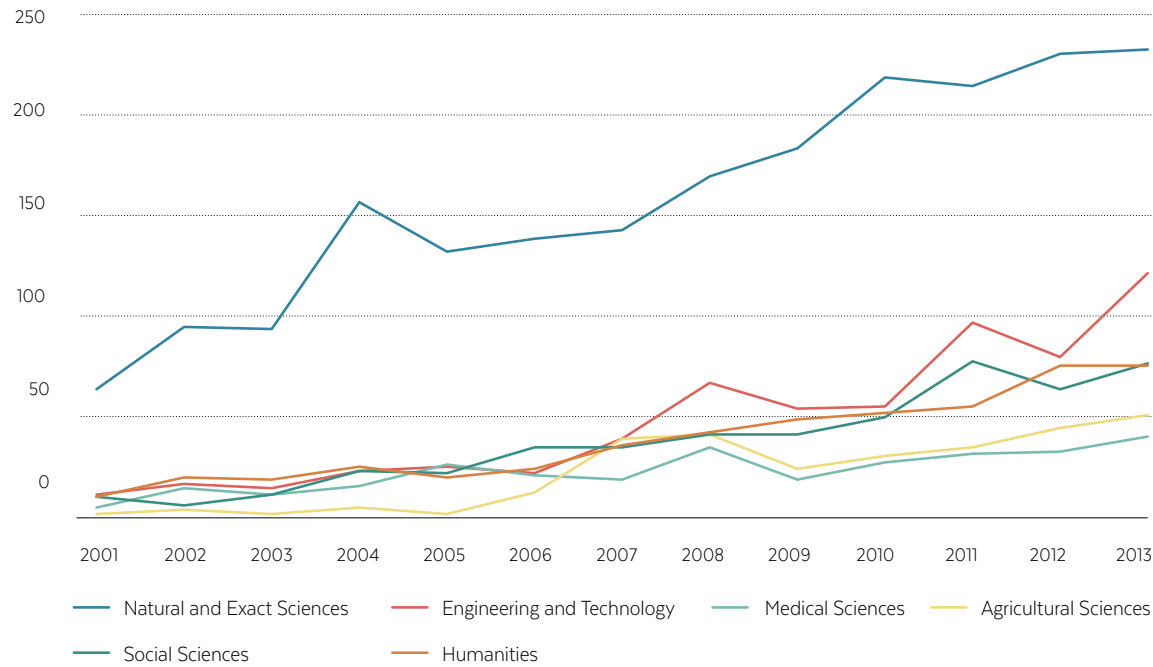
In the case of natural disasters, it has been found that they tend to be concentrated in few universities and limited regions, generally dealing with the physical dimensions of natural hazard events and generally with little multi-hazard research. In the case of water resources, most specialists also concentrate on understanding the physical phenomenon. They mainly study in three regions, although they tend to work in different areas across Chile.

Both cases reach the same conclusion: there are few professionals dedicated to these major country challenges and the different areas of knowledge tend not to be properly integrated to deal with such complex phenomena. In particular, the scarce participation of social science researchers in these important topics for Chile is striking. Progress towards greater and more effective interdisciplinarity must continue to be promoted.

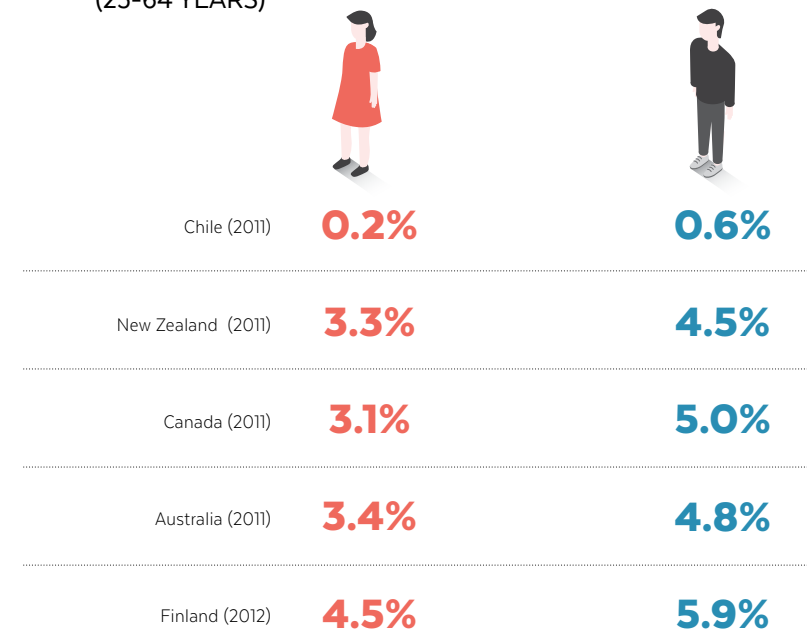
However, we must not forget the participation of technicians and engineers, who have a key and complementary role to that of R&D scientists.

1. [www.riicyt.org](http://www.riicyt.org)
2. OECD based on Careers of Doctorate Holders 2014 ([www.oecd.org/sti/cdh](http://www.oecd.org/sti/cdh)) and others. June 2015.
3. Conicyt Statistical Compendium 2013.
4. Conicyt, from academic staff reports 2008, 2009 and 2014 of SIES.
5. Ministry of Economy. Fifth National Survey on Research and Development Expenditure and Personnel.
6. Cameron Partner Innovation Consulting (2017). Water resources research, development and innovation capabilities in Chile. CNID Studies Collection. Santiago, Chile. In edition

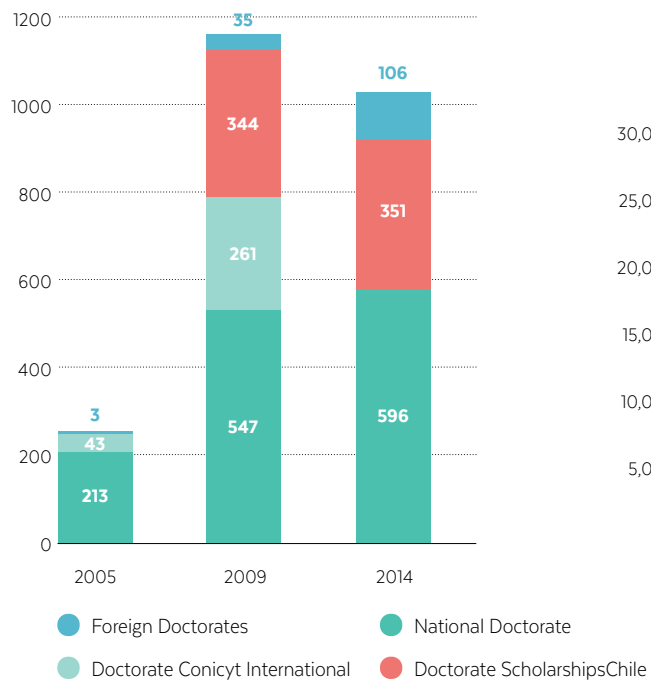
### DOCTORAL GRADUATES BY AREA<sup>1</sup>



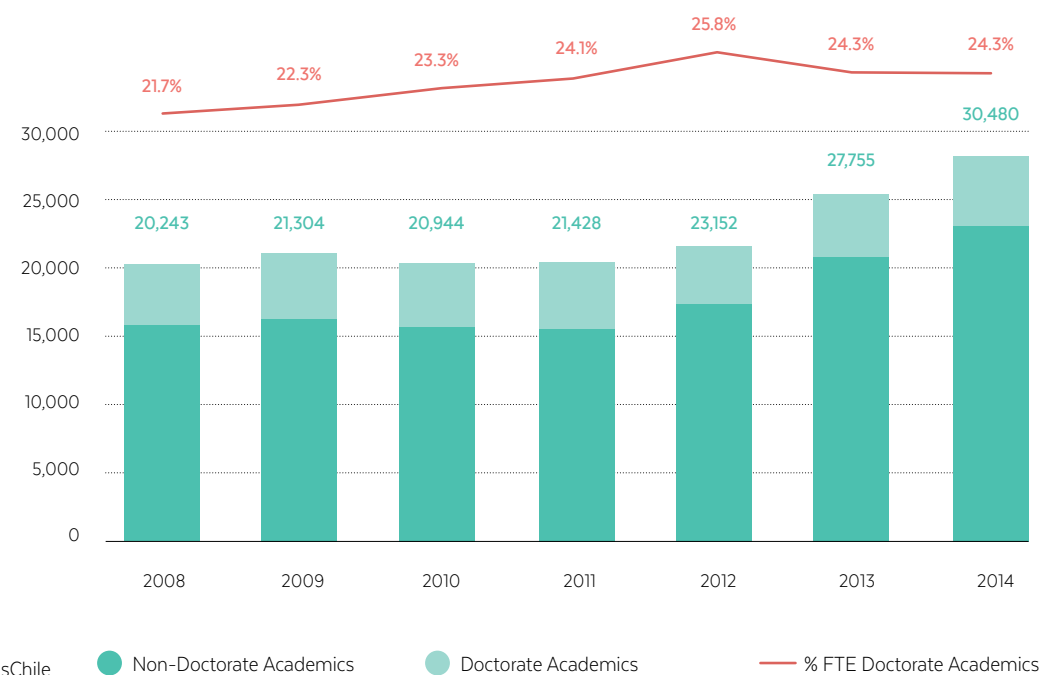
### PHDS IN POPULATION, IN WORKING AGE (25-64 YEARS)<sup>2</sup>



### CONICYT SCHOLARSHIPS<sup>3</sup>



### EVOLUTION OF THE NUMBER OF ACADEMICS BY DEGREE OF TRAINING (JCE)<sup>4</sup>



If the current trend continues, we would double the number of PhD professionals in seven years.

## The digital revolution offers huge opportunities that we must seize

Internet infrastructure must be widely accessible to offer to the population an unprecedented tool to deploy their potential.

We have maintained an advantageous position in STI infrastructure development in Latin America; however, this does not mean that we have reduced the gap with more developed countries, in fact the gap is widening, nor overcome the disparities within our territory.

In Chile, like the rest of the region, mobile telephone networks have helped to expand Internet access. It is the most dynamic market segment, and people use it intensely for communication and entertainment. However, its productive usage is much lower than in OECD countries, and activities are linked to large companies and the State.

The low demand for more sophisticated and widespread usage does not create incentives for companies in the industry to invest in more and better broadband coverage<sup>3</sup>. This deficiency is a real barrier to deploying our creative potential, to modernising companies and to providing excellent services to everyone.

We are undoubtedly facing “the chicken or the egg” dilemma. In fact, telecommunications companies prefer to invest in mobile coverage

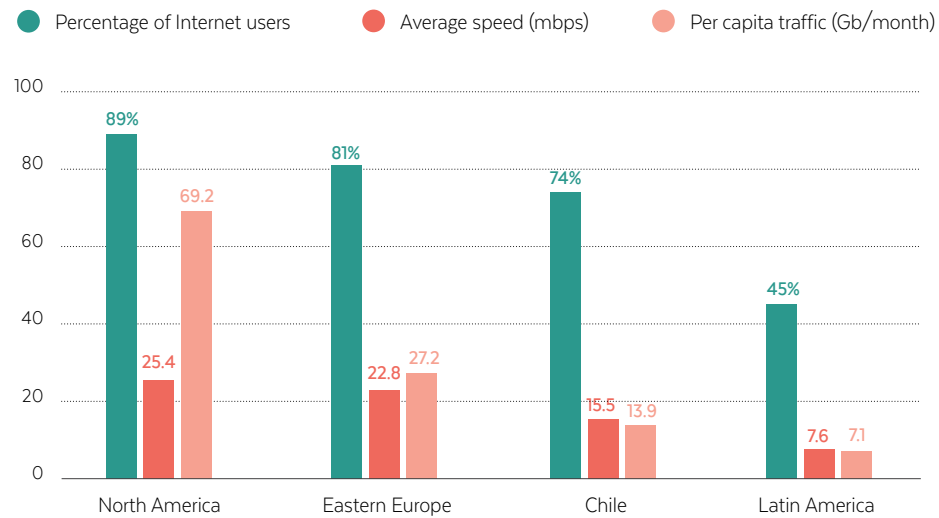
because it is the most in-demand service. However, if the communications infrastructure is not upgraded, the possibility of having a more sophisticated and productive network usage, such as telemedicine or advanced manufacturing, is severely limited, underdeveloped and its market is not created.

Meanwhile, OECD countries are moving even faster towards the next generation of Internet (5G) that promises ultra-fast download speeds and thousands of devices can connect at the same time. This opens huge opportunities to change the way services are currently produced and delivered. We need to seize this opportunity immediately.

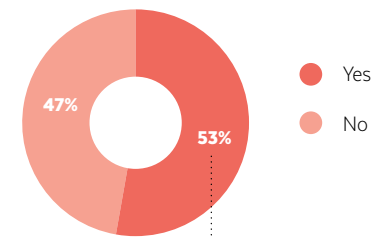
Until recently, the infrastructure that delivers internet services could be viewed as the capacity with which we compared ourselves, in relative terms, with high-income countries. Today we must do so in absolute terms, focused on broad access. Not to understand this is to condemn Chile to lag behind; it means not giving people access to an unprecedented tool to deploy their potential. Even more so, it means not considering it a fundamental right.

1. VNI CISCO, in Chile País Digital presentation.
2. OECD Digital Economy Outlook 2015. DOI: 10.1787/9789264232440-e Table 2.2, p. 120.
3. Companies can certainly offer high-speed broadband, via dedicated optical fibre, to customers who need it and can finance such an investment (as in the case of astronomical observatories).

## WE ARE LEADERS IN LATIN AMERICA IN INTERNET USAGE (2015)<sup>1</sup>



## HOUSEHOLDS WITH ACCESS TO FIXED BROADBAND IN CHILE



This percentage is similar to the number of households that had drinking water in 1965.

## INCREASE IN INTERNET CONNECTIONS IN CHILE, 2009 TO 2015

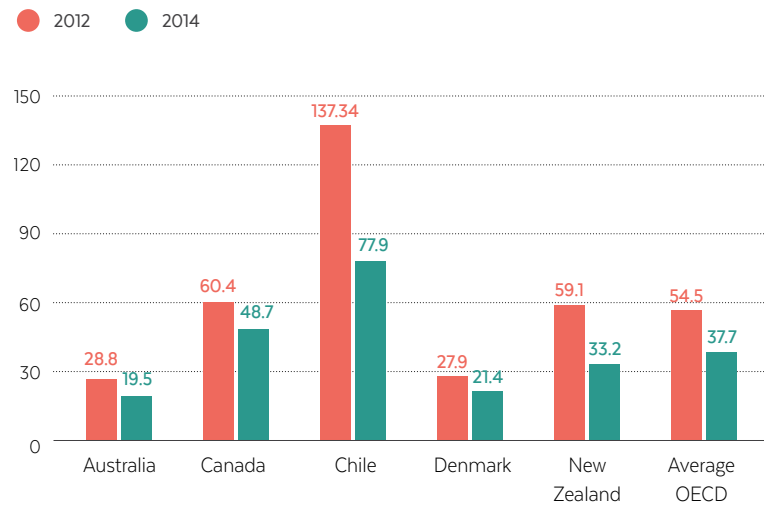
Fixed

**1,000,000**

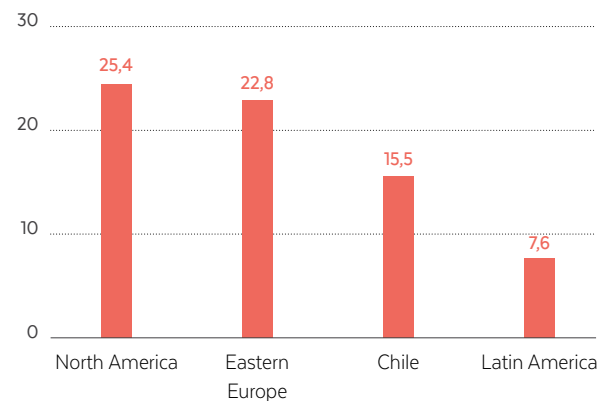
Mobile

**10,000,000**

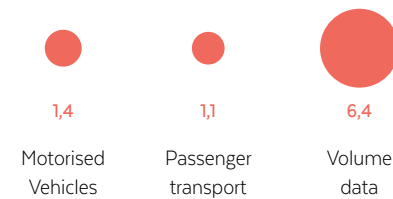
## MOBILE BASKET VALUE OF 300 CALLS AND 1GB SEPTEMBER 2012 VS. SEPTEMBER 2014 (IN US\$ PPP)<sup>2</sup>



## AVERAGE DATA RATE (MEGABYTES PER SECOND)<sup>1</sup>



## VARIATION IN 5 YEARS, BY INDUSTRY (2010-2015)



By 2015, 40 per cent of households in Sweden had access to 100-megabyte broadband. By 2020, the government aims for 90%. Almost 70% of the municipalities have an urban network, under public or private ownership, with free access to broadband.

The EU is committed to improving its transfer rates, deploying 5G by 2020.

## We need a paradigm shift to drive the digital world

To access the new possibilities offered by the new century, we must change our paradigm, our approach to deploying digital technology.

Telecommunications companies can offer all the broadband a customer needs via dedicated fibre-optic connection, provided the customer has the means to pay for the service. Large companies, banks or astronomical observatories are some of the customers who can afford broadband and high-speed Internet. Smaller businesses, as well as low-income households, can only access the level of service offered by the general communications infrastructure that is available.

The rapid growth of the Internet of Things -which will allow almost instantaneous communication, not only between people, but between objects and machines- is already revolutionising the way our lives are produced, consumed and generally developed. The new possibilities are enormous and still difficult to pinpoint.

In this context, marked differences in Internet access can have an impact on further increasing inequalities in people's quality of life and income. It is important to understand that this technology is not

just a communication or entertainment tool, as it is predominantly used in Chile. We are facing a process that will radically affect all areas of our lives.

A change of this nature also requires us to change the paradigm, our current approach to deploying digital technology, and we need to maintain the course of our efforts over the years.

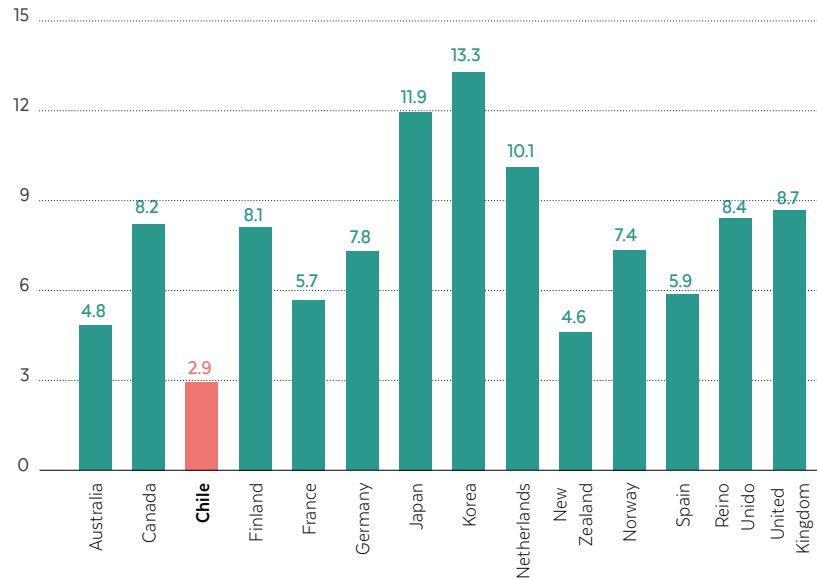
“Given that the Internet has become an indispensable tool for realising a range of human rights, combating inequality and accelerating development and human progress, ensuring universal access to the Internet should be a priority for all States. Each State should thus develop a concrete and effective policy, in consultation with individuals from all sections of society, including the private sector and relevant Government ministries, to make the Internet widely available, accessible and affordable to all segments of the population”<sup>5</sup>.

1. OECD.
2. Digital Country Foundation.
3. Digital Country Foundation based on *Séptima Encuesta de Acceso, Usos y Usuarios de Internet* data.
4. Smart industries program. Data from Yanyan Zhuang et al, “*Future Internet Bandwidth Trends: An Investigation on Current and Future Disruptive Technologies*”, Technical Report, No. TR-CSE-2013-04, Department of Computer Science and Engineering, Polytechnic School of Engineering, New York University, 2013.
5. ONU, General Assembly (2012) “*Report of the Special Rapporteur on the Promotion and Protection of the Right to Freedom of Opinion and Expression*” ([http://www2.ohchr.org/english/bodies/hrcouncil/docs/17session/A.RC.17.27\\_en.pdf](http://www2.ohchr.org/english/bodies/hrcouncil/docs/17session/A.RC.17.27_en.pdf)) Consulted in April. 2017. Page 22.

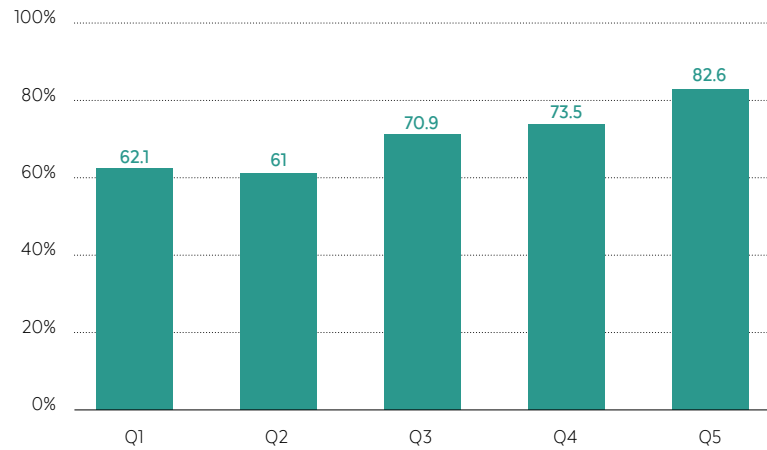
### INTERNET ACCESS SPEED<sup>1</sup>

(Second quarter 2013)

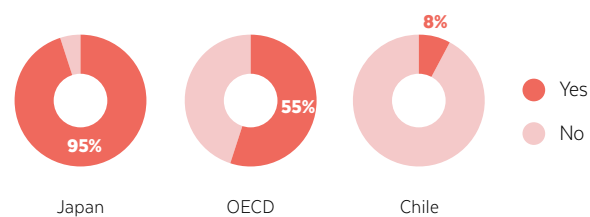
(Mbit/s)



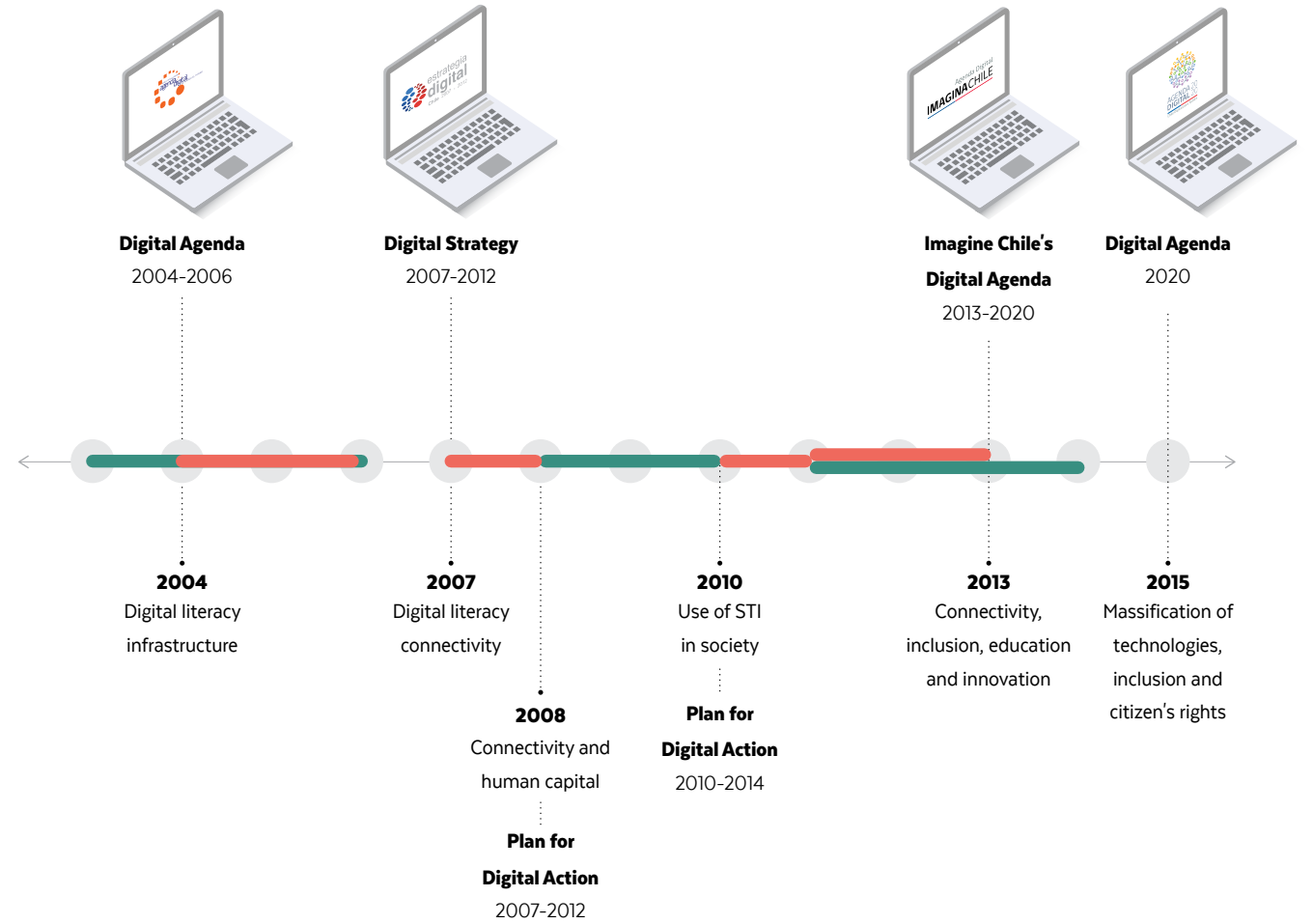
### HOUSEHOLD INTERNET PENETRATION BY INCOME QUINTILE<sup>3</sup>



### PERCENTAGE OF COMPANIES WITH A CONNECTION GREATER THAN 30 MEGABYTES PER SECOND

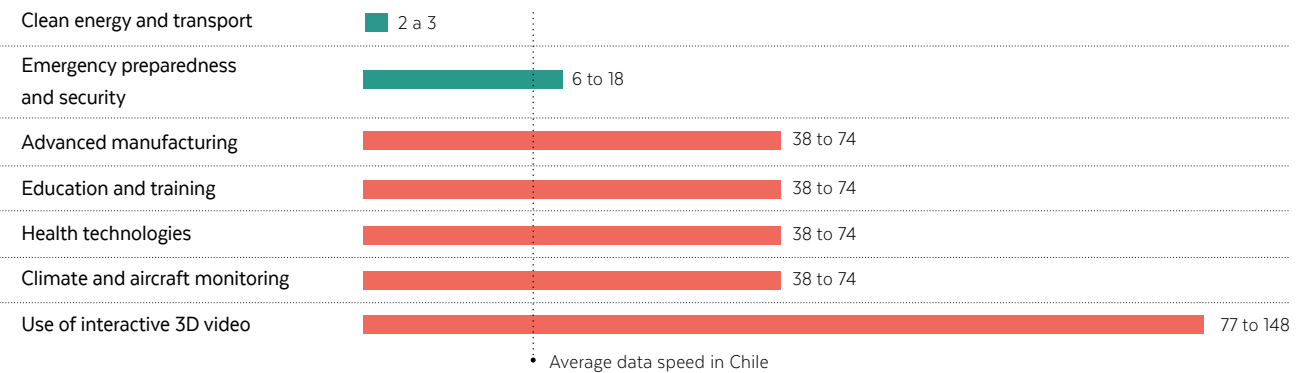


### SUCCESSION OF DIGITAL AGENDAS<sup>2</sup>



### REQUIRED BANDWIDTHS ACCORDING TO TYPE OF APPLICATION (MBPS)<sup>4</sup>

#### Mozilla Ignite and US Ignite projects





**Juan Rada Mladinich, CNID Advisor**

Juan studied Sociology and Economics at Universidad Católica, and finished his studies at University of London, where he obtained his PhD degree. He was an academic, founder and CEO (President) of the International Institute for Management Development (IMD) in Lausanne, Switzerland. He has had management positions at IT companies, finishing his career at one of the world's largest technology companies, Oracle.





## A paradigm shift in digital development

By Juan Rada Mladinich



The new critical infrastructure for this century is digital and it will condition all activities in society. It will determine the potential and extent of diversification of the production model, national and international trade, social practices, urban and interurban flows, the friendliness and efficiency of a city, business capacities and models, work organisation and daily life.

Digitalisation has evolved to produce a growing convergence of the Internet, TV and radio that will accelerate as the basic digital infrastructure increases its capabilities. This will lead to increasingly sophisticated digital network services, with cloud data and content available from different devices. The increasing use of automation in production processes, the “Internet of Things” (IoT) and Big Data are factors that will accelerate and deepen the changes thanks to enormous economies of scale and scope.

The rapid growth of IoT is based on trivialising the costs of temperature, motion, pressure, camera and smart sensors at a speed that was unimaginable just a few years ago. In addition, the continued convergence of these areas accelerates developments at a faster pace than we have today. Therefore, our challenge as a country is digital in-

frastructure and not just one of its components; telecommunications.

The above reasons explain that this is the most ubiquitous infrastructure ever known. For Chile, it is a major challenge to understand, review and renew our public policies, laws and institutions that today only scratch the surface. If we overcome this challenge, it will enable us to seize this great historical opportunity and to take a bigger leap forward. This window of opportunity is not for tomorrow. It is today, but we need a sustained effort of at least two decades to match the average of developed countries and benefit from specific areas.

What we need is to learn to understand the opportunities and challenges for households and families, productive sectors, education, health, the transformation of the State and much more. We must reach a consensus on the significant changes to carry out the main actions for a sustained modernisation; to build the most ubiquitous and critical infrastructure in history for our growth and development as a society.

## II. STI ACTORS: WE HAVE TALENT, NOW WE NEED TO NURTURE IT TO TAKE A BIG LEAP

## The quality of our science encourages us: few researchers but excellent skills

Our scientists are recognised around the world. But we must be clear: we will not be able to do much R&D with few researchers. And we have ten times fewer researchers than the OECD average.

Universities have played a fundamental role in the history of R&D&I around the world. In Chile, universities have historically concentrated most of the research work.

The system, strongly driven by public policies, has preferred research over technological development and innovation by making publications its main performance indicator. However, as the Chilean university system is very diverse, it means the influence of public policies on the R&D&I agendas of universities varies based on the type of university (private or public), internal governance systems and the level of public-sector funding dependence in relation to other sources of funding.

In this context, the higher education reform project in Chile is creating a new scenario for these institutions in general, and, in particular, the academia. Notwithstanding other objectives, this should be an opportunity to strengthen the R&D&I capacities of universities.

Regardless of their location, there are not many researchers in Chile, but they are highly productive and the quality of their scientific work<sup>6</sup>

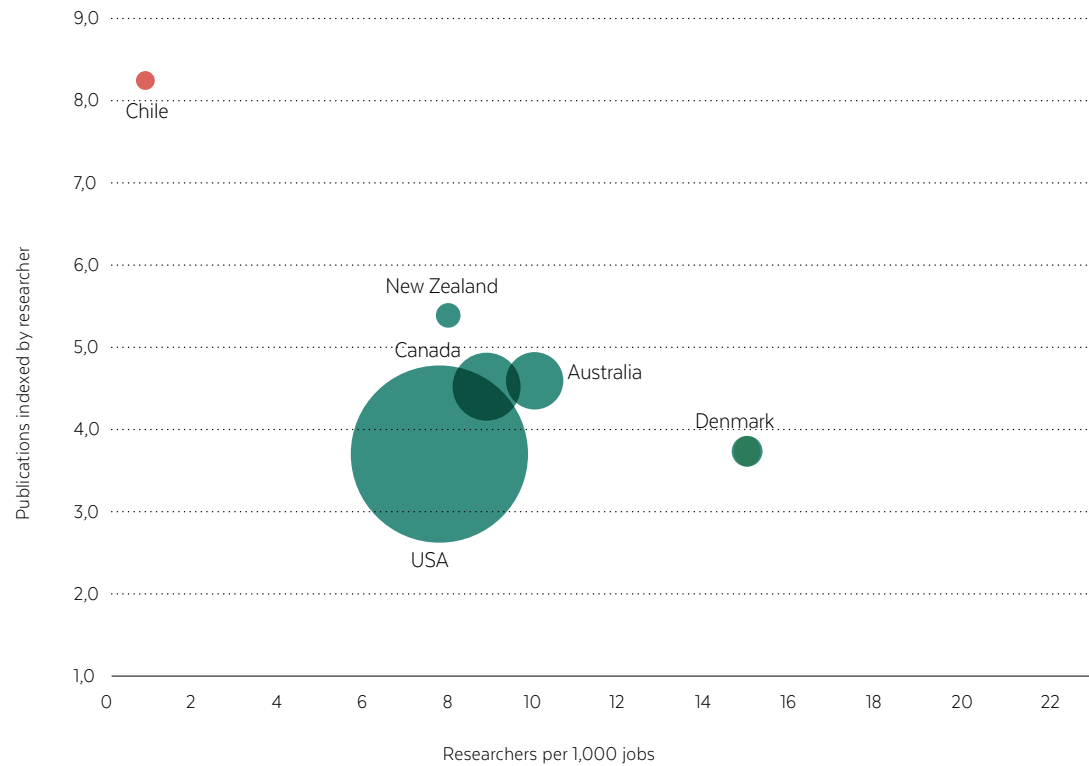
is globally recognised. For example, in 2011, the winners of the Nobel Prize for Physics publicly acknowledged that the contribution of the Astronomy Department of Universidad de Chile had been fundamental in revealing the key role of supernovas in measuring distances in the Universe. In other disciplines, Chilean researchers have also been internationally acclaimed, who have deservedly earned their prestige.

This is a great merit. But we must be clear: we will not be able to do much R&D with few researchers. We usually say that companies do very little research, but our biggest problem is the lack of researchers.

When Chile is compared to OECD countries, we have almost ten times fewer researchers per 1000 employed people. All the countries that have managed to increase their R&D activity have done so with a strong and rapid increase in the number of researchers. When Portugal, Spain or Turkey set out to make progress in this area, they more than doubled their capacities in under ten years and they did so more than once. In our case, from 2007 to 2014 (latest official data available), the progress made in relation to employment was practically nil.

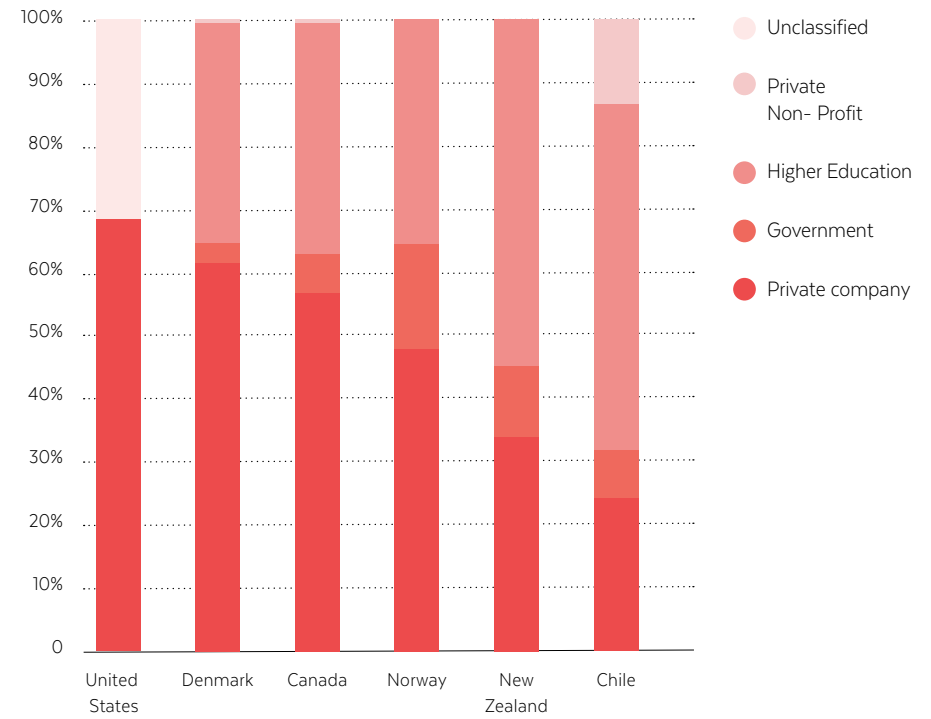
1. OECD, 2013.
2. OECD Science, Technology and Industry Scoreboard 2015.
3. Scopus and Ricyt.
4. Ninth Innovation Survey.
5. OECD, 2016.
6. Value of knowledge created by publications, measured by the number of citations.

## PRODUCTIVITY OF RESEARCHERS IN OECD COUNTRIES<sup>1</sup>



## RESEARCHERS BY EMPLOYMENT SECTOR<sup>2</sup>

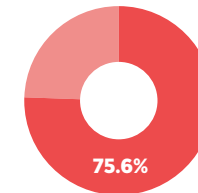
(as % of total full day equivalents, 2013)



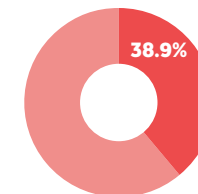
Chile is in the world average of citations per scientific publication:

**1.9**

Chile's percentage share of world production of scientific articles quadrupled<sup>3</sup>.



75.6% of the doctorates declared that their main activity was at university institutions<sup>4</sup>.



38.9% of R&D activities were carried out in higher education establishments<sup>5</sup>.

Note: The OECD definition of a researcher is used, i.e. "professionals involved in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the respective projects."<sup>6</sup>



**Juan Asenjo De Leuze, CNID Advisor**

Juan is a Chemical Engineer from Universidad de Chile and he has a PhD in Science at University College London. He is currently Director of the Centre for Biotechnology and Bioengineering (CeBiB). He received the National Award for Applied and Technological Sciences in 2004, and was President of the Chilean Academy of Sciences (2010-2016). He has been a professor at Columbia University, New York (1980-1987) and at University of Reading, United Kingdom (1986-1996).



## We have top-notch science and technology

By Juan Asenjo De Leuze



It is now widely accepted that education, science, technology and innovation are key to improving a country's well-being and its society while ensuring sustainable development.

Science, technology and innovation are elements that differentiate countries from each other in the international arena. They are also essential for the economic diversification across export products. Studies have shown that countries with a more diversified export structure have a more favourable Gini index, i.e., they have a smaller gap between the richest and the poorest.

In general, Chilean society is unaware of the quality of science and technology conducted in this country, which does not further its development as the accumulated knowledge and research is not used, nor the top-level scientists working in Chile and the excellent international networks in which they actively participate. Between 1981 and 2005, the citation value of international scientific and technological publications by Chilean authors was 8.94 higher than Argentina (7.62), Mexico (7.13) and Brazil (6.68), which are the only other countries with significant scientific research in the region. This behaviour continues and is even more accentuated in the decade 2003-2012.

We have important examples of scientific research with an impact on development. Fruit research is the basis of the sector's increased exports and our ecologists have saved several marine resources. Seismology and anti-seismic engineering have allowed us to study, monitor and incorporate state-of-the-art technology to deal with two of the world's most important mega earthquakes of the last century and to predict the location and magnitude of the 2010 event. We are the astronomy capital of the world and we are recognised for developing our own technology in some sectors, such as the Teniente converter in mining; the study of microorganisms in extreme environments, both in Antarctica and the Atacama Desert; patents with several industrial applications; and new antibiotics and anti-cancer drugs.

The importance of science and technology is not only evidenced through these successes, but also through failures. Lack of research or scientists is the root cause of all the problems in the salmon industry, the overexploitation of many natural resources and partly the education crisis.

## D&I actors: technicians and engineers

The ability to interact with technology can be the main difference in many of today's occupations. It is essential to move towards a lifelong learning system, that enables people to design their own training path.

We need more engineers and technicians. Moreover, we need them connected to new technological development and innovation opportunities. In Chile, graduate student participation in technology and engineering sciences has fallen steadily, affecting our technological development and innovation capabilities.

An encouraging fact is that, thanks to the sustained efforts of the public sector and universities, engineering has started to interact with other disciplines, creating a mutually enriching dialogue and more spaces for technology to be integrated into different domains of human endeavour.

The ability to interact with technology can be a significant factor in many current occupations and in the deployment of new goods and services. It is essential to move towards a lifelong learning system that enables people to design their own training path and take advantage of their own potential based on their interests and opportunities. This is

an old aspiration: to have a qualification framework to coordinate and create more flexible education systems to respond, in a relevant and timely manner, to the demands emerging from the surrounding environment. Hence, the recognition of prior learning and qualifications, certification of formal and informal learning, and other mechanisms that permit a greater connection between and within the different education levels are critical.

There is also a growing need to connect with international education. Online training platforms provide access to collaboration and learning opportunities across borders, which was unheard of until recently. It is also a great opportunity to support lifelong learning processes, and to incorporate people with different skills, inhabitants from remote areas or older adults. This trend is already essentially challenging the traditional organisation of awarding and recognising qualifications and certificates. We cannot continue to turn our backs and avoid the debate on how we will be able to take advantage of this revolution.

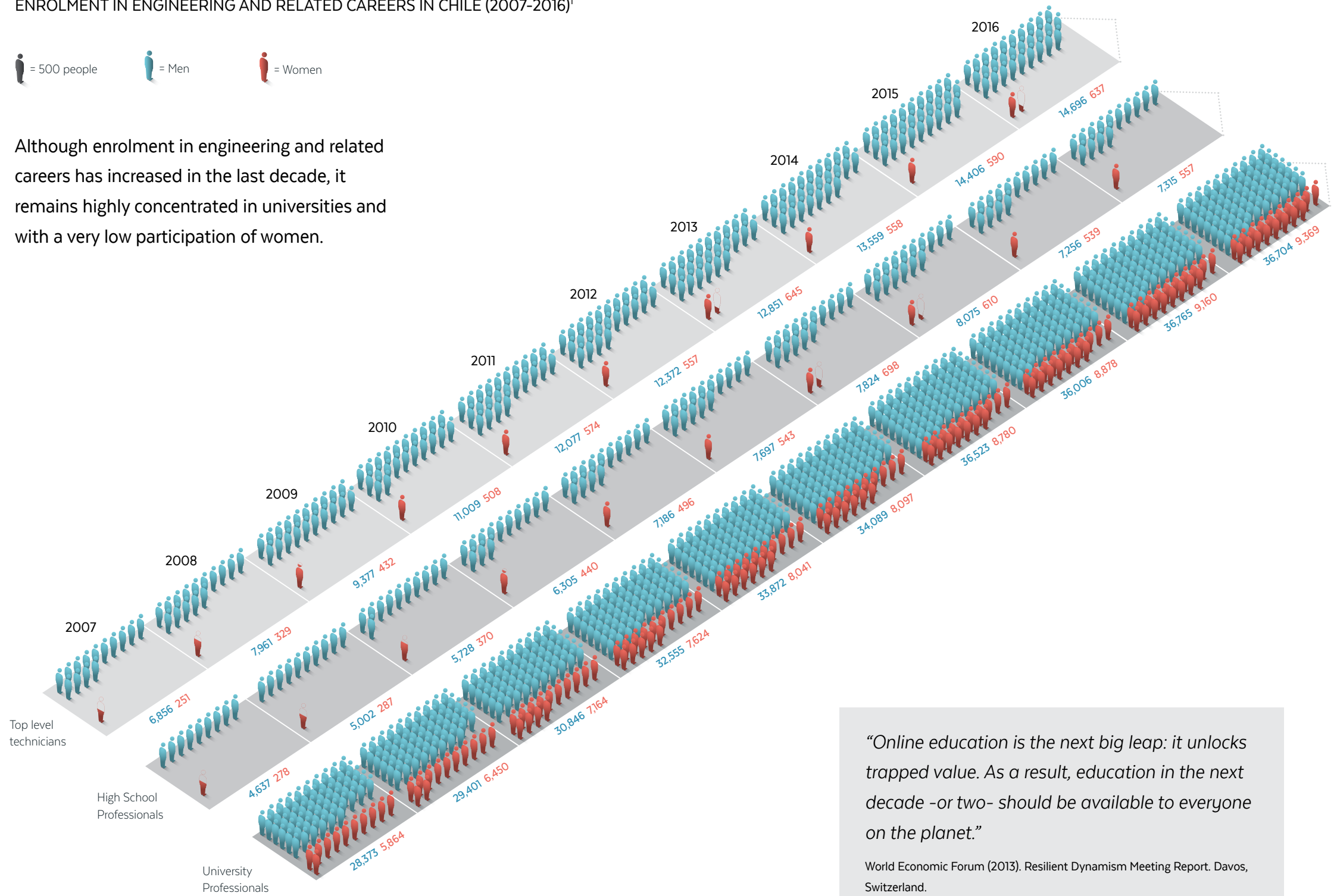
"A National Qualifications Framework should be developed, covering all academic and vocational qualifications from secondary education to doctorate (...) Qualifications could be based on achieved outcomes and competencies, not on time/hours of study. With all these measures, (...) a National Qualifications Framework should help and stimulate a lifelong learning process"<sup>2</sup>.

1. SIES, Mineduc.
2. OECD and the World Bank (2009) "*Review of National Policies for Education: Tertiary Education in Chile*". Ministry of Education. Page 315.

# ENROLMENT IN ENGINEERING AND RELATED CAREERS IN CHILE (2007-2016)<sup>1</sup>

 = 500 people    
  = Men    
  = Women

Although enrolment in engineering and related careers has increased in the last decade, it remains highly concentrated in universities and with a very low participation of women.



“Online education is the next big leap: it unlocks trapped value. As a result, education in the next decade –or two– should be available to everyone on the planet.”  
 World Economic Forum (2013). Resilient Dynamism Meeting Report. Davos, Switzerland.

~~~~~

We have deployed the research, it must be strengthened throughout the territory, in companies and in the State

~~~~~

It is possible to combine existing national universities of excellence with regional universities that also conduct research, by focusing on the most important global issues, from the particularities of their territory.

Contrary to what people normally believe, basic research is not currently prevalent in Chile. In fact, it is applied research (37.6%) that leads domestic spending on R&D, and experimental development has grown the most in recent years, from 21% in 2007 to 34.2% in 2014 (latest year data). This is in line with an increased number of researchers in companies, -although with ups and downs from year to year: from 17.7% to 24.9% of total. However, in absolute terms, we have a very small research base which affects our opportunities to create value from knowledge.

If we now look at public versus private spending, when compared to other OECD countries they have more private R&D, which means that they carry out proportionally less basic research than Chile. But when we look at these countries when they had the same per capita income that we have today, they also had more public than private spending; their scientific research expenditure as a percentage of GDP was much higher than ours today. So, we must be careful not to get into false dichotomies, because we will engage in the wrong discussions.

Another important point is that in Chile the bulk of the research is primarily conducted in the Metropolitan Region. Research is mainly

conducted by Universidad de Chile and Pontificia Universidad Católica de Chile: they accounted for 39.9% of national scientific production in the 2008-2016 period (21.3% in the former and 18.6% in the latter)<sup>5</sup>. There are still very few regional universities that have managed to establish themselves as spaces for research excellence.

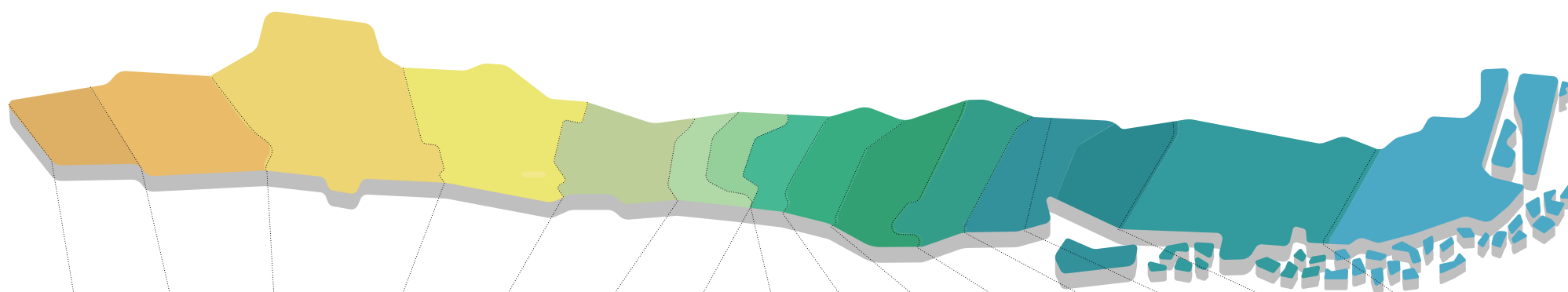
However, an interesting characteristic is that the universities that have made progress in this field have had a strong connection with the concerns and opportunities in their territories. This greater connection with the locations where some regional universities are located, provides an opportunity to escape the trap resulting from the debate about how many complex universities of excellence can exist in Chile.

It is possible to combine the existence of national universities of excellence with regional universities that also do research, preferably focusing their research and specialised training on topics of global importance, based on the particularities of their territory. Archaeological research in the north, food research in the central region or climate change research in Patagonia and Antarctica are valuable examples of this approach.

“Existing asymmetries between the Metropolitan Region and the rest of the country limit the capacity of the regions to receive the benefits from research, to have an advanced human capital in the region that thinks about local issues.”<sup>6</sup>

1. Ninth Innovation Survey (2013-2014).
2. Conicyt (2015). Scientometric Report. Scopus data. SCImago Research Group analysis.
3. OECD.
4. OECD.
5. Conicyt, 2016.
6. Conicyt (2015). Main scientometric indicators of the Chilean scientific activity, Santiago, Chile. Page 63.

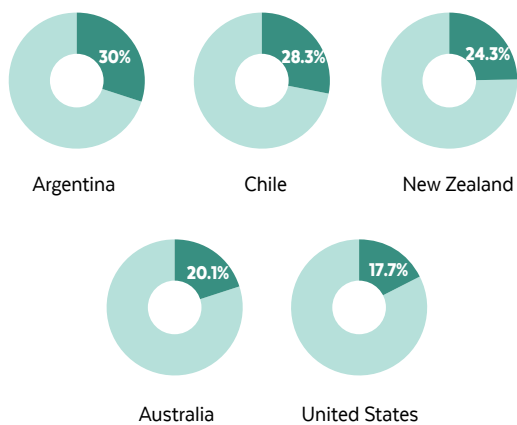




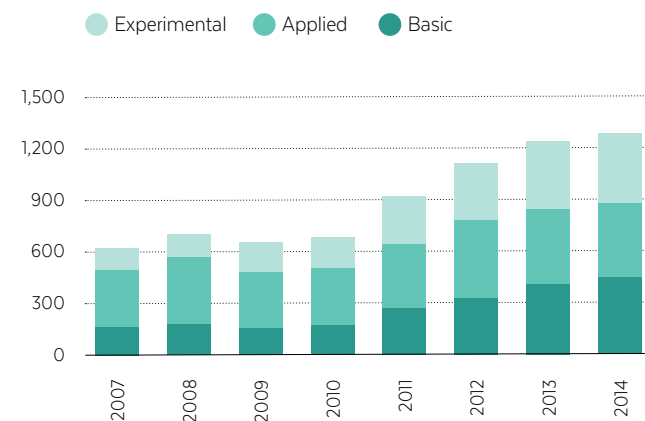
|                                                                                 | Arica y Parinacota | Tarapacá | Antofagasta | Atacama | Coquimbo | Valparaíso | Metropolitana | O'Higgins | Maule | Bíobío | La Araucanía | Los Ríos | Los Lagos | Aysén | Magallanes y Antártica |
|---------------------------------------------------------------------------------|--------------------|----------|-------------|---------|----------|------------|---------------|-----------|-------|--------|--------------|----------|-----------|-------|------------------------|
| Spending on innovative activities, by region of execution (% 2014) <sup>1</sup> | 0.8%               | 1.6%     | 4.9%        | 0.9%    | 5.1%     | 9.1%       | 45.3%         | 7.6%      | 5.6%  | 4.8%   | 4.4%         | 2.3%     | 4.5%      | 1.2%  | 2.0%                   |
| Percentage of excellence 1 lead <sup>*2</sup>                                   | 0.5%               | 0.0%     | 0.0%        | 0.0%    | 0.0%     | 0.7%       | 0.3%          | 0.0%      | 0.5%  | 0.2%   | 0.2%         | 0.4%     | 0.0%      | 0.0%  | 0.0%                   |

\*Proportion of items in a domain, included in the 1% most cited in a year in the same domain.

### PARTICIPATION % OF BASIC RESEARCH IN TOTAL R&D SPENDING<sup>3</sup>



### CHILE: EVOLUTION OF R&D EXPENDITURE BY TYPE OF EXPENDITURE (MILLION US\$ PPC 2011)<sup>4</sup>



## Companies – particularly large ones – can do more

Companies in the forestry and agricultural sector invest in R&D far more than the OECD average. In all other sectors, there is ample room for innovation.

In Chile, business innovation is comparatively limited, the companies that have declared themselves to be innovative in the last ten years<sup>3</sup> are showing signs of stagnation.

Innovative activity is concentrated in large companies and export companies. The importance of large companies in this area is indisputable: they account for nearly 60% of private R&D expenditure in 2014<sup>4</sup>.

In general, innovations by national companies are more associated with improving the business model, especially commercial and financial, than with creating new products or processes. In this area, our more advanced business sector runs smoothly. However, there is significant lack of technological innovation and very few companies develop technologies. They tend to adopt foreign innovations and, hence, maintain their competitive position<sup>5</sup>.

Using and adapting technologies created by others is a valid and even advantageous alternative when you are lagging behind. But it cannot go on forever. First, because these technologies are not necessarily

designed for the particularities of our territory. Second, because it does not allow companies to influence the rules of the game<sup>6</sup>.

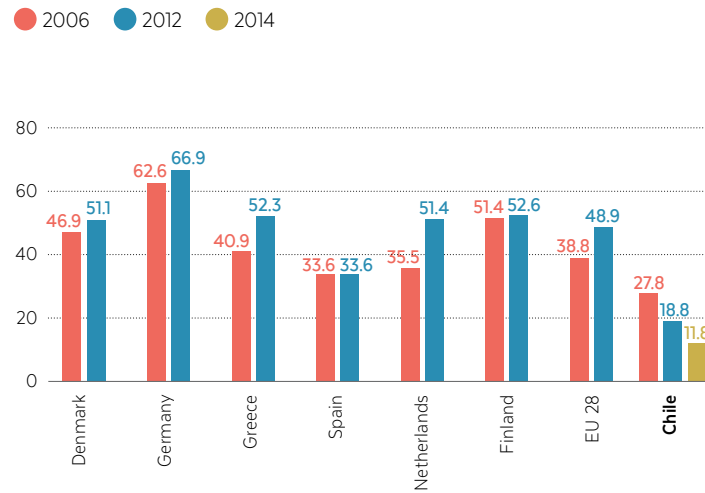
If we focus on some sectors, i.e. mining, industrial, service and construction sectors, large companies clearly lag behind OECD countries. In mining, particularly productivity issues, the gap is significant: spending by large companies is 0.14% of GDP by sector, in contrast to 0.68% in other countries.

It is the forestry and agricultural sector that makes a difference with a major achievement: its private R&D expenditure represents 0.56% of GDP by sector, significantly higher than the average for OECD countries (0.35%). If this sector maintains this standard, the mining sector gets closer to the OECD average and the other sectors double their investment in R&D, we could reach similar levels to Australia, Canada, Denmark and New Zealand when they had the same GDP per capita.

Therefore, large private companies have ample room to innovate.

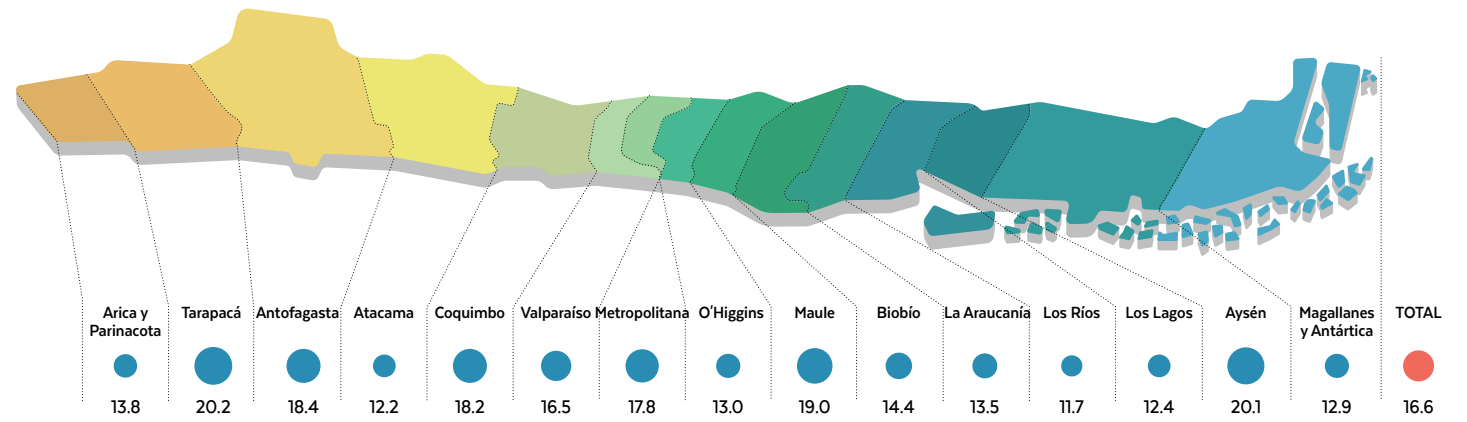
1. Community Innovation Survey for the EU. For the Chile data, the 5th, 8th and 9th Innovation Survey of the Ministry of Economy has been used.
2. Ninth Innovation Survey (2013-2014).
3. Data from the latest National Innovation Surveys.
4. Defined as those with 250 or more employees.
5. Katz J. and Araya C., (2015) *Reflexiones en torno al largo plazo de la salmonicultura chilena*, CNID, Working Papers Collection. Santiago, Chile. In edition.
6. Masterful analysis by Keun Lee on this topic. See "Shumpeterian Analysis of Economic Catch-up". Cambridge University Press, 2013.

### PERCENTAGE OF COMPANIES INNOVATING\*1

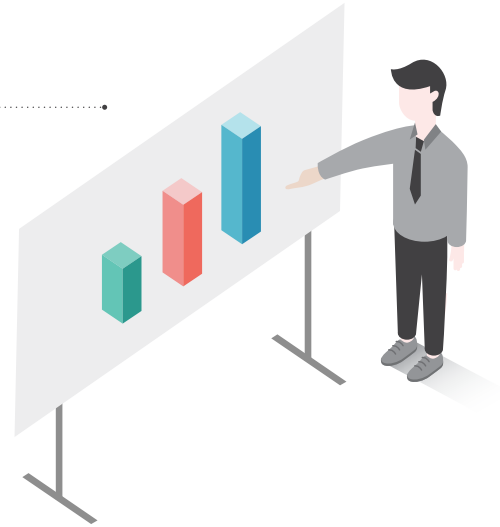
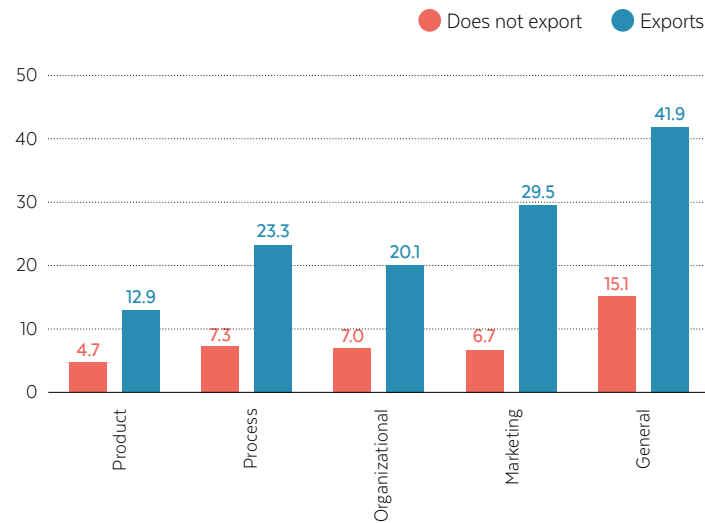


\*Includes innovation projects at all stages: suspended, cancelled and in operation

### INNOVATION RATE, BY REGION OF IMPLEMENTATION (% , 2013-2014)<sup>2</sup>



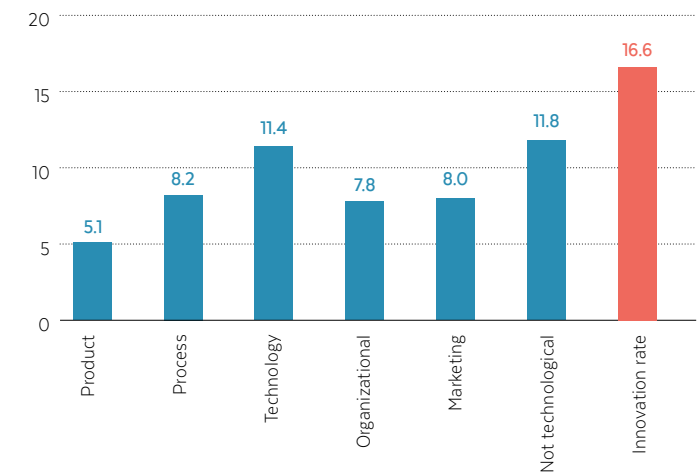
### INNOVATION RATE AND EXPORTS<sup>2</sup>



The EU has set out to improve its transfer rates by deploying 5G by 2020.

### PERCENTAGE OF COMPANIES PERFORMING ONE OR MORE TYPES OF INNOVATION (2013-2014)<sup>2</sup>

The same company can do more than one type of innovation



## How could we develop the business innovation we would like?

There are encouraging signs and examples of emergence and expansion, based on continuous innovation, capable of becoming technological leaders. We need more companies to follow this path.

The answer is not obvious. In addition to the coordination and classical market failure analyses reviewed in the literature, we can identify other factors to improve the discussion and shed light on possible solutions.

One of these refers to our production structure, dominated by the exploitation of natural resources, particularly in the export sectors. At a global level, companies in these sectors tend to use technologies and innovate after they have acquired them, but they do not develop new ones. Even though they have highly sophisticated operations, in general, it is not part of their business model to systematically invest in R&D to create new technologies. The world's pharmaceutical, machinery and equipment, electronics and communications industries are leaders in this type of spending.

On the other hand, R&D associated with natural resources has a long maturing process before achieving results. As it is difficult

for companies to undertake this challenge on their own, in other OECD countries the public sector has led the way for years. It is not surprising, then, that very few companies in Chile have facilities and specialised personnel for R&D activities. Furthermore, the number of firms providing knowledge or technology-intensive services to the natural resources sectors is still low, although there are some very notable cases that have increased over time.

Another major area for our companies is trade and services; here innovation is focused on differentiation through marketing and logistics capabilities, fields where information and communication technologies are currently revolutionising business rules.

In this context, an often-overlooked issue is that even our business management capabilities are far from world class: according to international surveys, our managers score well below their peers in Mexico and Argentina<sup>4</sup>.

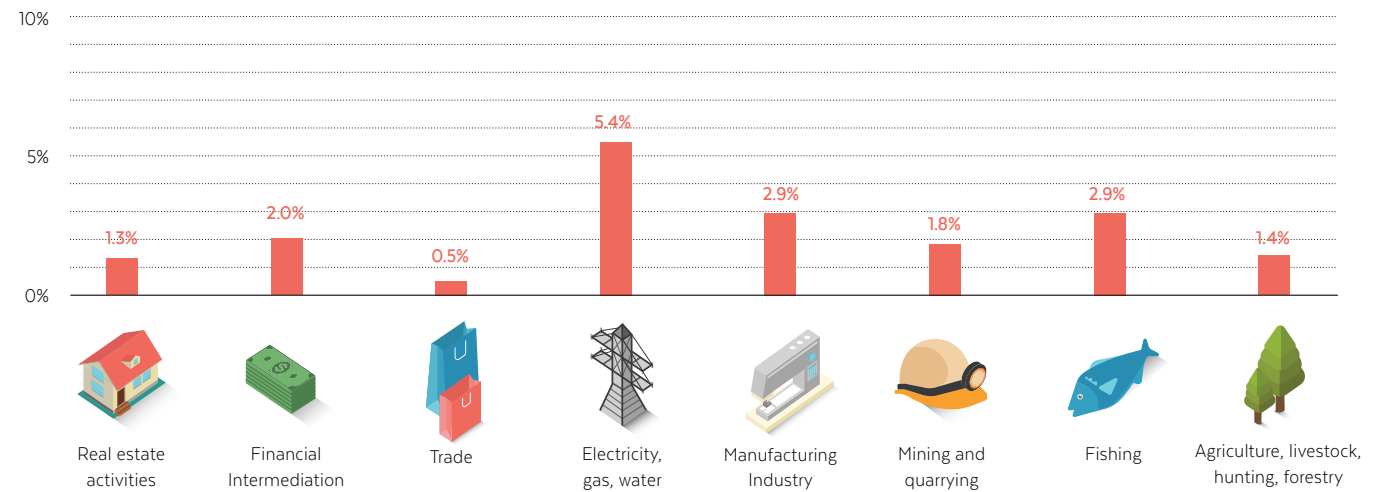
In short, our companies have a lot of room for improvement. There are undoubtedly encouraging signs and examples of emergence and expansion, based on continuous innovation, and they could become technological leaders in their fields. We need more companies to follow this path.

1. World Economic Forum Reports.
2. Ministry of Economy, 2015.
3. Author's own work based on OECD data.
4. Lederman, D., Messina, J., Pienknagura, S., Rigolini, J. (2014). *Latin American Entrepreneurs: Many firms, but Little Innovation*. World Bank, Latin American and Caribbean Studies series, Washington D.C., USA.

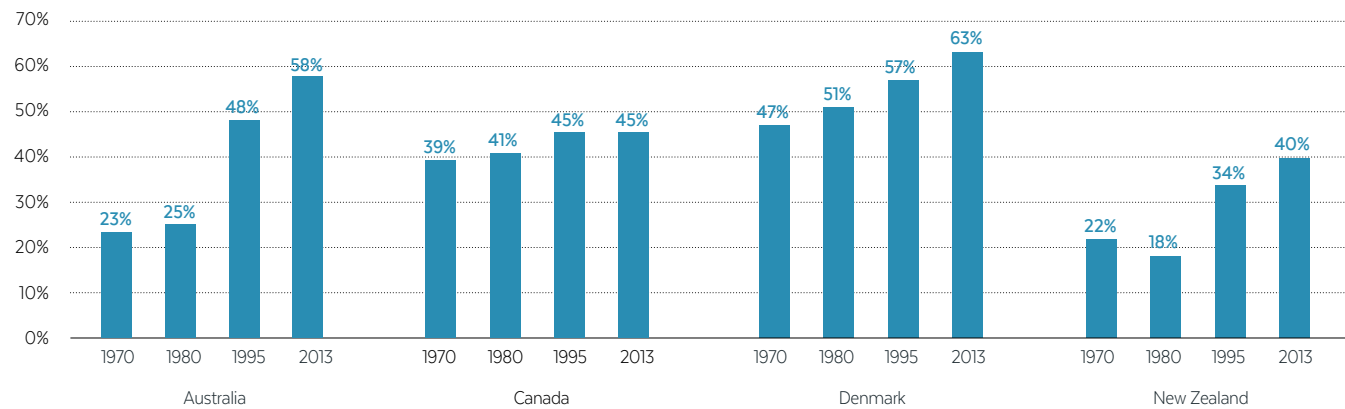
PILLARS OF INNOVATION AND BUSINESS SOPHISTICATION ACCORDING TO WEF NOTES ON CHILE (SCALE 1 TO 7)<sup>1</sup>

|         | BUSINESS SOPHISTICATION | INNOVATION |
|---------|-------------------------|------------|
| 2008-09 | 4.7                     | 3.3        |
| 2009-10 | 4.5                     | 3.4        |
| 2010-11 | 4.3                     | 3.5        |
| 2011-12 | 4.3                     | 3.4        |
| 2012-13 | 4.2                     | 3.5        |
| 2013-14 | 4.2                     | 3.6        |
| 2014-15 | 4.2                     | 3.5        |
| 2015-16 | 4.1                     | 3.5        |

COMPANIES WITH LABORATORY OR RESEARCH FACILITIES<sup>2</sup>



EVOLUTION OF PRIVATE PARTICIPATION IN R&D EXPENDITURE, 1970-2013 (% OF GDP)<sup>3</sup>



In 2014, the business sector financed 32% of R&D expenditure. In resource-intensive countries, private participation takes decades to increase



It has taken more than 7 years to obtain a new variety of raspberry.



It took BioSigma twelve years to obtain industrial level bioleaching of low-grade sulphide copper ores.



**Patricio Meller Bock, CNID Advisor**

Patricio is a Civil Engineer from Universidad de Chile and he has a PhD in Economics from the University of California, Berkeley. He is currently President of Fundación Chile and Senior Research Professor and Project Director of Corporación de Estudios para Latinoamérica (CIEPLAN). He was a director of CODELCO (2005) and served as an IDB consultant and in the World Bank.



## Research and Development in production companies

By Patricio Meller Bock



The traditional innovation indicator is Research and Development (R&D) expenditure as a percentage of GDP. Chile spends about 0.4% on R&D.

This value is reduced relatively further when we consider who does the innovating (companies, universities or the public sector) and it becomes clear when we count how many US dollars productive companies invest in R&D per person employed.

In a globalised world, what matters is not the GDP percentages, but the amounts spent on R&D per person employed. In this regard, while in South Korea the private sector spends US\$ 1,627 per employee on this item, in Chile the equivalent figure is US\$ 56 per employee, i.e., twenty-nine times less.

Why do Chilean productive companies invest relatively little in R&D?

In our opinion, the Chilean businessman views imported machinery as a “black box and a plug”. The only thing he is interested in is to plug in the machine to produce. In contrast, in South Korea, they are interested in and concerned about understanding how the machinery works. So, they disassemble “the black box” and reassemble it.

This is what is called reverse engineering, which is a process to acquire technological learning and knowledge on how innovation is made.

The Chilean entrepreneur is a passive user of technology. He does not think it necessary to incur in costs associated with learning modern technological know-how.

In an integrated and globalised world, it is less expensive and less risky to constantly import technology produced by developed countries. While Asian entrepreneurs are interested in understanding the technology to facilitate the adoption and technological adaptation process. Furthermore, they have a long-term goal, i.e., they produce innovations and improve modern technology. The Asian entrepreneur also has a (long-term) goal of eventually becoming a technology exporter.

To be competitive in the 21st century requires learning to continuously innovate. For this purpose, Chilean entrepreneurs should adopt the vision and behaviour of Asian entrepreneurs.

## Innovation is not the same for everyone: the wide world of small-sized enterprises

The challenge is not only to make firms more innovative, but to also make this effort worthwhile.

It is a well-known fact that small-sized enterprises dominate the Chilean business scene. To be precise, microbusinesses are the most common, representing almost three-quarters of all existing firms. SMEs account for almost all the remaining quarter. For all these enterprises, it is not easy to innovate and benefit from these innovations.

Innovation requires the ability to develop or incorporate knowledge into the activity undertaken, thus creating value for customers. Hence, one of the barriers faced by our small-sized businesses is the relatively low education level of their owners and managers, which declines as the firm size decreases.

Although years of formal education are not a perfect predictor of business management capability, there is a strong connection. In the more advanced OECD countries, this difference in education level of the people responsible for the different sized businesses is not significant.

The recent Business Development Centres<sup>7</sup> aim to overcome this barrier in small and micro enterprises, as they present a progression

route and have the support of higher education institutions to provide support entrepreneurs.

However, there are additional problems. Based on a study conducted using national survey data<sup>8</sup>, return on innovation investment varies proportionally with the business size; it becomes negative in the case of small businesses. In other words, most microbusinesses that claim to have innovated did not experience a rise in sales or a reduction in cost that would make their effort worthwhile.

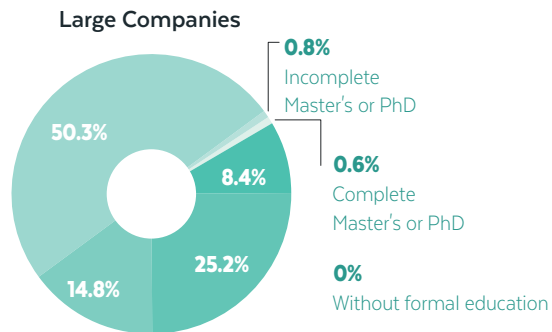
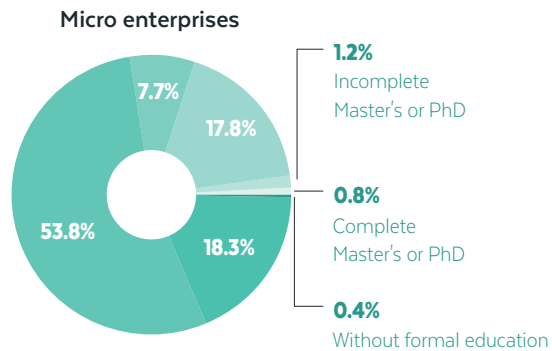
This indicates that there are additional factors to be considered, such as access to distribution networks and the opportunity to secure funding to scale up operations. This may also be influenced by other elements, such as barriers imposed on established companies or regulations that do not leave room for innovations developed by innovators. These aspects require further study, but they reveal that the challenge is not only to make businesses more innovative, but to also make this effort worthwhile.

1. Ministry of Economy. Fourth Microenterprise Survey. December 2015.
2. III ELE, Ministry of Economy.
3. Department of Economic Studies and Taxes of the Subdepartment of Strategic Management and Tax Studies of the Internal Revenue Service; data as of September 2016.
4. Ministry of Economy (2016). *Dinámica empresarial: brechas regionales y sectoriales de las pymes en Chile*. 2005-2014.
5. Department of Economic and Tax Studies of the Sub-directorate of Strategic Management and Tax Studies of the Internal Revenue Service (SII), data as of September 2016.
6. Álvarez and Crespi (2015).
7. Created by SERCOTEC and based on the successful experience of the US Small Business Development Center.
8. Álvarez, Roberto & Crespi, Gustavo (2007). *Multinational Firms and Productivity Catching-up: The Case of Chilean Manufacturing*. Central Bank Working document, Santiago, Chile.



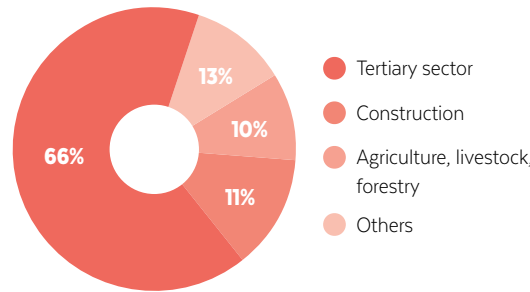
46.3% of microentrepreneurs declare that they earn between 0 and \$225,000 per month.<sup>1</sup>

EDUCATIONAL DIFFERENCE BETWEEN LARGE AND MICRO BUSINESS OWNERS<sup>2</sup>

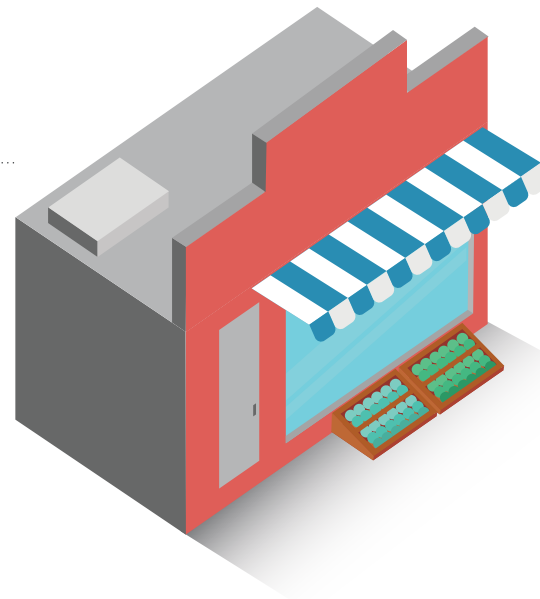
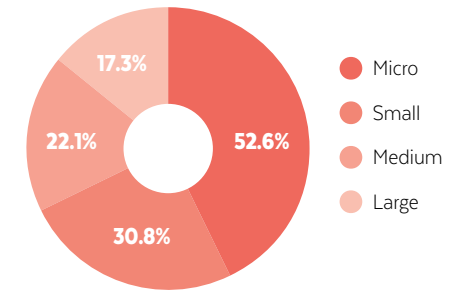


- Complete Master's or PhD
- Higher education completed
- Complete school education
- Without formal education
- Incomplete Master's or PhD
- Incomplete higher education
- Incomplete school education

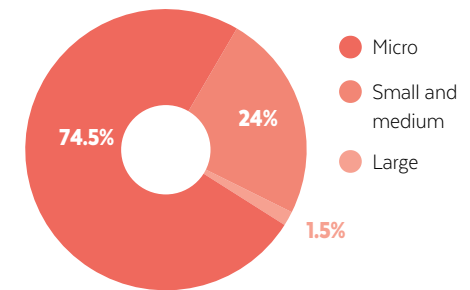
IN WHICH SECTOR?<sup>3</sup>



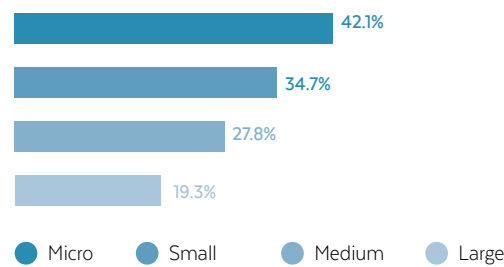
HOW MANY OF THE COMPANIES CREATED IN 2007 ARE STILL ACTIVE IN 2014?<sup>4</sup>



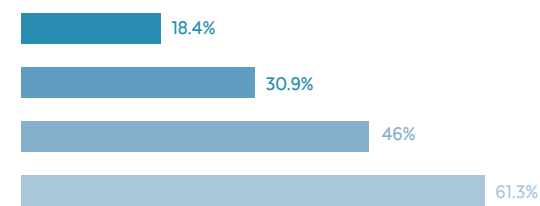
WHAT PROPORTION ARE THE SMALLER COMPANIES?<sup>5</sup>




WHAT PROPORTION OF COMPANIES HAVE FINANCIAL RESTRICTIONS?<sup>6</sup>




WHAT IS THE PROPENSITY TO INNOVATE IN COMPANIES OF DIFFERENT SIZES?<sup>6</sup>



The smaller the company, the less likely it will innovate and the greater the financial constraints



## Information and communications technologies offer great opportunities for small businesses



Spreading the full potential of STIs to boost efficiency and productivity in small-sized enterprises, and to support their effective incorporation into business, should be a priority.

Most small businesses are involved in trade and service activities. These areas are where the use of communications and information technologies can make a big difference.

For instance, the impact these technologies have had on taxi services. More than the emergence of alternative systems, the truth is that today traditional services have outstandingly improved their efficiency and productivity thanks to the contribution of various mobile applications. Thus, for example, by using these apps drivers can now be contacted by mobile phone and they provide the estimated time of arrival, or to find the fastest route to a destination, which saves time and fuel. Drivers also have applications that allow them to locate cheap fuel and spare parts stores. These apps provide multiple benefits for everyone who is directly involved and they also increase overall economic efficiency.

However, this is a rather exceptional use of these technologies by small entrepreneurs in Chile. In fact, in most cases, the Internet

and its applications are used for very limited and trivial tasks. Apart from sending emails or paying bank accounts, more sophisticated uses, such as access to financial market data or to make online purchases or sales, are rare. We are even further away from those small entrepreneurs who hire specialised services to manage their local market positioning via social media, which today are common in other countries.

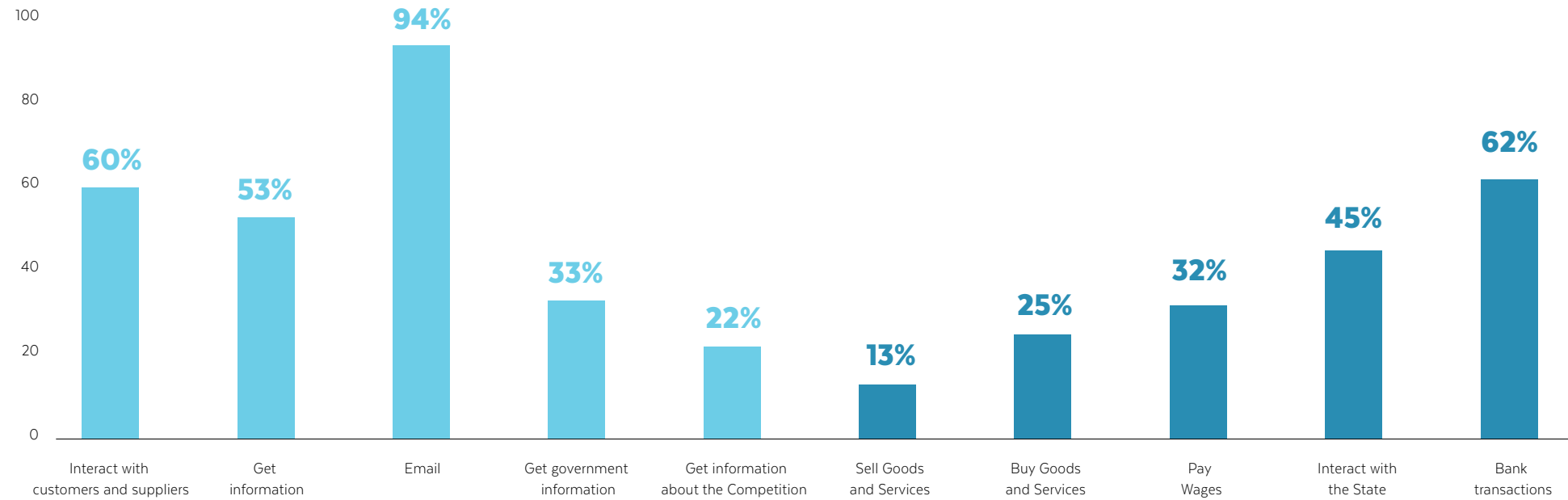
The lack of knowledge about the opportunities to improve their performance, and the lack of preparation to use them, explains to some extent the low penetration rate of these tools in small-sized businesses (although it is fair to say that our large companies do not do very well in this area either). Given the high participation rate of these businesses in trade and service activities, spreading the full potential of these communications and information technologies to boost efficiency and productivity, and to support their effective incorporation into business, should be a priority for the outreach activities carried out with public support.

However, these are not the only obstacles faced by our small-sized enterprises.

1. III ELE, Ministry of Economy.

## WHAT DO SMALL-SIZED BUSINESSES USE THE INTERNET FOR?<sup>1</sup>

● Basic level ● Advanced level



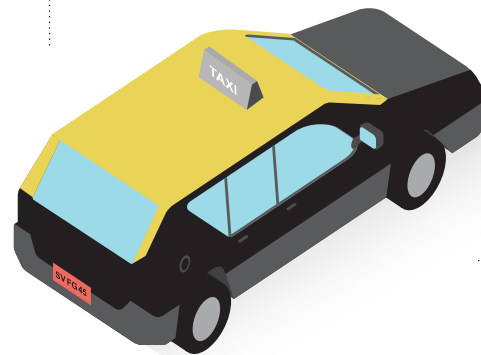
## THE IMPACT OF DIGITALIZATION CAN BE KEY FOR SMES

### Demand Connection Application

- Convenient way to order and pay trips.
- Customer safety.
- Taxi drivers don't waste time or fuel looking for customers.
- Customers and taxi drivers save time and money.

### Connection sensors and vehicle status

- Reduced maintenance costs.
- Reduced insurance costs.



### GPS navigation system for route optimization

- Saves time.
- Reduced fuel consumption and wear and tear on the vehicle.
- Transparency in the relationship with the passenger.

### Applications for access to inputs

- Cost reduction.
- Time reduction.

## Small-sized businesses face multiple obstacles to their development

Levelling the playing field for small-sized businesses and incorporating them into the present technology revolution is key for them to have better opportunities to thrive and to close gaps.

The use of digital tools offers small-sized businesses interesting ways to improve their efficiency and productivity. It also gives them the opportunity to incorporate new marketing channels. However, it is astonishing that even relatively simple tasks are not done using these technologies.

This cannot be simply attributed to a lack of knowledge or understanding of how the technology works. A clear example is the low penetration rate of electronic payment methods in farmers' markets. The advantages are obvious: for example, they facilitate the customers' shopping experience, they do not need cash, and it reduces the risk of theft associated with handling cash. But why are electronic payment methods not extensively used in farmers' markets? One reason is that transaction fees are too high and more significant than for large companies.

This is just one example of the difficulties faced by small-sized businesses. For the businesses that embrace radical innovation and change the way they do things, collusive practices by large companies can create major barriers, as can permits or authorisations managed by officials who, when in doubt, prefer to avoid risks and choose to reject applications.

Significant efforts have been made. Initiatives such as Empresa en un Día and Escritorio Empresa, have made entrepreneurial processes easier and much more efficient.

Continuing to level the playing field and helping small-sized businesses to join the present technological revolution continues to be an important task for them to have better opportunities to thrive and thus reduce the productivity and inclusion gaps in our economy.

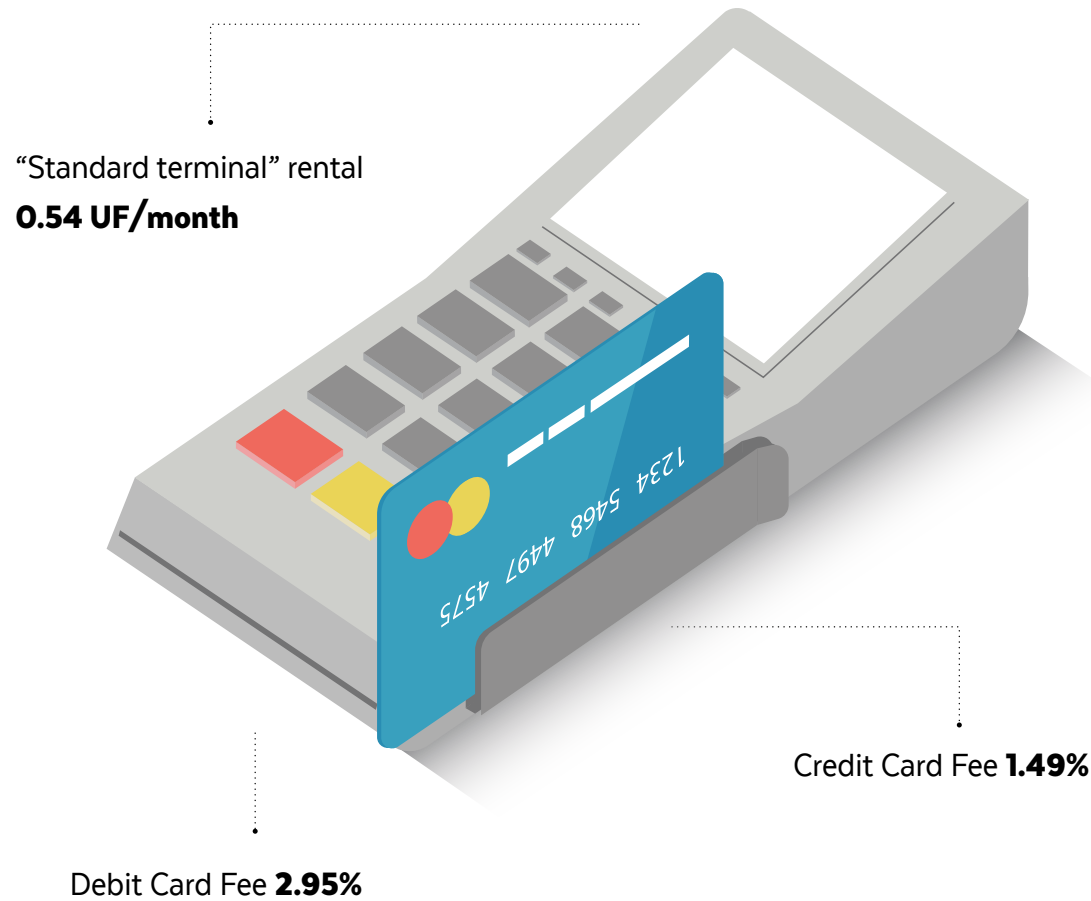
### Sweden leads the race to become a “cashless society”<sup>3</sup>

“According to the Riksbank, cash transactions made up barely 2% of the value of all payments made in Sweden last year - a figure some see dropping to 0.5% by 2020. In shops, cash is now used for barely 20% of transactions, half the number five years ago and way below the global average of 75%.

Astonishingly, about 900 of Sweden's 1,600 bank branches no longer keep cash or take cash deposits”.

1. [www.transbank.cl](http://www.transbank.cl)
2. Asech (2014). Report: “Libre competencia en Chile y el ingreso de los emprendedores al mercado” Asech, Santiago, Chile.
3. The Guardian, 4 June 2016. <https://www.theguardian.com/business/2016/jun/04/sweden-cashless-society-cards-phone-apps-leading-europe>. Consulted in March 2017.

STANDARD SERVICES FINANCED BY AN SME\*  
FOR ELECTRONIC TRANSACTIONS<sup>1</sup>

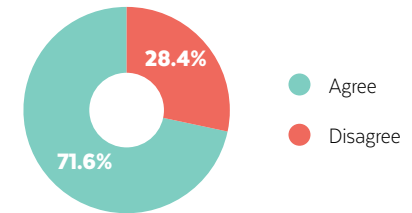


\*For the areas of farmers’ markets, kiosks, bakeries, pastry shops, rotisseries, fish shops, butchers, refrigerators, prepared foods, beauty salons, cosmetology, hairdressers, haberdashery and parcel shops, minimarkets and convenience stores, video clubs, betting shops.

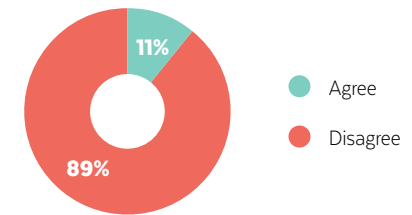
\*Transbank offers discounts for transaction amounts based on a table. But for smaller businesses it is difficult to get a big discount because of their transaction levels.

“Multicaja, Kross, Atrapalo, Benedictino, are some cases of enterprises that are stuck or delayed for reasons beyond their control (monopolistic practices and abuse of dominant position by the competition).”

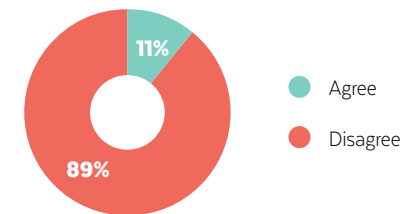
Do you think that in in your market, there are anti-competitive practices by your competitors?<sup>2</sup>



Do you think that in today’s Chile there are conditions for small businesses to compete with large ones?<sup>2</sup>



Do you think the government has succeeded in regulating antitrust practices?<sup>2</sup>





**Pamela Chavez Crooker, CNID advisor**

Pamela is an Aquaculture Engineer from Universidad de Antofagasta, she has a Master of Science and PhD in Molecular Microbiology and Biotechnology from Kyoto University, with postdoctoral studies at University of Hawaii, Manoa. She also completed Columbia Business School's Executive Business Program, USA. She is currently a senior researcher and partner of Aguamarina S.A., a mining biotechnology firm located in Antofagasta.



## Innovating from the regions

By Pamela Chávez Crooker



Innovation, especially technological innovation, seeks to solve challenges based on knowledge. A technology-based company must also take its solution to the market in a timely and competitive manner.

In mining, a key extractive industry for Chile, we have managed to establish in the north of Chile a group of these companies that combine “mining know-how” with scientific-technological knowledge. This is the case of Aguamarina, applying biotechnology to large-scale mining; Neptuno Pumps, innovating in circular economy, with mining pumps and energy and water projections; PowerTrain Technologies, supporting engine failure at high altitude caused by reduced oxygen; Nanoprocess, exporting copper as nanoparticles of highly competitive sizes; Scrum, providing logistics software to the mining sector and now also to the communications industry; Bejos Ingeniería, manufacturing bricks for industrial construction using ash from thermoelectric power plants; Propipe, from an engineering approach, it supports innovation in metallurgical processes. These companies all produce patents, high-level publications and exports. Some have offices in other countries.

Initiatives that bridge the gap between science and industry are essential. For example, the World-Class Suppliers Programme launched by BHP Billiton, which has helped to reveal the technological


challenges in mining and ensure technological developments reach the customer. This programme has helped to go from dozens to hundreds of technology-based companies and to accelerate industrial scaling of solutions in addition to a business plan to distribute them inside and outside Chile and not just in the mining industry.

This is the natural space for talent, i.e., new engineers, doctors and post-doctoral students who should return to Chile over the next few years, creating an effective bridge between Science and Industry.


This is what opens the way towards knowledge economy and towards Chile’s growth.

To believe in technological entrepreneurship in Chile is to believe in local talent, which is extraordinary. Chileans should feel proud of what we have achieved. To move towards development and a better quality of life for everyone, we must trust people, talents and move firmly forward with programmes that support new generations to be entrepreneurs.

Investing in knowledge entrepreneurship is to invest in Chile’s development.



## The irruption of our entrepreneurial culture has gained worldwide recognition



Chile has become an important leader in the region by building an ecosystem and culture to boost innovative business.

For almost two decades now, Chile has been creating conditions for dynamic entrepreneurship.

Chile has gained a leading role in the region by building an ecosystem and culture to boost innovative business. In some areas, this leading position goes beyond our continent. To a large extent, this reflects an active and prolonged public policy that has fostered the development of support organisations and laws that early on create favourable conditions for different types of venture capital.

Thus, for example, Chile has always led the quality ranking of the regulatory and institutional environment for venture capital that LAVCA<sup>3</sup> periodically prepares for the region. It is also in the world's top 5 in acceleration activities. And, of course, the Start Up Chile programme has helped to position Chile as a country that encourages entrepreneurship in the eyes of the world.

Thus, unlike the diagnosis of only a few decades ago, the enthusiasm for entrepreneurship has spread to places where it used to be something foreign. For example, this is the case of university students.

The incorporation of laboratories or entrepreneurship courses in practically all the country's universities has also contributed to this, as well as the proliferation of shared work spaces (coworking) throughout Chile.

This interest also extends beyond business activities to achieve social impact. For example, every year thousands of people participate in the International Festival of Social Innovation (IFIS).

In short, Chile has undeniably created an environment to promote dynamic entrepreneurs.

### **Bulk internet at local corner shops**

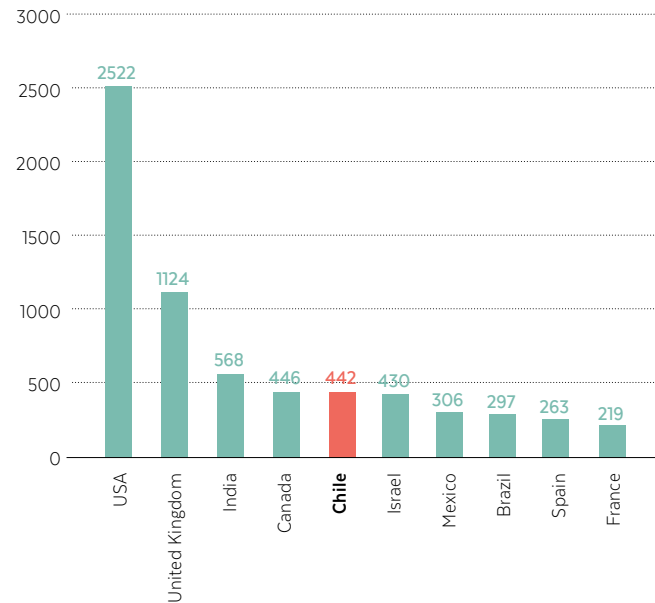
Algramo's social innovators – bulk distributors in local stores and winners of the 2015 Chivas Venture “The Venture” award, created the company Alcom that provides Internet through the same “red zone” shops, i.e., urban areas where telecommunication distributors do not have coverage. The stores receive a signal from a wireless point-to-point system transmitted by antennas installed in safe locations nearby, approximately one kilometre away.

1. Global Accelerator Report 2015.
2. Chilean Chapter of the Global Entrepreneurship Monitor.
3. Latin-American Equity and Venture Capital Association.



## TOP 10 IN ACCELERATION OF START UP VENTURES<sup>1</sup>

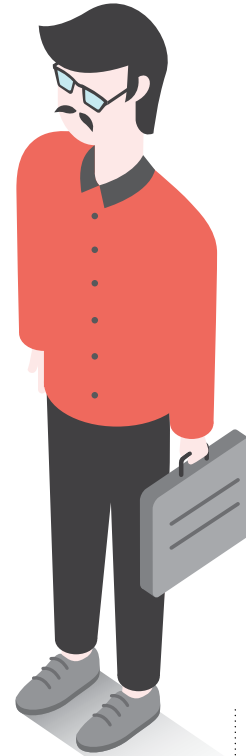
Amount in US\$



### Between 2008 and 2015

Chile has led the way in the business environment for venture capital in Latin America (LAVCA Scorecard 2016 Reports).

The enthusiasm for entrepreneurship has spread in Chilean society, even in areas where it was unheard of.



## NEW FORMS OF SOCIAL ENTREPRENEURSHIP EMERGE<sup>2</sup>

### 2015

Adolfo Ibañez University opens the Philanthropy and Social Investment Centre, the first of its kind in the country.

### 207

is the number of social entrepreneurs in Chile in 2015, with an average age of 40.

### 2010

the first Investment Fund is created Social (FIS), managed by Ameris Capital.

### US \$10 MM

have been spent in the impact investment market between 2002 and 2016.

*“Entrepreneurship and innovation are now required in over a hundred courses.”*

El Mercurio, 20 June 2016.

## The challenge of driving innovative entrepreneurship

So far, entrepreneurial growth and productive transformation have not been significant. Except in a few cases, they have not had a major impact on the economy.

Despite achievements in creating a dynamic entrepreneurial ecosystem, the truth is that so far, growth and productive transformation results have not been significant. Except for a few companies that have achieved or are on the way to achieve global presence, they have not had a significant impact on our economy.

Different factors seem to explain this weak impact. First, as shown in a recent study commissioned by the CNID<sup>5</sup>, only recently the government-supported Venture Capital Funds have started to invest in technology companies. In fact, it is only since 2010 that investment portfolios have recorded a presence of about 40% of this type of enterprise.

Second, entrepreneurs perceive that these funds negotiate their participation disproportionately in terms of the actual value they add. At the same time, the people who manage the funds complain

about the entrepreneurs' lack of understanding. As a result, few negotiations are successful.

Third, Chile does not seem to have the conditions to globally escalate business. In order to do so, companies look to set up business directly in the U.S. and receive U.S. funding, reducing local impact. There are also those who argue about the importance of giving time to learn and for the ecosystem and different actors to mature.

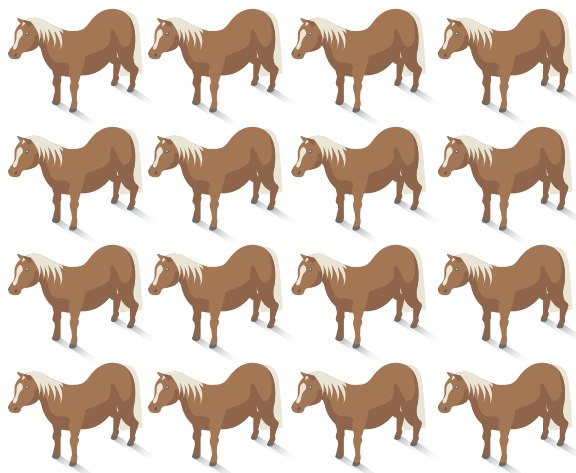
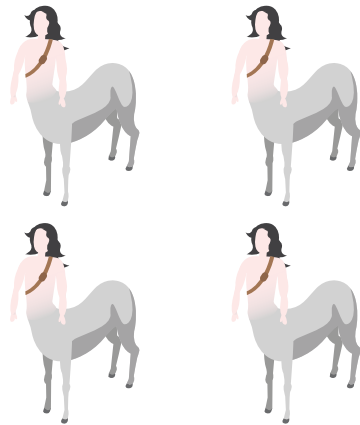
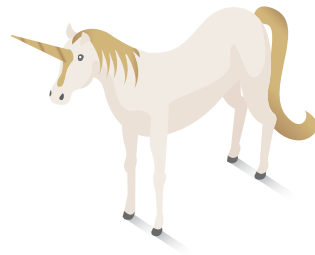
However, an encouraging sign is that there are more technology companies in the fund portfolio.

In any case, international experience shows that, except in very few places and in special circumstances, this is not a high-impact path. In general, venture capital represents a low figure as a percentage of GDP and has flourished more in areas with a vibrant capacity for technological innovation, such as Silicon Valley, Israel or Boston.

This is by no means saying that this line of activity should not be promoted, but it does warn us not to set expectations too high for its role in a structural change process.

1. <http://www.economiaynegocios.cl/noticias/noticias.asp?id=216452>. Published on 4 January 2016.
2. Start Up Chile Impact Report 2016.
3. Echeopar, G. (2017). *Estimación del Impacto de la Política Pública de Apoyo al Capital de Riesgo*. CNID Studies Collection. Santiago, Chile.
4. Corfo UDD, 2016.
5. Echeopar, G. (2017). *Estimación del Impacto de la Política Pública de Apoyo al Capital de Riesgo*. CNID Studies Collection. Santiago, Chile.

ASSESSMENT OF THE MOST SUCCESSFUL CHILEAN START-UPS<sup>1</sup>



In Chile there is an estimated ecosystem of over 1,000 startups and, according to Corfo estimates, only one of these companies is in the Unicorn category: Crystal Lagoons.

THE CHILEAN START-UP PROGRAMME IN FIGURES<sup>2</sup>

**670**

Active start-ups as of 2016

**32%**

Have activities in Chile with about 500 users

**30%**

Of job creation in Chile

**15%**

Sales are from Chile

VENTURE CAPITAL INDUSTRY

**1998 - 2015**

**US\$ 531 million**

**US\$ 394**

CORFO

**US\$ 137**

Private

Only in recent years has the venture capital industry turned to technology investments: From 2010 they represent about 40% of their annual investments.<sup>3</sup>

**33**

Operating Administrators

**46**

Funds created

**234**

Supported Companies

WHY IS OUR VENTURE CAPITAL INDUSTRY INEFFECTIVE?

**1**

Not willing to relinquish control to scale up globally.

**2**

The market is small.

**3**

There's a lack of specialization.

**4**

There are few exit investment options.

**\$18M**

is the average annual income of the social innovators who file them (57%).<sup>4</sup>

## The disruptive potential of foreign direct investment on R&D&I

Attracting more foreign firms to carry out R&D activities is a path we need to explore in Chile.

Transnationals are responsible for most of the R&D conducted by the private sector worldwide. In 2010, in the US, they accounted for 71% of all business R&D. Most were foreign companies, and they represented 14%. No less than 85% of R&D in the US was carried out by this type of company<sup>6</sup>.

These companies conduct most of their R&D activity outside their country. For example, 14% of private R&D in the United States is conducted by foreign companies. For the top 1000 transnationals doing R&D, 91% was conducted outside their headquarter countries, spending an average 55% of their budget abroad<sup>7</sup>.

This is a long-term trend, particularly given the US corporate facilities in Europe. But in recent decades, this has dramatically increased. In fact, in countries such as Belgium, Israel or Ireland, almost half of the investment in R&D is done by the transnational headquarters.

Chile has been a very important recipient of foreign direct investment (FDI). Between 2008 and 2014, this represented 7.8% of nominal

GDP, a much higher percentage than in the world and Latin America (2.0% and 2.8%, respectively). In the competition to attract FDI, Chile is among the top 20. Our economy has undoubtedly benefited from this process, including innovation and technology transfer cases that allowed, for example, the wine sector to be radically transformed, thanks to the influence of the Miguel Torres winery.

But we can benefit much more from FDI if we manage to attract more foreign firms to conduct R&D in Chile.

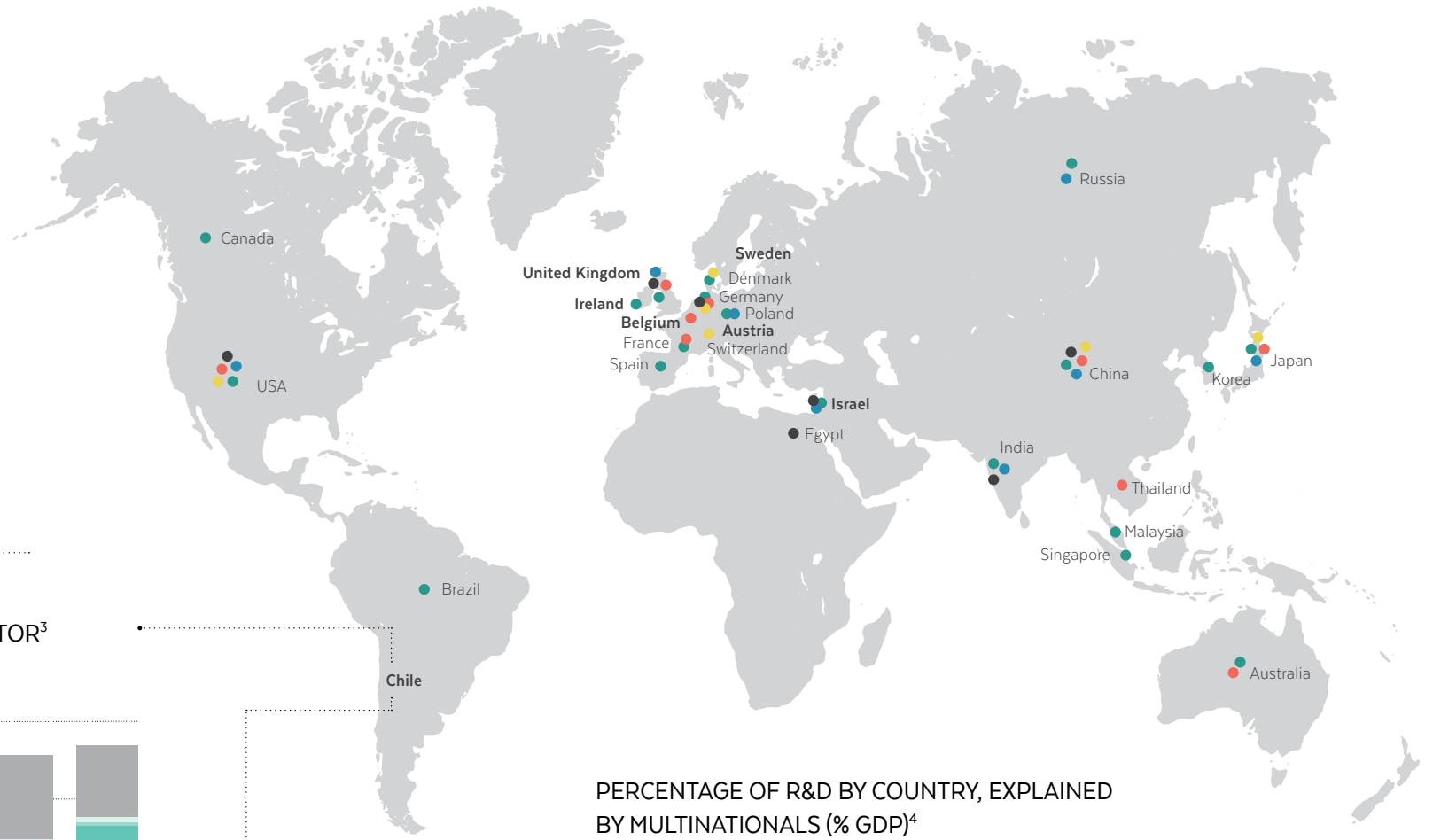
Improving engineering and technical education is certainly essential, but targeted campaigns are also required, accompanied by programmes to connect foreign firms with local capabilities. In the past, Corfo implemented a well-assessed programme with this profile, unfortunately, it was discontinued when it was transferred to the then Foreign Investment Committee. The recently created Invest Chile, a specialised agency and successor of the Committee - is set to return to this path.

1. Porter, M. & Stern, S. "Innovation: Location Matters" MIT Sloan Management Review 2001.
2. Author's own work, based on institutional data from each company.
3. Central Bank.
4. OECD MSTI (2015) and OECD (2014).
5. Marcelo Pino, Corporate Affairs Manager Huawei Chile at <http://www.biobiochile.cl/noticias/ciencia-y-tecnologia/ciencia/2016/11/23/huawei-instalara-su-centro-regional-de-innovacion-en-chile-para-la-industria-de-las-tic.shtml>
6. See study by the National Center for Science and Engineering Statistics <https://phys.org/news/2016-02-multinational-companies-majority-business.html> Consulted in December 2016.
7. World Bank, 2010.

Foreign companies doing R&D outside their home countries could give a boost to our innovative capabilities.

EXAMPLES OF R&D CENTRES OF MULTINATIONAL COMPANIES<sup>2</sup>

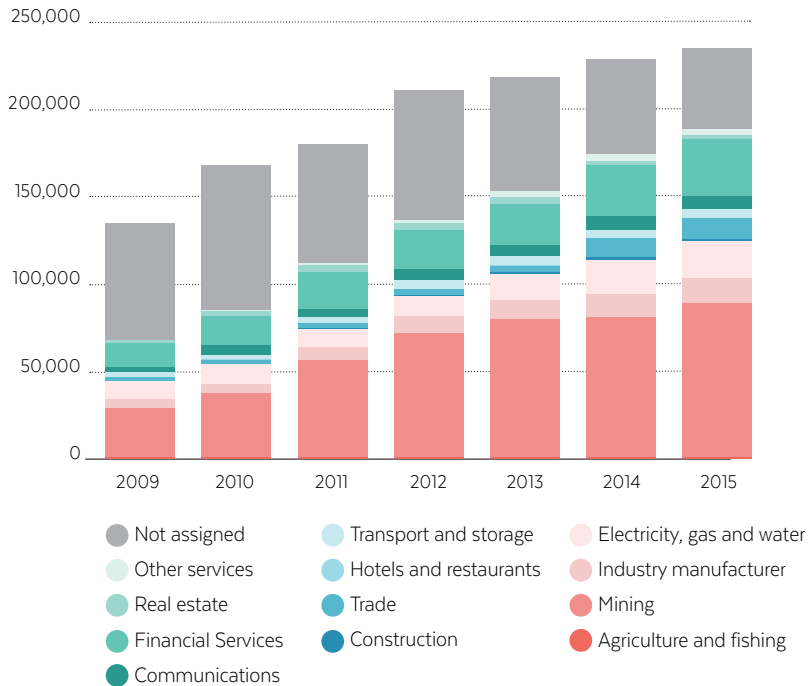
● Roche ● Motorola ● Samsung ● Toyota ● Microsoft



The greater the innovative capacity, the greater the probability of multinationals in situ<sup>1</sup>.

DIRECT INVESTMENT STOCK BY ECONOMIC SECTOR<sup>3</sup>

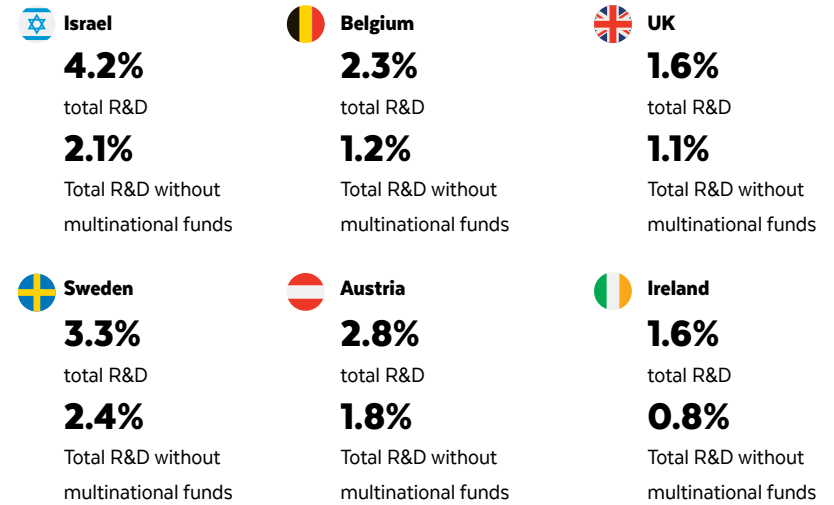
(US\$ MM)




Huawei to install its Regional Innovation Centre in Chile


Chile offers the best in the region to develop these initiatives and deserves to be a point of reference in Latin America.<sup>5</sup>

PERCENTAGE OF R&D BY COUNTRY, EXPLAINED BY MULTINATIONALS (% GDP)<sup>4</sup>





## The State could be much more active by using and promoting R&D&I



Science, technology and innovation allow the State to address challenges that are specific to its activities, improve its efficiency, increase its capacity to understand and even recreate its relationship with society.

Traditionally, we tend to focus on the role of the State in supporting STI by transferring funds to other actors, such as universities, companies or research centres. However, the State can drive STI development based on how it organises and addresses its tasks. Perhaps the most recognised case of radical innovation driven by the public sector was the SII [Chilean Inland Revenue Service] digital platform for income tax returns. This is a remarkable example because of its impact and exceptionality. In general, the Chilean government does not take full advantage of the opportunities offered by STI.

STI can contribute in different ways to the work undertaken by the State: addressing major challenges inherent in its work; improving its performance efficiency; helping to increase its capacity to understand and anticipate emerging phenomena; and even by helping to recreate its relationship with society.

How? First, by tapping into the creativity of other people. In fact, the State can expand and improve its performance by capturing what

society creates, both in terms of technology or innovative products, and what emerges from social innovation.

Second, the State can play a leading role in developing R&D&I. It can take advantage of employee skills, opening competitions such as the current “It Works!”, and promoting cross-functional management favouring innovation within the public sector. It’s true transformation obviously requires committed and motivated professionals, but it cannot ignore the need for more structural transformations in the State organisation and logic, so that it can effectively respond to the growing complexity of public challenges.

Finally, the State can take advantage of STI initiatives it has helped to finance. Today there is a growing interest in the research community to contribute to national development. For the latter, helping to improve the design and implementation of public policies and initiatives is natural. The State, to effectively harness this potential, requires the skills of counterparties, who can devote time to this work and have the power to influence decisions.

NATIONAL INSTITUTE OF INDUSTRIAL PROPERTY<sup>1</sup>

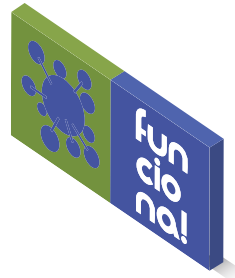
## First government agency to implement teleworking.



- The work is carried out outside Inapi's premises
- Only one day per week in the institution.
- There is no time control
- Commitment to increase production.

CONTEST WORKS!<sup>2</sup>

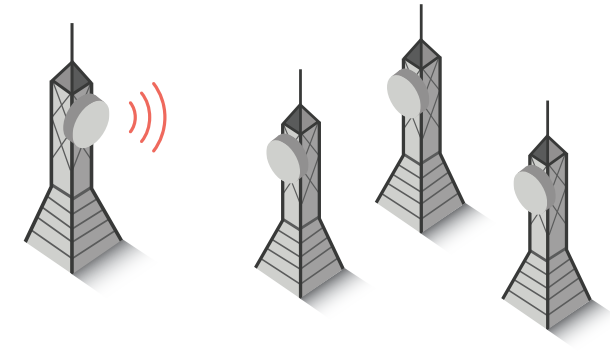
## Recognition of innovation



Recognition given by the Civil Service to public officials who promote innovation to improve management and generate more effective and efficient processes within their institutions.

PUBLIC MICROWAVE INTERNET

## Radio Frequency Network in Los Rios Region

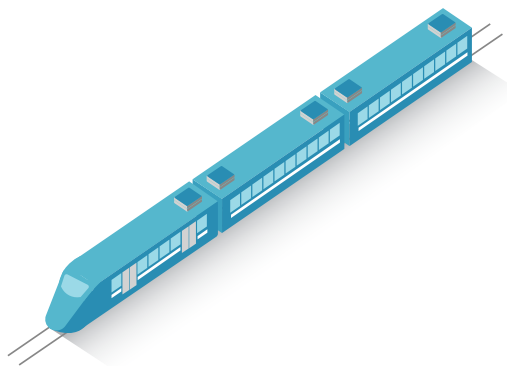


One of the winners of the Innova Salud 2016 contest, which maintains connectivity of health facilities in remote areas.

The State can also be an actor in science, technology and innovation.

METRO<sup>4</sup>

## 42% will be solar-powered from 2017

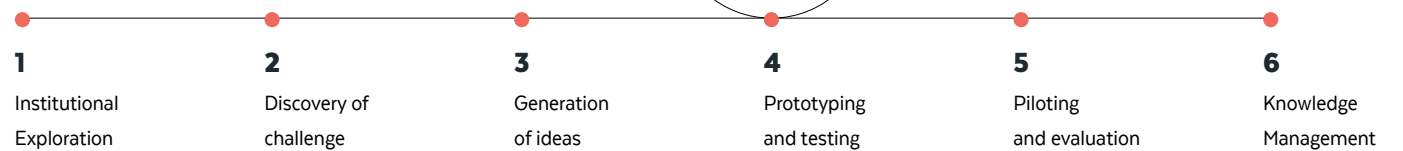


GOVERNMENT LABORATORY<sup>5</sup>

## How to manage innovation in public services?

The Government Laboratory develops, facilitates and promotes user-centred innovation processes within Chilean state institutions.

**Public Sector Innovation Model:**



### III. THE MOST IMPORTANT THING IS TO CREATE AND FOSTER CONNECTIONS, THE VITAL LINKS IN THE SYSTEM

## Institutions that connect scientific and technological research with public interest issues are emerging

The best performing innovation systems are populated by actors who specialise in filling the gaps between capabilities and needs, identifying and interpreting opportunities and challenges for the different parties.

A lesson learned from running national innovation systems is that coordination between the supply of skills (universities, researchers, technology companies) and the needs or opportunities for innovation (arising from companies, the State, or society) does not occur directly or spontaneously.

They do not necessarily know each other nor have natural meeting spaces. They do not necessarily have common interests or motivations, and, in many cases, they do not share languages or codes.

Hence, the best performing innovation systems are populated by actors who specialise in filling these gaps, identifying and interpreting opportunities and challenges for the parties.

In Chile we have few of these connectors. Some created in the '60s (technological institutes) never managed to recover from the neglect they were subjected to in the '70s and '80s.

Fundación Chile is one of the few organisations that has managed to maintain a value offer in this area, but even so, its own technological capabilities have undergone a sustained decline.

A low density of connectors makes it difficult for research results to be transformed into technological developments or innovations that will eventually be used, or for companies to find support for their innovation projects, or even to access knowledge from available technologies or practices. Fortunately, in the past decade this trend has started to reverse.

International centres of excellence, when they successfully establish collaborative relationships, reveal their contribution to transfer. In other cases, however, there seems to be competition with national organisations.

Different actors are gradually becoming aware of the need to improve transfer mechanisms. Several research centres have identified the need for specialised personnel to transform scientific results into innovative applications (where appropriate) and to disseminate the knowledge they create to the community.

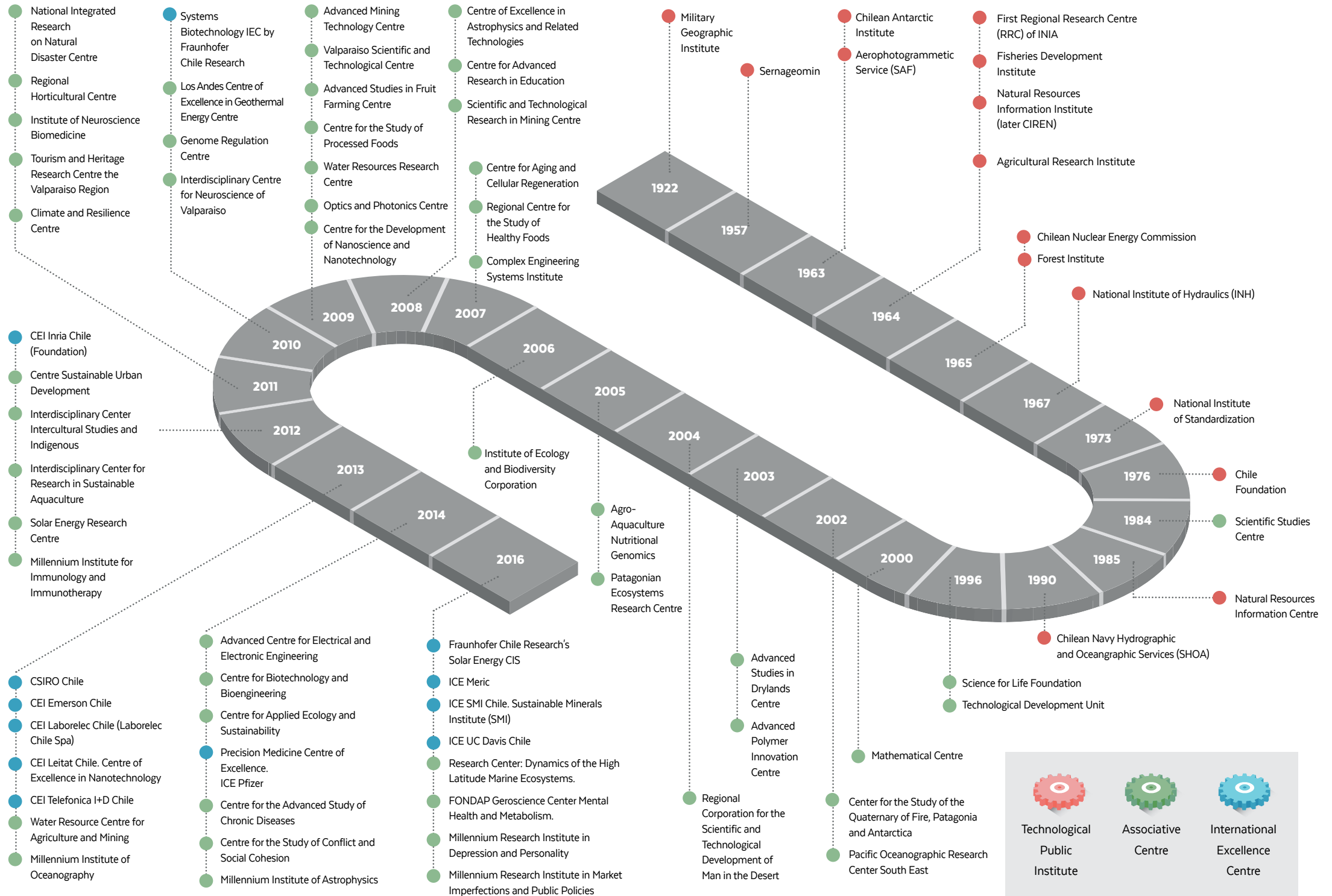
Many STI policies around the world have taken up the challenge to promote collaboration between different actors<sup>1</sup> in order to cause a significant impact for sustainable and inclusive development.

Source: Author's own work.

1. Nature Index Collaborations, 2015. 'Opening Borders and Barriers'. Nature 527, S80-S82 published online 11 November 2015. doi:10.1038/527S80a.



# GOVERNMENT-FUNDED SCIENTIFIC AND TECHNOLOGICAL RESEARCH CENTRES





**Servet Martínez Aguilera, CNID Advisor**

Servet is a Mathematical Engineer from Universidad de Chile and he has a PhD in Mathematics from Pierre-et-Marie Curie University, France. He is currently a researcher at the Centre for Mathematical Modelling. In 1993 he received the National Prize of Exact Sciences. He was President of the Academy of Science (2004-2009) and until 2012 he was the President of the Mathematics Union in Latin America and the Caribbean (UMALCA).



## Scientific Collaboration

By Servet Martínez Aguilera



Three decades of scientific development in Chile help to have a deeper understanding of the relationship between science and society: the virtuous circles between creation of ideas and socio-economic development that have named the successive eras since the Renaissance, and today are building national scientific centres.

Chile has been accumulating issues that cause significant social impact, such as natural-social disasters and the quality of education. They challenge our research capabilities because the entire national scientific research equals a good, medium-sized US research university. Therefore, the scientific activities needed to boost our development would have to be of epic proportions and this also requires a close scientific collaboration, both real and of excellence.

Science, like any activity, is marked by human factors, in this case scientific reflection, what it inspires and how scientists collaborate and share. Collaboration between research groups from different institutions (e.g., high-performance computing laboratory) is necessary to have reliable teams across disciplines, enabling Chile to properly tackle some of the major issues.


Science is capital-intensive: the budgets of the world's top universities are slightly below the national GDP. This means that sustainable

scientific growth requires a strong international presence, and although Chile does not have many problems to tackle, a successful outcome is not guaranteed.


In the long run, scientific disciplines are evolving. Some groups disappear as others emerge. This is basically due to global changes, to some of the ideas and paths that open or solve something, and to investments made by governments, universities and corporations in leading countries.

Thus, a long-term policy in Chile requires researchers and scientific centres to observe trends and progressive changes. An excellent cultural and basic science education is the best way to detect and deal with changes.

Likewise, our real comparative advantages are our cultural and scientific capital, our collaborative capacity, our national and international networks, integrating science into society and citizen culture: they allow us to continuously seize opportunities as they arise or as we create them.



## The ever-growing interest to connect is fertile ground for the leap we need



Science and technology allow us to improve the quality of our deliberation about the future we want to build together.

Decreasing returns on natural resources, ageing populations, social demands, global warming, industry 4.0 pose challenges of such magnitude that they require new development strategies based on cooperation, knowledge and dialogue.

For the world of science this means engaging more with the needs of society. However, we must be aware that the situation is more complex than, for example, requesting fewer publications and more patents.

One way to make a difference is by broadening the space for purpose-driven (or mission-driven) research, where both basic and applied science are equally necessary, and collaboration with other actors is possible and necessary.

The business world also needs to be more willing to work together. Hence, it is encouraging to see spaces such as the Innovation Club, which brings together a growing number of partners. The technology consortia have proven that the expectation of stakeholders can be adapted to build successful collaboration between science and industry, which can be sustained over long periods of time.

Likewise, in the context of Engineering 2030, new and promising ways to connect are being used, such as research internships organised by the Universidad de la Frontera or the Hub Maule Costa of Universidad de Talca. This is also the approach taken by Corfo to promote and create new technology transfer centres.

And we need to go much further. The agreement promoted by the CNID in pursuit of a virtuous, inclusive and sustainable mining industry, expanded the dialogue and collaboration to trade unions, indigenous peoples, local authorities, as well as to researchers, businessmen and politicians. In this process, the participation of everyone who contributes the vision of the social sciences and humanities is essential.

“The sciences have an irreplaceable role to reflect on our projects and opportunities for the future. They show us the Universe we are part and the opportunities presented to us. They help us anticipate new challenges and innovate how we respond. Finally, they remind us, with the disinterest and passion with which they seek the truth, what we are and the human meaning of everything we do”<sup>1</sup>

Source: Author's own work.

1. Excerpt from President Michelle Bachelet's speech at the inauguration of the Presidential Commission on Science for Development. January, 2015.

## MULTIPLY SPACES OF ENCOUNTER BETWEEN SOCIETY AND THE WORLD OF RESEARCH

### Maule Costa Hub

Universidad de Talca and companies in the region training professionals in strategic management for territorial innovation, with a plan to strengthen local capacities.

### I+T Node

Universidad de la Frontera's support programmes for closing researcher-company gaps, multidisciplinary research and entrepreneurship technology

### Associative research Centres

More than fifty associative research and interdisciplinary centres.

### Engineering 2030

10 engineering schools strengthening their links with productive sectors, with the support of Corfo.

### Regional Centre

13 research centres that address local needs with Regional Governments, with the support of Conicyt

### Research Centre Networks

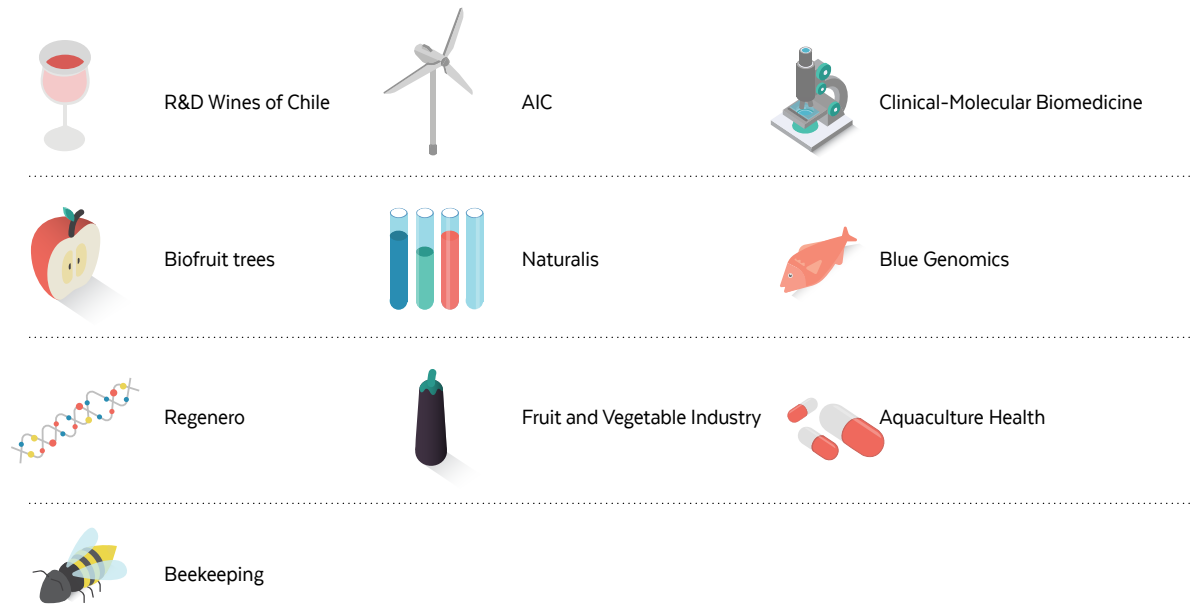
Network of 25 centres dealing with water resources (RedH2O) and Network of 9 Biomedicine centres.

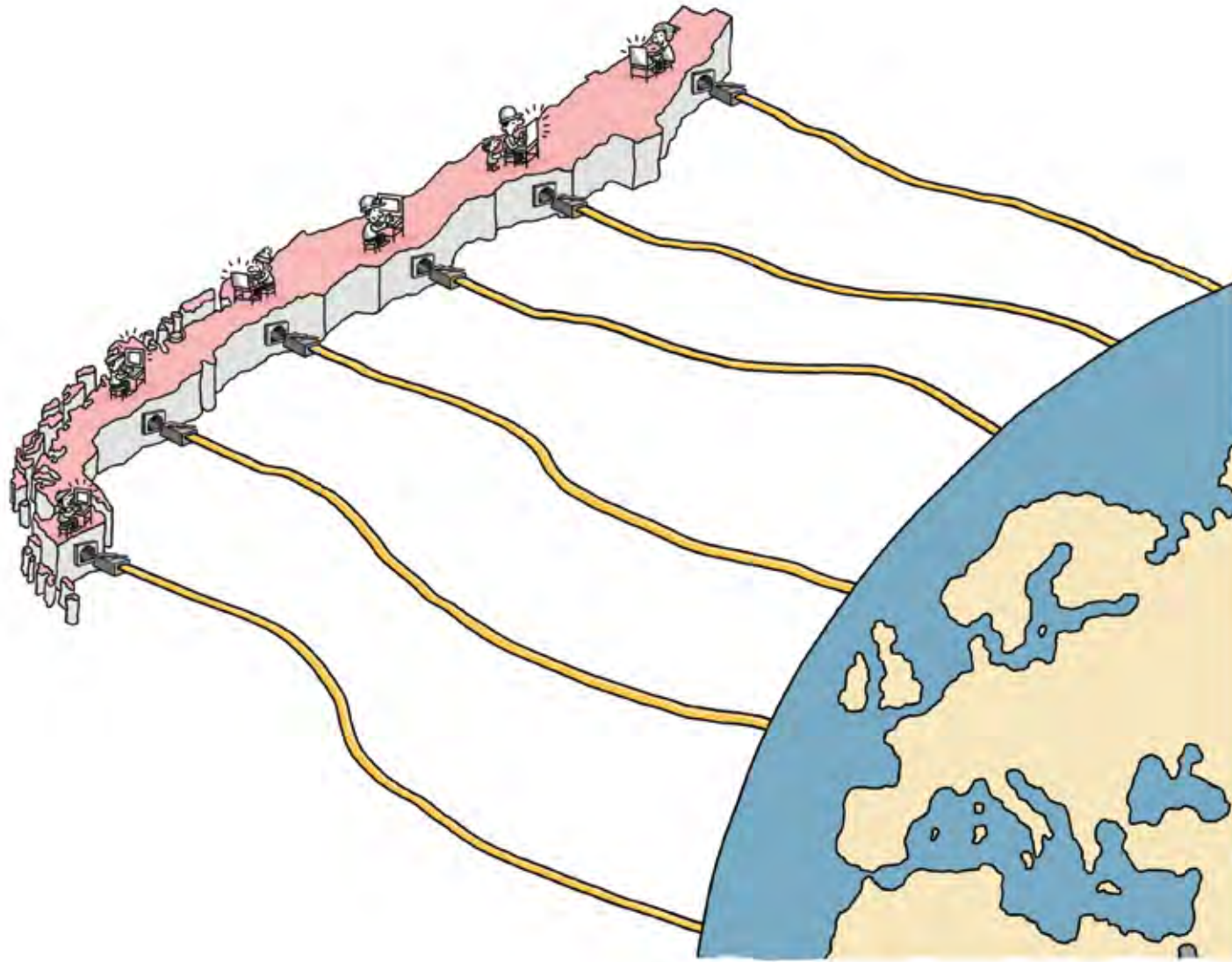


## An unprecedented process: COORDINATION EFFORTS IN THE MINING INDUSTRY



## ACTIVE TECHNOLOGY AND BUSINESS CONSORTIA





## 2030 Vision of Emerging Agents for Innovation<sup>1</sup>

---

“Chile in 2030 truly believes what is public is really public, that we believe in people again and where human beings are not a means to an end, they are at the heart of our concerns.

This is a country where education is designed for the 21st century, where creativity, critical thinking and the comprehensive growth of its people are encouraged. Where students are familiar with technology.

Chile in 2030 is a country that integrates difference; a country that is not divided by professional education or where people live; an equitable country where we all have the same opportunities at a starting line; a country where we value the difference between people and we understand it as an enormous power that drives our human creative and social potential.

Chile is a country where logic has changed, where individual decisions take second place, while joint and deliberative decisions take first place. A country where we have

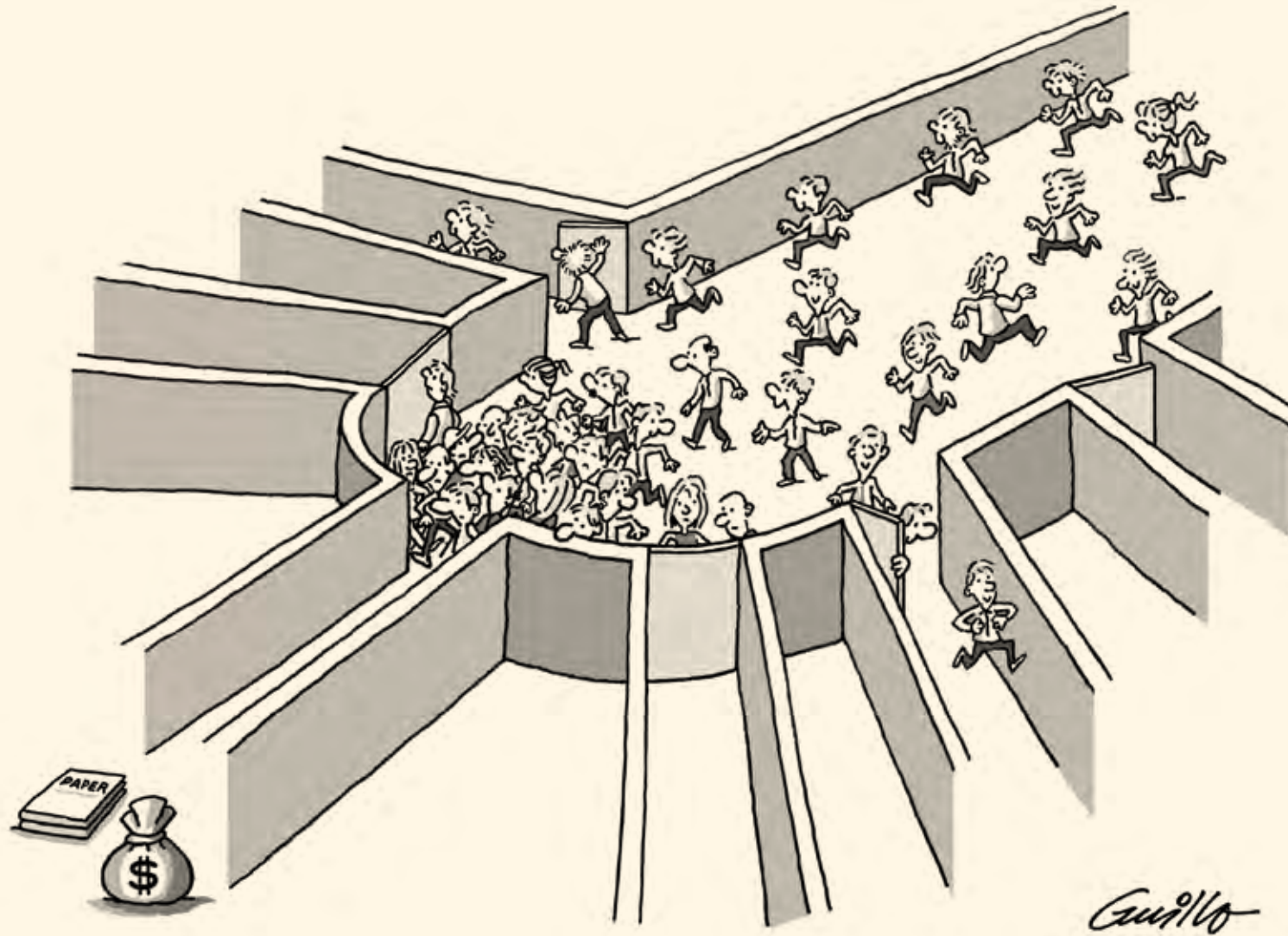
collaborative and democratic spaces for decision-making.

In 2030, we are a sustainable country, where we take into consideration the ecosystem in our production process and where, instead of using it as a means for our economic production, we feel part of it.

Finally, in the Chile of 2030, we are really integrated into the world, more than integrated, we are significantly contributing to society and to the globalised economy of the 21st century. Our researchers are making world-class contributions, our innovators and entrepreneurs are the pride of Latin America, and Chile is recognised as a leading country in development... but a comprehensive, sustainable, inclusive and human-scale development.”

1. Emerging Agents for Innovation Committee (2016). “Soñando futuro. Una generación comprometida con el desarrollo”. CNID, Santiago, 2016. Page 5.







## CHAPTER 4



## Our public policy on science, technology and innovation



### Presentation

The invitation is to look at our history, recognising our weaknesses and limiting beliefs and, at the same time, to identify and reveal experiences that show us we can move forward and expand more promising paths.

Science, technology and innovation have not, until now, been a real concern of public policy in Chile. Apart from a few major capital injections, the truth is that investment in this area has followed GDP growth. It has stagnated over the past few years.

In recent years, and despite the efforts of many - including the Council - with a few honourable exceptions, we have not managed to agree on and sustain a national or regional government policy, guided by goals that overcome differences, often more ideological than real, that divide us into governments of different stripes, and into scientists and economists.

Public action in science, technology and innovation calls for a systemic and comprehensive approach involving the whole of the State. So far, it has been built almost exclusively on the shoulders of Corfo and Conicyt. The positive performance of these two agencies has provided important achievements, but today we need, more urgent than ever, to understand that the role of STI is the responsibility of all public sector entities.

We can use multiple public policy tools to promote STI, which today are used in OECD countries, including but not limited to, transfer of resources, rules and regulations, public procurement and the continuous modernisation of the State.

Today we are also able to address the momentum in STI, overcoming entrenched beliefs that have been based on untimely comparisons with OECD countries. The reality in these countries, when they had the same income per capita as Chile has today, shows us that the

public sector continued to be the main contributor to R&D spending. Likewise, science was a priority, contrary to what happens when we look at the current reality of economies and societies that have reached a high level of sophistication.

The certainties that have guided the debate about the meaning and role of public policy in STI must be reviewed to move forward with more clarity and chances of success.

Today, in multiple initiatives and conversation spaces, more and more cross-cutting agreements are beginning to take shape, making us feel optimistic about moving towards a new stage in public action in the field of STI.

The invitation is to look at our history, recognising our weaknesses and limiting beliefs and, at the same time, to identify and reveal experiences that show us that we can walk and widen more promising paths.

## I. THE STI POLICY OVER THE YEARS: MORE WORDS THAN ACTION

## We have not succeeded in having decisive public efforts in science, technology and innovation

With few exceptions, our public efforts have not exceeded the natural increase in government spending and product over the years. The lack of clear goals around which to rally and coordinate policy efforts, has also been part of this history.

Since the turn of the century, public policy has focused on promoting STI, particularly in the context of its contribution to the country's economic development. For example, the significant increase in public spending to support STI, with sharp inflection points: the increase generated by copper mining royalties approved in 2005, and Innovation and Competitiveness Fund (FIC) was created; the Becas Chile programme was launched in 2008 by Conicyt; and the creation, through Corfo, of the innovation tax credit line launched in the first administration of President Bachelet and expanded by President Piñera.

However, apart from these specific events, our public efforts have not exceeded the natural increase in government spending and product over the years, which have even stagnated in recent times.

The idea of linking royalties with STI spending through a law was not approved by Congress, mainly because we could not agree on how to distribute these funds between Chile's mining and non-mining regions. This meant that, although there were additional funds from this source that went to the Competitiveness Innovation Fund (CIF), the funds were less than the tax revenues and failed to break the inertia of an increase based on GDP.

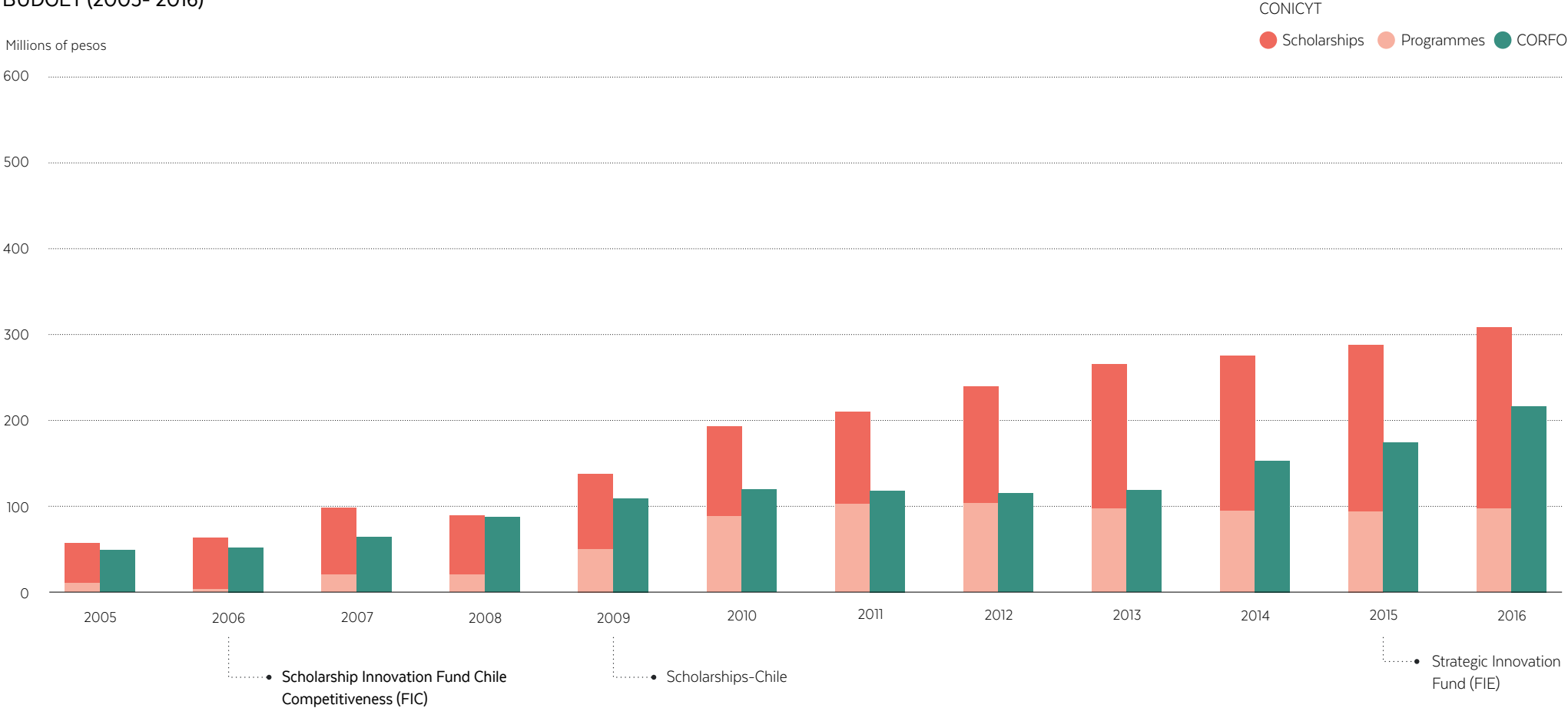
Thus, because of short-term needs and divisions, we lost an opportunity as a country to sow for the future.

The lack of clear goals around which to rally and coordinate policy efforts, has also been part of this history.

One of the reasons for creating the Becas Chile programme was to take advantage of the need to spend government surpluses abroad, rather than within the framework of a comprehensive policy of post-graduate development that considers a joint approach to training, attraction and placement, as pointed out by this Council at the time<sup>3</sup>. Today this action, which has certainly provided more PhDs, is faced with the challenge of placing the people who have been trained abroad, making evident the need for a comprehensive approach to STI policies.

1. Author's own work based on Budget Department.
2. Budget Department.
3. Guidance on institutional structure for advanced human capital development CNIC, 2009.

CONICYT VS CORFO (NO PSME PROMOTION)<sup>1</sup>  
 BUDGET (2005- 2016)



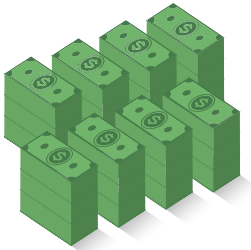
BETWEEN 2007 AND 2015

The specific mining tax collected

**\$1,904,141,933**

The Competitiveness Innovation Fund spent

**\$731,038,329**



AVERAGE ANNUAL GROWTH RATE OF FISCAL EXPENDITURE IN STI, WITH AND WITHOUT GRANTS AND R&D+I, 2003 - 2015 (BILLIONS OF 2014)<sup>2</sup>

**9.6 %**

STI including human capital (Scholarships)

**7.8 %**

STI excluding zhuman capital (Scholarships)

**7.4 %**

R&D&I

<sup>1</sup>Millions of real pesos 2006=1

## We need a policy that gives us purpose, facilitates coordination and, above all, adds more hands

In practice, and despite different government attempts, there has been no sustained policy to guide and coordinate efforts to support science, technology and innovation.

The institutional framework that organises public actions on science, technology and innovation has been structured around two fundamental pillars: the Ministry of Education (under which is Conicyt) and the Ministry of Economy (under which is Corfo). The assumption we embraced was that coordination between the world of scientific research, innovation and entrepreneurship, as well as the incorporation of other key public actors to implement major policy goals, would take place in the Inter-Ministerial Committee on Innovation. The latter would have to make its policy decisions based on the guidelines provided by the CNID (CNIC until 2014).

In fact, this theoretical scheme has not worked. The main proposals put forward by the CNIC in the 2008 strategy were partially adopted by the government at the time, but were later discontinued with the new coalition government, with different political views, because they

did not have broad political support. As a Council, we have not kept the same approach, nor do we have our own political weight needed to exercise influence. The Inter-Ministerial Committee on Innovation has hardly met during this period and, when it has, very few ministers have participated.

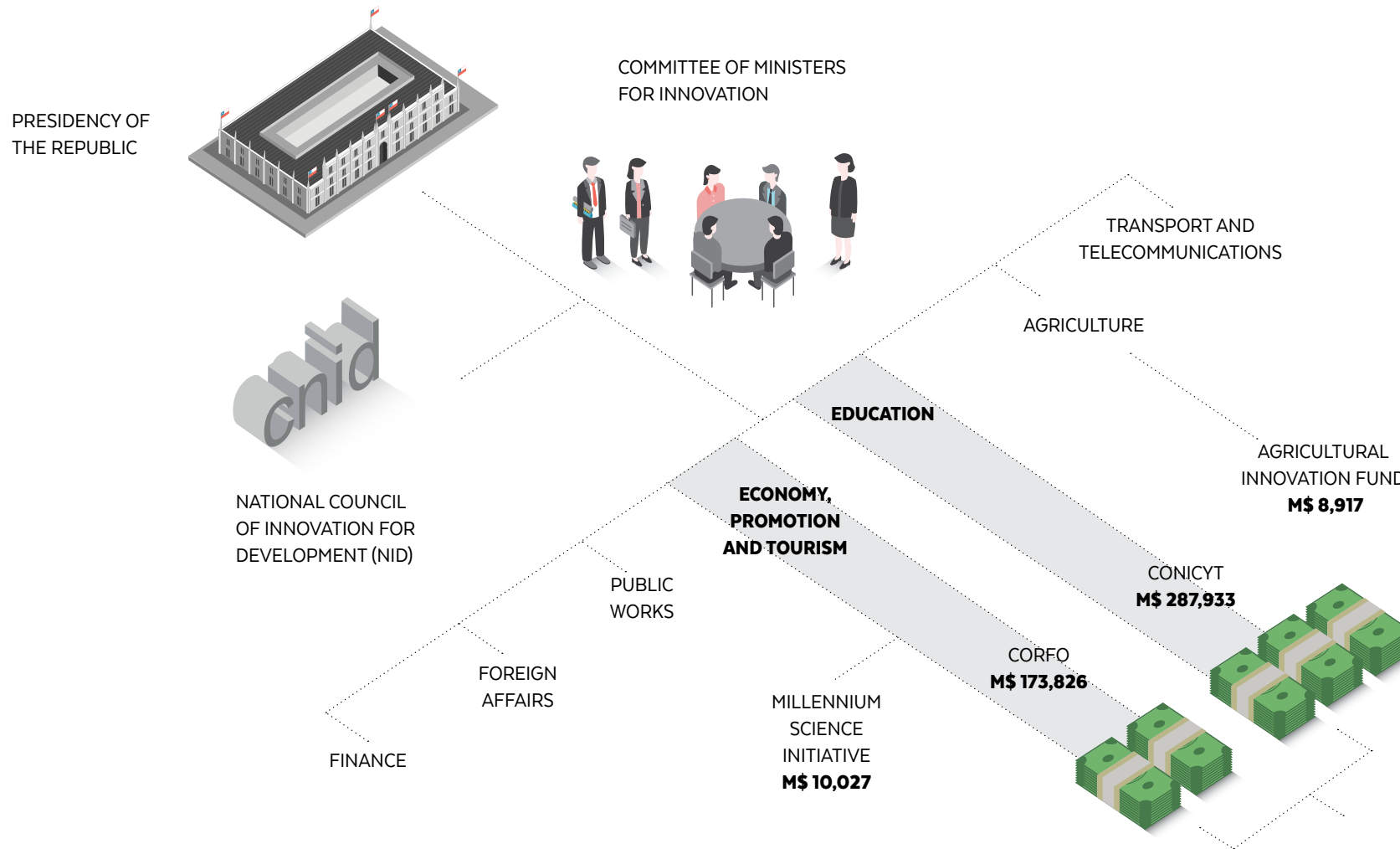
Thus, in practice, and despite different government attempts, there has been no sustained policy to guide and coordinate efforts to support science, technology and innovation.

What has essentially prevailed is the action to provide funds, through various instruments and programmes. Most have been carried out by Conicyt and Corfo, including key cases, but they have acted independently. There have been few connections between the two worlds and, additionally, the field of technological development has been in no man's land for a long time.

Another important effect in this area is that, despite the strength and prestige of both agencies, government actions in the field of STI have remained limited to these entities, and have not been adopted, as has been the case for many years in most OECD countries, by the whole public apparatus.<sup>2</sup>

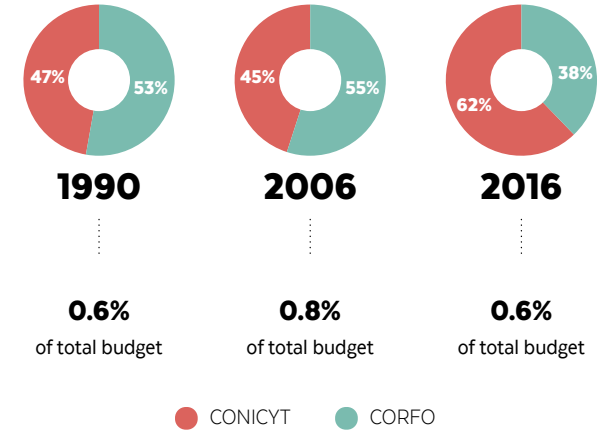
1. Author's own work based on Budget Department data.
2. See OECD (2009). "Work on Innovation. A Stocktaking of Existing Work STI." Science and Technology Policy Working Paper.

CHILEAN NATIONAL INNOVATION SYSTEM:  
A TWO-PILLAR MODEL<sup>1</sup>



Budget 2015. The amount of Corfo corresponds to entrepreneurship, innovation and competitiveness.

CONICYT AND CORFO BUDGETS



## The case of Corfo: an active agency that has accumulated knowledge, what does it need to do more?

The knowledge accumulated by Corfo is an asset that can thrive even more, if we are able to persevere and allow time for the processes to mature and bear fruit.

Corfo has made and continues to make an important contribution to the development of Chile. Its current role and scope have undeniably changed from the '50s or '60s, but it is difficult to find a successful innovative SME in the past twenty years that has not been supported by this agency.

Since the end of the '90s, it has been consolidating its role in encouraging innovation and entrepreneurship, while maintaining its role of promoting production. The institution's capacity to design and implement instruments and programs to add value in these different fields<sup>1</sup> has been endorsed by various impact evaluations.

However, despite budget increases, there seems to be a problem of scale in interventions; this hypothesis is supported by the large number of instruments managed by the agency. The assessment of Corfo's capacity to intervene in different areas has been combined with the variety of challenges facing our productive development, making this agency a tool and a partner on very different fronts.

Despite the contributions it makes in each area, today we need to coordinate this broad range of instruments into larger programmes.

This exercise requires broad agreement, both on how to define the different approaches regarding the intervention methods, since any far-reaching initiative involves longer periods of maturity and, therefore requires continuity. In this sense, the steps taken through the strategic programmes, which identify, together with business, academic, civil society and public sector actors, the challenges facing sectors or cross-cutting issues of our economy, offer an interesting opportunity by focusing on the generation of public goods. Support for stakeholder coordination and the provision of sectoral public goods are two of the tools that have been proven to be the most powerful in modern productive development policy.<sup>2</sup> The knowledge accumulated by this agency is an asset that can thrive even more, if we are able to persevere and allow time for the processes to mature and bear fruit. We believe that the conditions are already in place for this to happen.

Source Diagram: Author's own work based on Corfo data.

1. For example, see López, A. (2009). "Las evaluaciones de programas públicos de apoyo al fomento y desarrollo de la tecnología y la innovación en el sector productivo en América Latina. Una revisión crítica." Technical Note Inter-American Development Bank, April 2009
2. Sabel, C.; Fernández-Arias, E.; Hausmann, R.; Rodríguez-Clare, A.; Stein, E. (2012) "Export Pioneers in Latin America." Washington D.C., 2012.

Integrated Program by species Seriolay Corvina IPRO: Support Program for Productive Investment for the Reactivation Special Projects for the Improvement of the Entrepreneurial  
 Glossary 03 For the evaluation and/or monitoring of projects and programmes PROCIVE: Program to Support Investment in Innovative Cities Innovation Challenges and Technological Entrepreneurship SSAF-D SSAF-I SSAF-S  
 LFI: Product or Process Innovation (Prototypes) Technology Consortia for Innovation FAT: Technical Assistance Funds PDP: Supplier Development Program "Co-work and Global Hub" Social Enterprise Development and Inclusion  
 Prototypes for Business Innovation LF2: Validation and Packaging of Innovations Nodes for Competitiveness Program: Typology Nodes Export Promotion Platforms Redes Ángeles PAE Regional PRAE PRAE Incubadoras  
 Public Goods for Competitiveness Valuation and Packaging of I+D Projects Nodes for Competitiveness Program PAR: Support Program for Focal Reactivation FOCAL: Tourism Sector Seed Capital Mentor Networks  
 Incorporation of Advanced Human Capital in Innovation PIAM: Pre-Investment Program in Artisanal Fishing Management Areas School Internships Abroad PROFO: Associative Development Projects "early stage" Funds  
 Technological Associations for Competitiveness (PAM): Associative Projects for Microenterprises Competition Solar Power Concentration Plant (CSP) Regional Training Program for Competitiveness (PFC)  
 Extension Centers High Technology Innovation PEL: Program IPRO: Productive Investment Support Program for Reactivation  
 Innovation Management in Companies Value Sharing Creativas - Audiovisual Distribution  
 Social Business Innovation Business Technology Consortiums PE-Design: Strategic Programs of Intelligent Specialization for Competitiveness - Design P.I.R: Pre-investment Program in Irrigation  
 Project Applied R&D - L2 Basal funding for the generation of public goods Program to Support Creative Industries - Film Schools of Engineering Excellence Program for the Genetic Improvement of Fruit Growing  
 Innovation High Technology Micro and Macro Algae Consortiums Creative Industries Support Program - TV FAT - Technology Transfer Groups Go To Market Start-Up Chile Acceleration of in Strategic Sectors  
 Valorization - L3 PDT (Missions, internships, specialized consultancy, etc.) Contest to Support Investment in Opportunity Zones Technology Programme Strengthening applied R&D  
 Installation Centers of International Excellence Applied R&D Profile - LI Technology Contracts (Company - University) Subsidy for the implementation of the Strategic Technology Programme Strengthening OTL and OTL 2.0 (CITES)

## Corfo has 96 instruments, 47 linked to promoting innovation

### TOP FIVE THAT PROVIDE MORE FUNDS

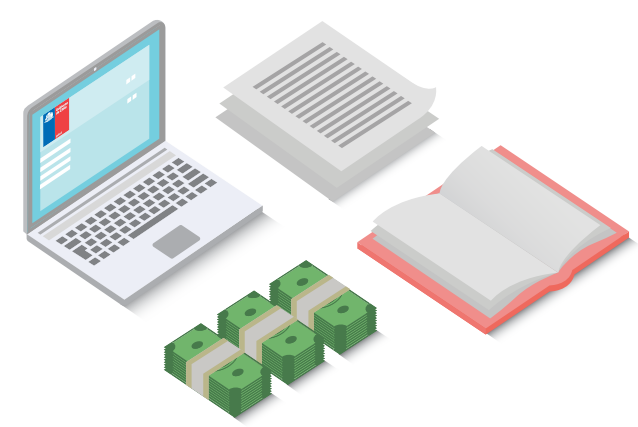
- \$12 billion**  
Strategic Technology Programmes (10 years)
- \$9.7 billion**  
Strengthening and Building Technological Capacities Enabling Innovation (10 years)
- \$8 billion**  
Technological Program Development of Solar Photovoltaic Technology Desert Climates and High Radiation (10 years)
- \$6.14 billion**  
Strengthening and Building Technological Capacities Enabling Innovation (10 years)
- \$4 billion**  
Technological Program Creation and Adoption of International Standards for Mining Interoperability (5 years)

### THE FIVE THAT PROVIDE THE LEAST AMOUNT OF FUNDS

- \$9 million**  
Pre-investment in Irrigation:  
Intra-Farm Model Programmes
- \$9 million**  
Pre-investment in Artisanal Fishing Management Areas - Base Studies Programmes
- \$7 million**  
Innovation Voucher for Women's Businesses
- \$3 million**  
Pre-investment in Irrigation:  
Intra-Farm Model Programmes
- \$2 million**  
Pre-investment in Areas of Artisanal Fisheries Management - Monitoring Programmes

### STABLE INSTRUMENTS (MORE THAN 8 YEARS)

1. Public goods for innovation
2. Technical assistance fund
3. Business Incubators
4. Networks of angel capitalists
5. Seed Capital
6. Innovation Management
7. Extensionism support (nodes)



Note: when identifying large and small programmes, those which are loans, capital contributions or are in a list of organisations accredited by Corfo, were not included.

## The Conicyt case: a key institution in the history of research. How to further boost collaboration and connection with country challenges?

We need to strengthen Conicyt to play its key role in the development of science and technology. This is a leap Chile needs to make.

Since its origins, Conicyt has been the house of science in Chile. Most of its funding lines have continued over time, and it has had two main roles: provide funding to researchers via Fondecyt and national postgraduate scholarships and Becas Chile. Together, these lines account for 69% of the institution's budget for 2017<sup>2</sup>.

Today, the main challenge is to strengthen support for associative research, which together with the Millennium Science Initiative has had a key role in creating and maintaining research centres. For over a decade, support for conducting this type of research has been a priority, and today we have clear examples of how it has had a key role in promoting a more multidisciplinary science connected to Chile's challenges.

Moving forward in this direction and allowing this institution to have a more strategic management, requires political leadership

that has not been provided by the Ministry of Education or the Inter-Ministerial Committee, which echoes the policy diagnosis of the entire STI sector.

However, in Conicyt a more specific limitation has been the lack of public investment to support the agency's operations, putting stress on its management. While funding has continued to increase, staff or support costs have not.

Permitting Conicyt to play its key role in the development of science and technology, also involves overcoming the bureaucratic behaviour stifling public sector organisation in general. Most civil servants -but also scientists- should spend much less time on funding allocation and rendering procedures, and much more on promoting science, technology and innovation, i.e., using them.

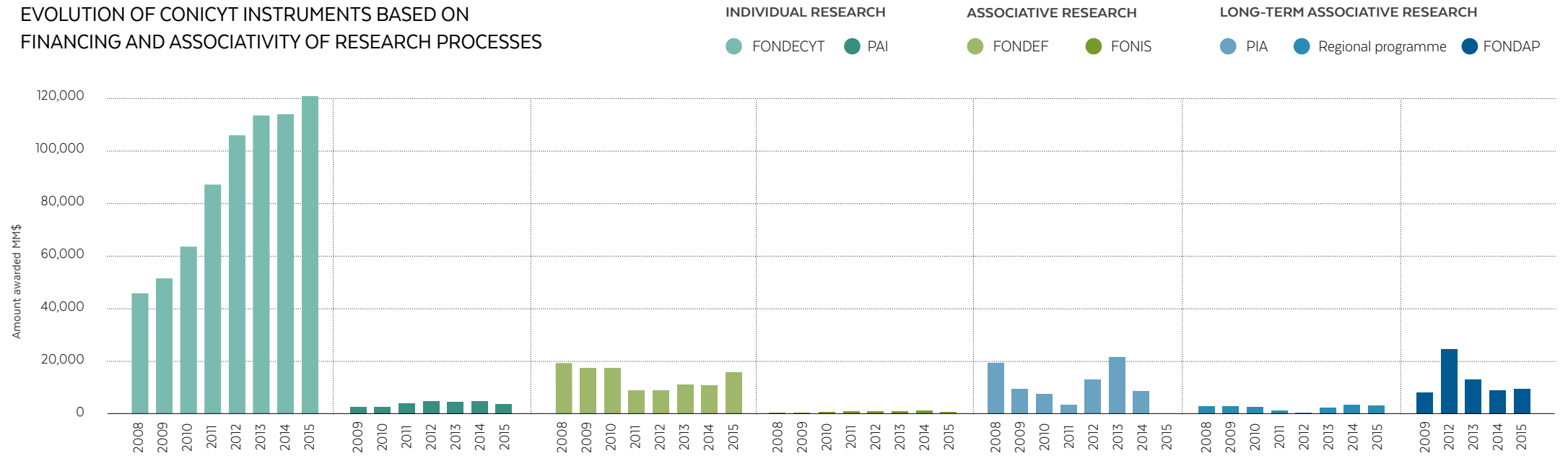
Today Chile needs to make this leap, and this agency deserves to be the springboard to our dreams.

Source Diagram: Author's own work based on Conicyt 2016 data.

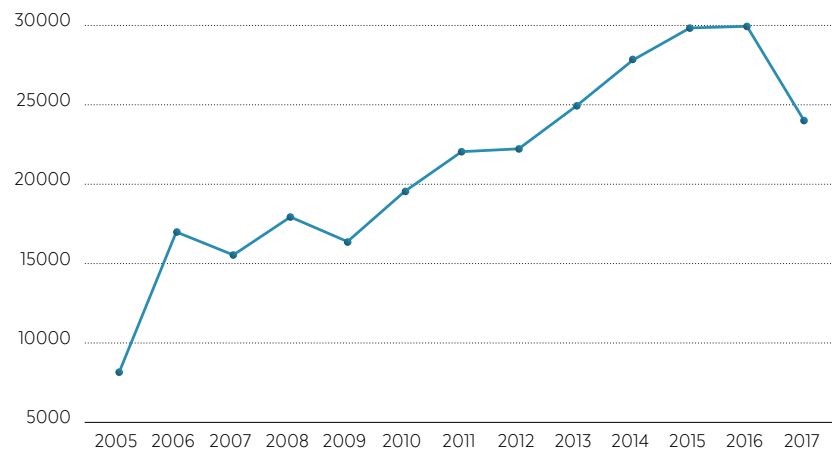
1. The percentage rises to 72.4% if only the current transfer budget is included (all Conicyt programs).



## EVOLUTION OF CONICYT INSTRUMENTS BASED ON FINANCING AND ASSOCIATIVITY OF RESEARCH PROCESSES

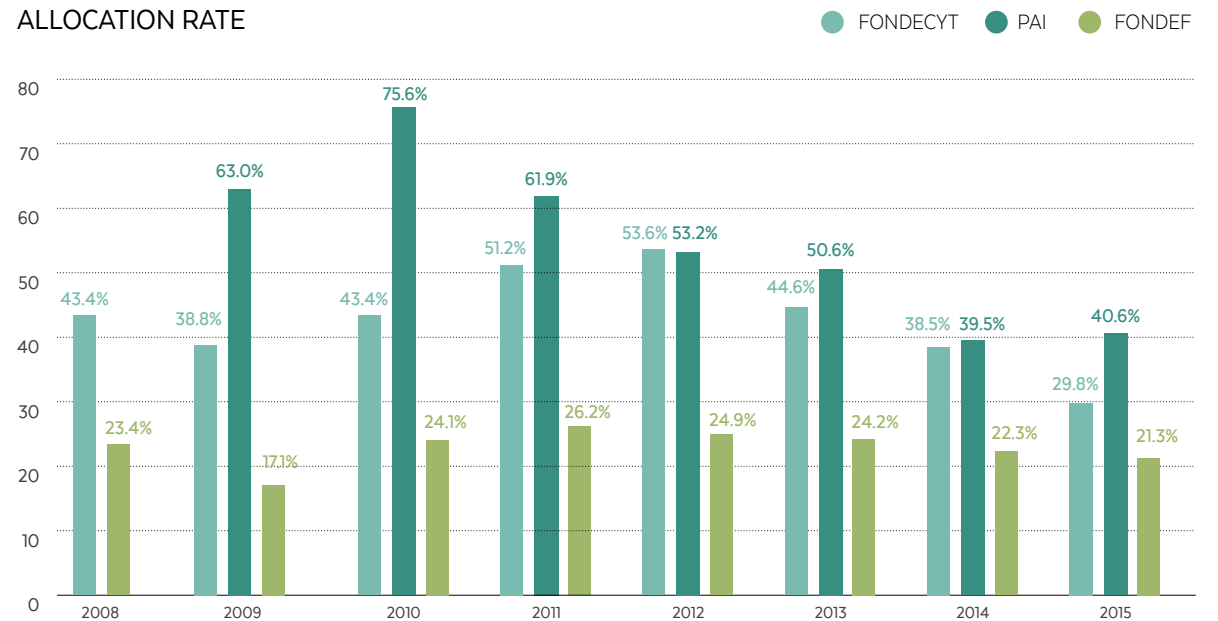


## PROGRAMME SPENDING PER THOUSAND PESOS ON PERSONNEL



The amounts awarded grew by an average of 10% per year, while the cost of hiring people increased by around 8% per year.

## ALLOCATION RATE



Between 2008 and 2015, the number of projects applied for Conicyt programmes increased at an average rate of 3% per year, with relatively stable allocation rates (35%).

## Ambitious goals that bring us together and mobilise more resources: a story we can tell about the future

The truth is that, apart from a few attempts, we have not managed to agree on a broad perspective with major goals that coordinate and mobilise the different actors.

Until today, the lack of integral leadership in the support of STI and a quantitative leap in resources are the dominant features of this period, and which we have not been able to change since the diagnosis carried out by this Council ten years ago.

It is not like we have not tried. In fact, governments have created mechanisms to address this problem. When the Innovation for Competitiveness Fund (FIC) was created, for example, these funds were expected to create inflection points in public actions that followed strategic orientations by continuously injecting new capital into the system. And although important STI initiatives have been financed by this fund, this expenditure quickly became carry-over resources (covering payment commitments from previous years). In this way, it was no longer a main instrument for strategic adjustments.

During the government of President Piñera, when 2013 was declared as the Year of Innovation, a cultural transformation was called for, rallying people's interest by showing how innovation was already happening in Chile and coordinating examples of this effort from

the different ministries. Nor did this effort succeed in perpetuating itself over time.




Apart from these attempts, the truth is that we have not been able to agree on a broad perspective with major goals that coordinate and mobilise the different actors. This is where our exacerbated differences become a fundamental barrier that conspires against tackling major challenges, expanding our efforts and giving it continuity. Furthermore, there is a lack of STI appreciation that predominates in certain circles, where paradoxically STI are often associated with the idea that “they do not seem to make a fundamental difference”.

And yet for our meagre efforts, the results are substantial. How much more could we do if we had more!

Today there are positive initiatives. For example, the coordinated efforts for a virtuous, inclusive and environmentally sustainable mining industry, enabling agreements with broad support from business, social, academic and political actors. This led to the call for R&D projects that combine the efforts of universities, research centres and companies through Conicyt (Fondef line), focusing on the challenges faced by copper mining, and defining areas of interest based on the Mining Technology Roadmap prepared by Fundación Chile, commissioned by Corfo. It was proof that this is a potential path for Chile.

1. Author's own work based on MINECON data (2008). *Guía de Instrumentos para el Emprendimiento - Chile Emprende*; FIA (2012), Institutional Report; MINECON (2016), Expenditure by instruments according to Management (Information System in construction); CONICYT (2016), Statistical Compendium CONICYT 2013-2015.

**CORFO**  
STRATEGIC PROGRAMMES,  
2015

- Food
- Construction
- Creative Economy
- Smart Industry
-  Solar Industry
- Export logistics
- Mining
- Advanced manufacturing
-  Fishing and Aquaculture
-  Health
- Tourism






Poor convergence of thematic areas



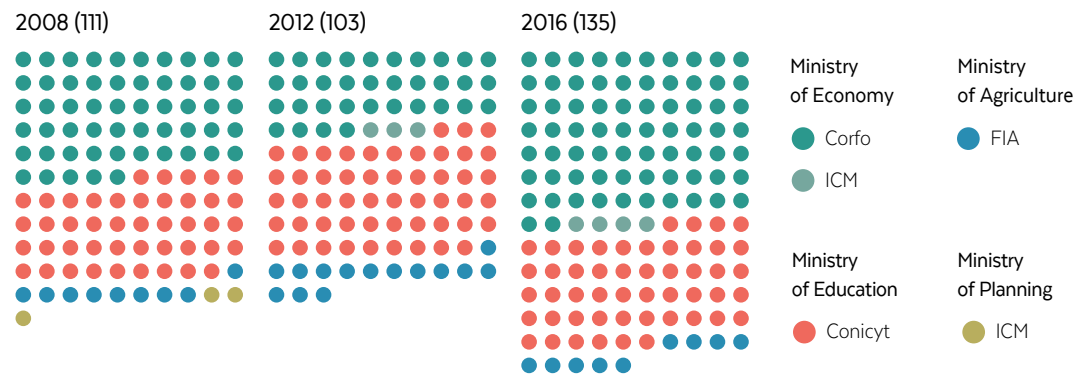
**AN EXAMPLE OF COORDINATED ACTION,  
SUPPORT FOR MINING INNOVATION**

Traction Nuclei CORFO  
Technological Roadmap developed by the High Grade Programme:  
Foundry and Refinery, Hydrometallurgy, Tailings,  
Mineral Concentration, Planning  
and Operation, Mining  
FONDEF Competition  
Competition focused on Mining whose  
financing areas are based on traction cores

**CONICYT / FONDAP**  
THEMATIC AREAS, 1998 - 2015

- |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>Sustainable Agriculture and/or Aquaculture </li> <li>Agricultural</li> <li>Scientific Basis of the Environment</li> <li>Biomedicine</li> <li>Geological Sciences</li> <li>Materials Science</li> <li>Marine Science</li> <li>Natural Sciences</li> <li>Environmental Sciences</li> </ul> | <ul style="list-style-type: none"> <li>Biological Sciences</li> <li>Social Sciences, Humanities and Arts</li> <li>Sciences of the Universe</li> <li>Climate Change</li> <li>Conflict and Coexistence</li> <li>Antarctic Science</li> <li>Air Pollution</li> <li>Biological Sciences, Technologies and Medical Sciences </li> <li>Sustainable Urban Development</li> </ul> | <ul style="list-style-type: none"> <li>Natural Disasters</li> <li>Early Human Development</li> <li>Chronic Diseases </li> <li>Aging </li> <li>Solar Energy </li> <li>Plant Physiology and Biotechnology</li> <li>Native Peoples</li> <li>Water Resources</li> <li>Engineering Science and Technology</li> <li>Science and Technology</li> </ul> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

INSTRUMENT DEVELOPMENT<sup>1</sup>



Public funding initiatives that take the form of subsidies or incentives to encourage entrepreneurship and innovation, through competitive funds, investment mechanisms or open window public programmes managed mainly by CORFO (entrepreneurship and innovation directed to the business sector) and CONICYT (scientific and technological research).

FIC DRAG  
PERCENTAGE  
**95.8%**

## Aspiration and need to reconcile perspectives: country and regions

Strengthening regions should help to build local decision-making bodies to allocate resources, install and strengthen the capabilities of the people who approve initiatives, and ensure the proposed goals and objectives are achieved.

Driving innovation has already been included in regional programmes for several years, in a specific institutional context. Regional Governments (Gores) have fewer tools, because Conicyt does not have any local offices. As a result, more than the lack of coordination between agencies, the main issue is that they have to act based on strategic objectives that reconcile regional challenges with national programme guidelines, which last over time and give consistency to the efforts made.

Over the last fifteen years, different types of regional bodies have been created to meet this objective. First, the Regional Science and Technology Councils (Corecyt) promoted by Conicyt. Then, Corfo created the Regional Agencies for Productive Development that prepared the Competitiveness Improvement Programmes for the strategic sectors prioritised by the Gores. Next, they were required to review and/or design the Regional Innovation Strategies based on the Regional Innovation Strategy (RIS) method, and they were

transformed into the Regional Development Corporations to make them independent from Corfo. Subsequently, these corporations were asked to move towards Smart Specialisation, while at the same time a process was implemented to transfer competencies to the Regional Governments in the areas of Regional Planning, and more recently, Productive Promotion, in response to Chile's decentralisation process.

These exercises share conclusions as well as implementation issues relating to their recommendations. In fact, there is still an asymmetry in the room for manoeuvre between the Central Government and the Regional Government. For example, the National Fund for Regional Development (FNDR) represents two out of every ten pesos of public investment in regions. In the remaining eight, there is generally no adjustment between national policies with regional development axes, causing subject and territorial dispersion, as well as a lack of clarity about a project's effect.

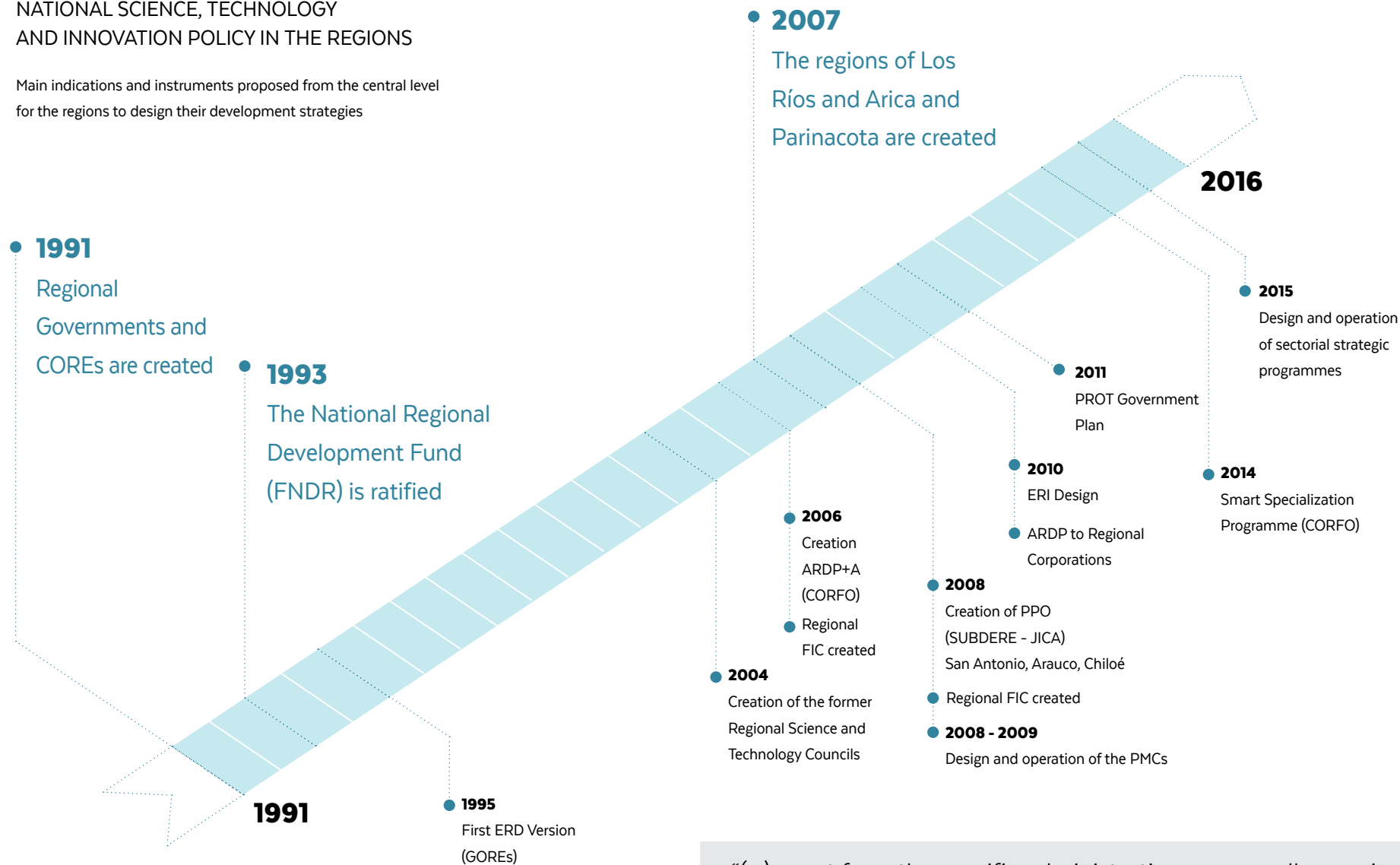
The institutional reforms under way to strengthen the regions should help to build regional decision-making bodies to allocate resources, install and strengthen the capacities of the people responsible for approving initiatives and ensuring the proposed goals and objectives are achieved.

Source: Author's own work.

1. Science Committee for Development of Chile, "Un sueño compartido para el futuro de Chile", CNID, 2015

## NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION POLICY IN THE REGIONS

Main indications and instruments proposed from the central level for the regions to design their development strategies



**ARDP+A:** Regional Agency for Productive Development + Regional Agenda for Productive Development (CORFO)

**OPDR:** Provincial Offices of Productive Development (SUBDERE)

**PMC:** Competitiveness Improvement Programme, based on the industrial cluster

**ERD:** Regional Development Strategy

**ERI:** Regional Innovation Strategy

**CIF-R:** Innovation Fund for Regional Competitiveness

**FRIL:** Regional Local Initiative Fund

**Government Plan:** regional expression of the government's programme agenda

**PROT:** Regional Land Management Plan

**PMG:** Management Improvement Programme

*"(...) apart from the specific administrative design, it requires permanent attraction and coordination spaces for the different actors, so that they can create, with autonomy, knowledge of excellence and relevance. This dynamics requires strengthening local capacities in this area, in the public, private and academic sector,*

*as well as an innovative governance model that considers participatory and collaborative dynamics with the central level. The latter should create spaces and incentives for the development of autonomous regional strategies, but in dialogue with the national science, technology and innovation policy."*<sup>1</sup>



**Gonzalo Herrera Jiménez, CNID Director**

Gonzalo is a Civil Engineer from Pontificia Universidad Católica de Chile and he has a PhD from the Catholic University of Louvain-la-Neuve, Belgium. He was Executive Secretary of the Technological Development and Innovation Programme of the Ministry of Economy and later Director of FONDEF (Conicyt). Currently he is the Vice-Rector for Innovation and Technology Transfer at Universidad de Talca.



## Innovation, universities and territories

By Gonzalo Herrera Jiménez



When national strategies are designed and public policies are created in Chile, regardless of the subject matter or issue, with few exceptions, they are prepared in Santiago by people who live in the capital. And, since a certain awareness has been created regarding the need to incorporate the regions in these initiatives, some sections are normally included to spread their benefits to Chile's regions. Sometimes, most actions included in these strategies or public policies are carried out in different regions or locations... following a plan conceived and designed in the Metropolitan Region.

Most of the efforts deployed by the Presidential Advisory Committee on Decentralisation and Regional Development arose from a call to look at Chile's development from a comprehensive perspective of its territory, considering its significant heterogeneity, wealth and local capacities to decide on multiple aspects about daily life.

The above is fully applicable to a subject area that involves the future institutional structure of our universities, as well as the announcement by the Government regarding the creation of a Ministry of Science and Technology.

We need to specifically think about the development of Chile's different territories, considering the irreplaceable role science, technology and innovation, mainly developed in our universities, will have. Our natural resources are, and will continue to be for a

long time, the base for Chile's productive development. Therefore, one major challenge we face is how to add intelligence and, hence value, to what we extract from our land and seas. And the science and technology needed for this must primarily be developed in the territories themselves, because these are local challenges.

The new institutions that are being created, responsible for the public dimension of science, technology and innovation, will necessarily have to consider the previous reality. A ministry that is limited to making national public policies in this area, but does not include the territorial specificities thereof, will contribute little to productive and social strengthening of Chile's different territories.

We should not think about Chile as the sum of Santiago and its tributary regions, but rather as a vast, rich and complex human territory.

## II. WE HAVE THE OPPORTUNITY TO BROADEN AND DEEPEN PUBLIC ACTIONS TO BOOST STI

### The State has different ways of boosting science, technology and innovation that we still have not seized

Laws to raise business standards, public procurement, targeted foreign investment attraction, and changes in public sector operations are different ways we can boost STI.

So far, we have promoted science, technology and innovation as a sectoral policy. And although this may be a stage in the evolution of public policy, we need to transcend the discussion that has tended to focus on how many resources we manage to mobilise at Corfo and Conicyt, taking a shortcut to make STI a dimension that crosses all government actions.

The State has numerous ways of promoting science, technology and innovation. For example, through legal changes raising business standards, for example, environmental requirements. There is little doubt that setting stricter emission standards in California was a key factor for the car industry to develop cleaner engines. The recent approval of a law in Germany that bans road traffic of internal combustion engine

cars will undoubtedly boost innovation. The positive and stimulating impact of innovation, through stricter environmental regulations, has been documented by several studies applied in OECD countries.<sup>1</sup> A key aspect to using these mechanisms is to combine higher demands with support for those who have more difficulty in meeting these demands (e.g., SMEs), and to set adequate, but definite, time horizons for firms to adapt.

Laws to raise business standards, public procurement, targeted foreign investment attraction, and changes in public sector operations are all ways to drive STI.

In Chile we have cases that show the impact caused by this type of initiative. However, these are isolated experiences that did not arise from a science, technology and innovation policy that incorporated these dimensions into its development.

Source Diagram: Author's own work. 1. 1.

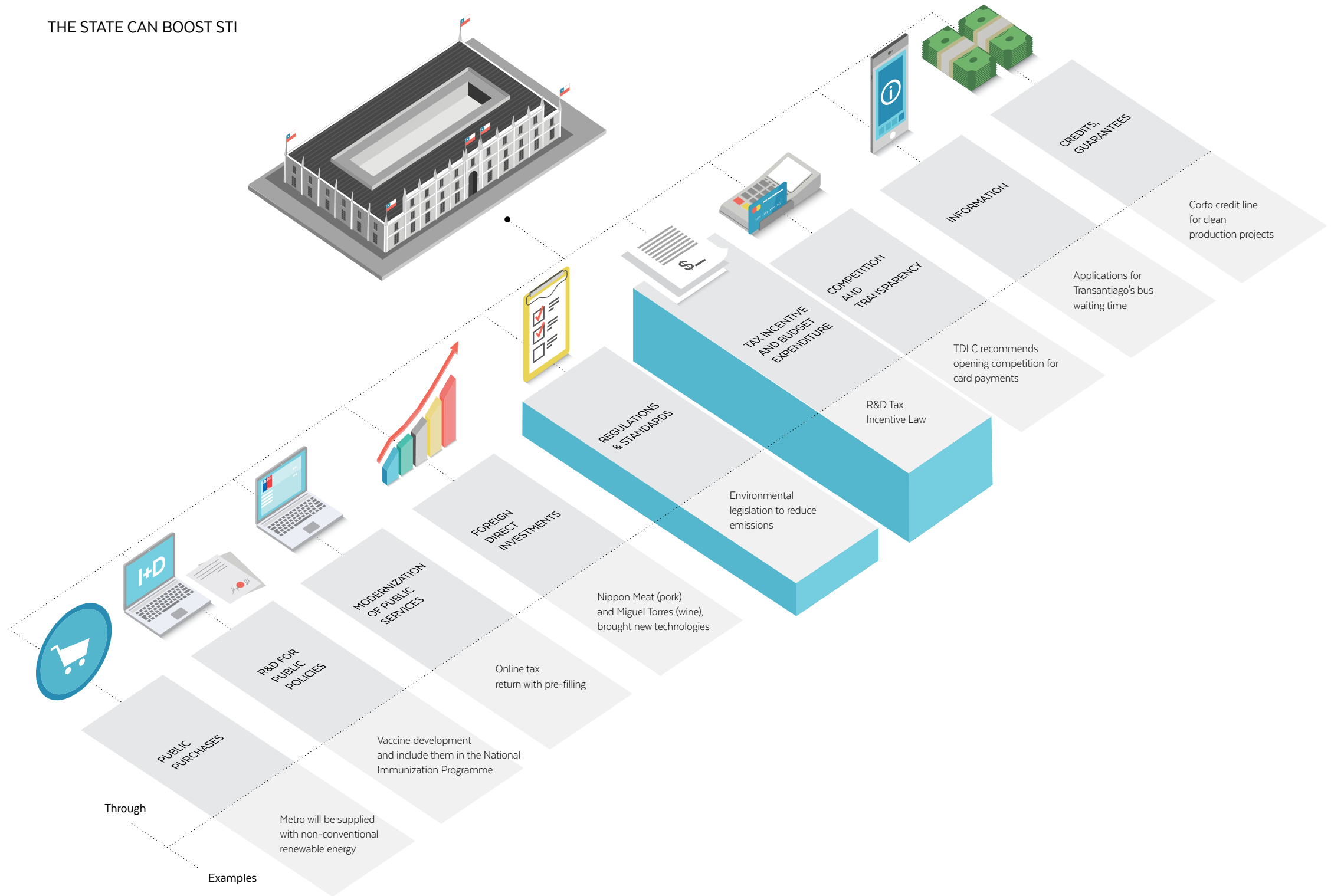
Constantini, V. Y Mazzanti, M. (2012):

1. *On the Green and Innovative Side of Trade Competitiveness? The Impact of Environmental Policies and Innovations on EU Exports*. Research Policy, Vol 41, 1.

Blind, K. (2012): *The influence of Regulations on Innovation: A Quantitative Assessment for OECD Countries*. Research Policy, Vol 41, 2.



# THE STATE CAN BOOST STI



~~~~~

We have become entangled in conflicting ideological positions, but are the differences really that big?

~~~~~

If we move away from the war of words, a larger space emerges for State rather than government policies.

STI efforts achieve results much faster than government efforts. Patience and perseverance are crucial for achieving results. Drastic changes of course will not let us move forward. Can we draft an agreement to support State policies?

If we are guided by the prevailing rhetoric in policy discussions, it seems that we are still stuck in the old dichotomy between market and State. The best expression of this antagonism has been the emblematic difference between the first term of President Bachelet (2006-2010) and that of President Piñera (2010-2014). In the first period, the approach focused on public efforts in a few high-potential clusters (sectors). This policy was discarded by the following government, it opposed the State acting selectively. Its flagship scheme was Start-Up Chile, encouraging people to become entrepreneurs.

The contrast between the coalitions, reflected in their preferential policy options, makes it difficult to think of an agreement. But, by

drawing back the veil of rhetoric and focusing on actions, a much more nuanced image emerges.

In fact, during President Piñera's term, the government continued to support the Mining Supplier Development programme that had been created within the cluster policy framework. A programme was also implemented to support the emerging astronomy-related services and technologies, and the Maersk container plant facilities in San Antonio received direct support. According to some authorities at the time, they were not opposed to working with specific sectors, but to choosing to give them funds without having mechanisms in place to ensure they were funding projects that had more merit than alternative options. In other words, we are not facing fundamental differences; the challenge seems to be to set goals and procedures based on common criteria.

Furthermore, despite the change of government, the Start-Up Chile programme continues in place, but some adjustments have been made to improve its operation and impact. In fact, policies to promote entrepreneurship have shown remarkable continuity since the first programmes were implemented in the late 1990s.

Consequently, if we move away from the war of words, a larger space emerges for State policies rather than government policies.

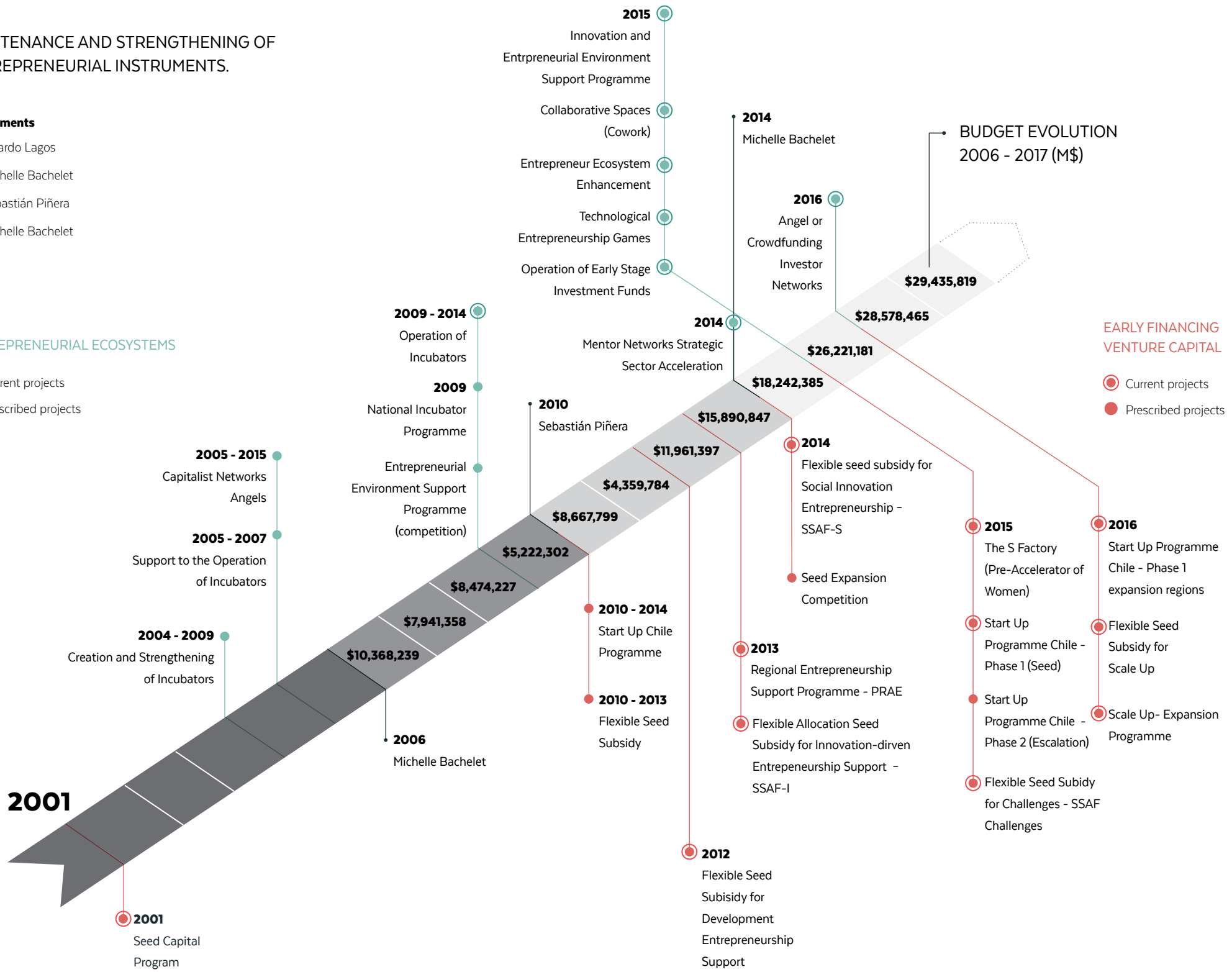
# MAINTENANCE AND STRENGTHENING OF ENTREPRENEURIAL INSTRUMENTS.

## Governments

- Ricardo Lagos
- Michelle Bachelet
- Sebastián Piñera
- Michelle Bachelet

## ENTREPRENEURIAL ECOSYSTEMS

- Current projects
- Prescribed projects



- ### EARLY FINANCING VENTURE CAPITAL
- Current projects
  - Prescribed projects



**Cristóbal Undurraga Vergara, CNID Advisor**

Cristóbal has a degree in Industrial Engineering from Pontificia Universidad Católica de Chile and a Master's Degree in Business and Administration from Stanford University. He was entrepreneurship manager and executive director of INNOVA, CORFO. Currently, he is the Development Manager of Ekonométrica and a board member of the Chilean Entrepreneur Association (ASECH).



## Continuity of entrepreneurship policies

By Cristóbal Undurraga Vergara



As evidenced in Chile and the world, innovation needs the energy, audacity and talent of entrepreneurs. When reviewing the evolution of CNID strategies and our public policies, we can see how this mobilising role has gradually been recognised and a more traditional view has been left behind, where the desire for innovation was only endorsed by large companies.


This consensus has been key to promoting entrepreneurship during governments of different political views and to simplifying the regulations that hinder SMEs and entrepreneurs. Stability in this support vector for new businesses has had multiple impacts, and has allowed the following:

- ❖ Significant increase in number of new companies, based on technology or new business models, since the first Seed Capital was created in 2001.
- ❖ Continuous improvement of public instruments to support entrepreneurship. Government agencies have been able to adapt and learn leading to quasi-dynamic policies, capable of incorporating knowledge and changes into the entrepreneurial environment.
- ❖ Building a reliable bridge between entrepreneurs (as an individual or in an association) and the State. This alliance has allowed them to work together on some public policies, from which proposals for high-impact regulatory changes have also emerged, such as the Company in One Day law.


- ❖ Emergence of an industry to support entrepreneurship through venture capital funds, private incubators, collaborative workspaces and exclusive products for entrepreneurs.
- ❖ Academic training, research on entrepreneurship issues and publication of several books supporting the creation of new companies.
- ❖ Chile to be at the forefront of entrepreneurship in the region and a place where people from all over the world want to start their projects.

The rising tide of entrepreneurship that today makes university graduates say they want to create their own company is the best evidence of the importance of long-term public policy consistency. And this consistency is only possible if we focus on who we want to support and not on ideologies and war of words.

Because, despite our differences, Chile's challenges require our entrepreneurial talent to be immediately expressed in new, more innovative companies with high social impact.



## The discrepancies about the role and value of science that divided us, begin to dissolve



There is consensus on the importance of combining curiosity-driven science with mission-driven science in the search for development that combines growth, sustainability and inclusion.

Antagonistic positions have not been limited to the government-market debate. They have also been manifested, and sometimes in an extreme way, in relation to the role and the way in which scientific activity contributes to this country.

For some, many engineers and economists, applied research must be favoured, particularly when it is linked to the challenges of our economy. In extreme cases, the very meaning of doing science in Chile is questioned, i.e., to invest in moving the universal knowledge boundaries is beyond our reach, which is absurd if we can use the knowledge generated abroad “for free”.

In contrast, we find a view entrenched in the radical autonomy of scientific research, emphasising the importance of knowledge generation. Thus, for some, research funding is captured by scientists who want the government to subsidise their personal careers, and for others, it aims to reduce the value of science to its ability to generate business.

Although this may be a caricature, these views have been present in the debate and have contaminated the relationship between the scientific community and public policy makers with distrust. However, as in the case of the State versus market dichotomy, in recent years we have seen a convergence with which more actors agree on. Researchers, particularly those working in interdisciplinary, associative research centres, have incorporated a sense of mission and shown that opposing basic and applied science makes no sense. Both are necessary to address a phenomenon, and there is an inherent continuum between basic and applied science. At the same time, views that reduced well-being to economic growth have also lost ground to the recognition of a far more complex reality.

The report “Science for Development: A Shared Dream for Chile”, which brought together many scientists, policy makers and entrepreneurs, evidences this process. Besides differences in institutional structure issues, there was consensus on the importance of combining curiosity-driven science with mission-driven science, in the context of achieving development that combines growth, sustainability and inclusion. In this context, the multidimensional value of science is revealed, including the contribution of philosophy, the arts and the humanities.

## FROM SCIENCE TO INNOVATION AND FROM INNOVATION TO SCIENCE: **TWO CONVERGENCE EXPERIENCES**



**ALEX BERG**  
ENGINEER, DIRECTOR UDT\*

### **On the effects of having incorporated basic science at a centre originally focused on technology transfer and development**

Besides publications (today we have 49 ISI with an average impact of 2.9 by 2015), having basic researchers at our centre, who study important aspects related to developing technologies, helps us to better understand problems, gives us ideas on how to solve them and opens paths that allow us to recognise developments of future interest.

### **The challenges of integrating basic and applied science to the same project**

A scientist must recognise a good technologist as an important ally and a technologist must consider collaborating with a good scientist to achieve his/her goals. Showing respect and recognising the other as a valuable ally seems to me to be the main challenge.

Interaction is key to establishing a collaborative platform. We had lunch together, played football, practised aerobics, and discussed current and future work. While we respect each other's motivations, there is strategic planning that guides scientific and technological challenges in a specific direction. Basic science does have a meaning. It is not knowledge for the sake of knowledge, but knowledge to understand and solve a problem or to open new areas of technological action.

The first challenge was in 2001, when a Fondap project brought together a group of astronomers from three institutions with very different cultural and bureaucratic backgrounds (from different universities, i.e., Universidad Chile, Católica and Concepción). We had always had to compete for meagre funding, but through collaboration we obtained the promised achievements more than satisfactorily.

From this new synergy, the next challenge came when we were awarded Base Funding associated with the Electrical Engineering Department of Universidad de Chile to design and build a Band 1 receiver for the Alma observatory. The result has been very positive, engineers have been trained in state-of-the-art technologies and some spin-offs have been developed that are of practical use.

### **On the effects of incorporating technological development at a centre originally focused on basic science**

The technological development challenge has shown us how the passion of scientists who need a new instrument for their projects, join the creativity of engineers.

This was possible because we were asked to develop an application area of science that would achieve economic benefit. This is how today we have a technological laboratory validated by the international community for its excellence and where other Alma projects are developed. The enthusiasm of the Calán lab engineers has helped them develop various applications that are being patented.

### **\* Technological Development Unit**

Created in 1996 at Universidad de Concepción, it develops science, technology and innovation in the area of bioeconomics. Its scope of action is forest biorefineries as a set of transformation processes to obtain different products through lignified raw materials, which can be transformed into high-value products.

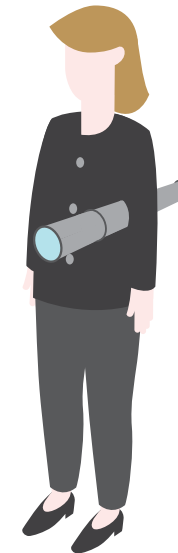
[www.udt.cl](http://www.udt.cl)

### **\* Center of Astronomy and Related Technologies**

It conducts astronomical research and promotes, nationally and internationally, associated technologies, while training frontier staff on these activities.

The unit was created in 2008, and its host institution is Universidad de Chile, and Universidad Católica de Chile and Universidad de Concepción are associated institutions.

[www.cata.cl](http://www.cata.cl)



**MARÍA TERESA RUIZ**  
ASTRONOMER, DIRECTOR CATA\*

## Trapped in myths and rhetoric: what were other OECD countries doing when they had our current per capita income?

We usually compare Chile's STI situation with what is currently happening in more advanced countries. This helps us to identify emerging trends and interesting practices to adapt to our reality. However, in this comparison we look at the situation of countries that have already made the transition to their current status. What happened to them when they had a similar level of per capita income to what Chile has now?<sup>1</sup> This other comparison helps us to understand the challenges we face.

A study carried out by the CNID<sup>2</sup> during this other temporality reveals, for example, three conclusions that remove the deeply-rooted beliefs in our debates.

1. Investing in R&D is not a luxury of a rich country, but a condition to be one. Contrary to the position that Chile should take advantage of the breakthroughs generated by more advanced nations, the trajectory of all OECD countries shows that they invested a much higher percentage of GDP in R&D than we currently do in this country.
2. In resource-intensive countries, the public sector contributes more than the private sector to R&D, a ratio that takes decades to reverse. This is contrary to the belief that one of our weaknesses is the fact that the public

and not the private sector is primarily responsible for R&D expenditure. Looking back, countries with a strong industrial base or very active industrial policies (such as South Korea), the private sector did in fact lead R&D investment. However, the opposite occurred in countries where natural resource-intensive activities prevailed. But in these countries, the State led R&D spending for many more years, one explanation is that the results of natural resource investing take longer to be achieved and, therefore, few companies can maintain this effort<sup>4</sup>. Thus, we need to ask the private sector to increase its R&D&I efforts, but levels of public funding must significantly increase too.

3. Scientific research was much more important than in Chile. Another common claim is that Chile allocates too much research funding to science instead of innovation. However, at that time, all OECD countries had a much higher percentage of researchers to the active population than Chile does today, and the number of scientific publications per capita was also higher.

Source Diagram: Author's own work based on OECD data.

1. This comparison is based on similar purchasing power.
2. ClioDinámica (2016) *"Análisis Dinámico de la Fase De Desarrollo Económico de Chile en Comparación con Fases Experimentadas por Países Desarrollados"*, CNID. Santiago, Chile.
3. Where natural resources and their by-products account for over 50% of its exports.
4. For example, obtaining new fruit varieties, and bioleaching of copper.



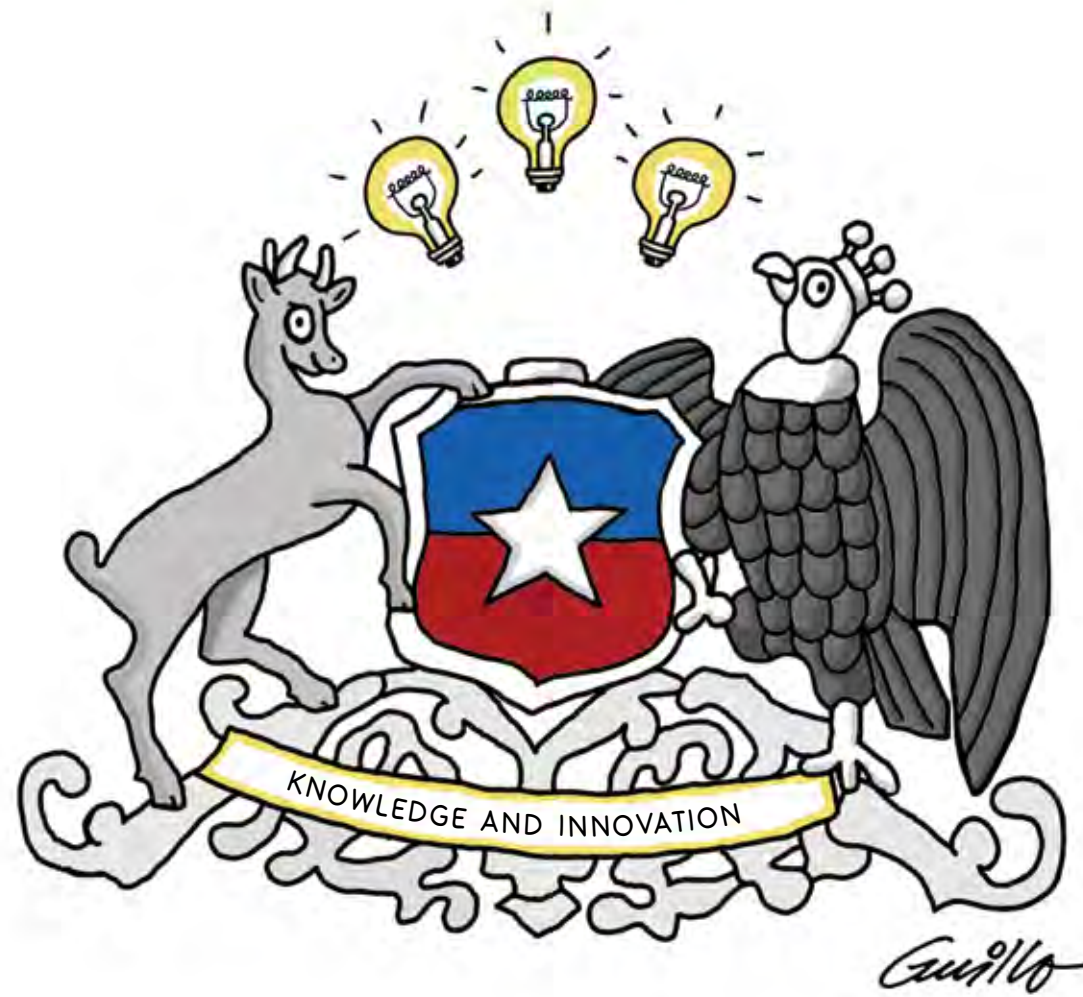
WHAT DID OTHER COUNTRIES HAVE WHEN THEY HAD SIMILAR PER CAPITA INCOME TO WHAT WE HAVE TODAY?<sup>1</sup>



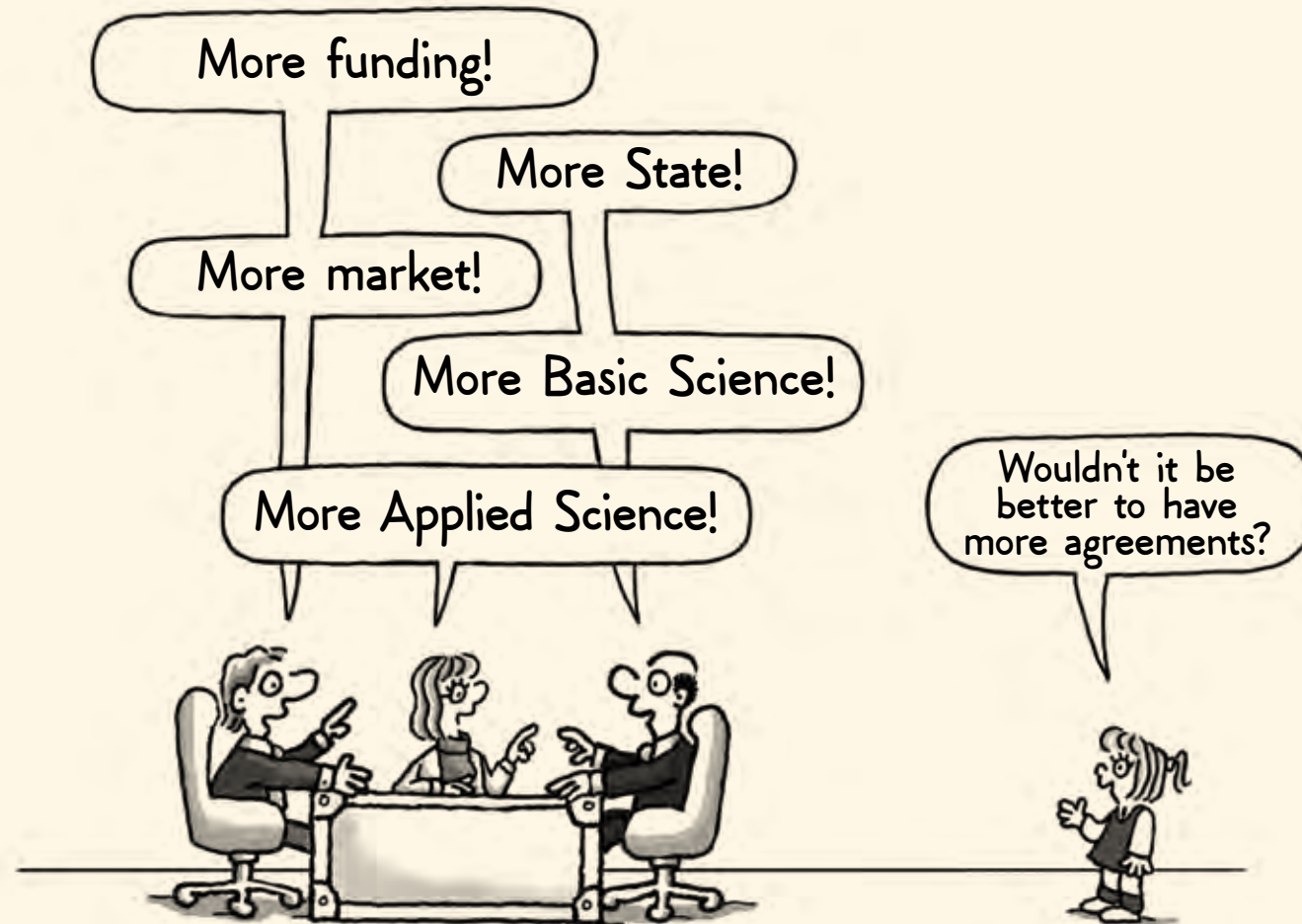
Researchers per million employed = 100 Researchers
 
 R&D funding as % of GDP
 

 Public
  Private

 % Participation in R&D







*Guillo*

## CHAPTER 5



## A new transformational drive towards development



## MORE PEOPLE BENEFIT FROM SCIENCE, TECHNOLOGY AND INNOVATION

Chile's development is confronted by its various dimensions: environmental sustainability, economic dynamism, and social inclusion and cohesion. We urgently need a new way of virtuously integrating and linking these three development dimensions.

We are not alone in this quest. The whole of human society is under pressure from the evident need to rethink the way we have interacted with the natural environment, and with each other, living a transition in the way we understand and approach the idea of progress.

The ways we have measured, classified and analysed are insufficient to account for the phenomena that we are beginning to recognise today. For example, to many, it is evident that the product or income per capita does not account for basic aspects of economic development, such as the integrity of nature, the value of ecosystem services derived from its different components, or the level of social inclusion and integration. The agreement reached on the UN's Sustainable Development Goals is a clear expression of this transition and it is our guiding star.

This is undoubtedly an emerging transformation. For some it is a radical lifestyle change, while others feel that changes are too slow and marginal. It is clear that this is a period of transition, that is changing the core of the way we have structured our coexistence

and how we live on the planet. Inevitably, this type of process causes anxiety and is marked by uncertainty. This is our current scenario and it will accompany us in the years to come.

As a Council, we are not, nor expect to be, certain about how this path will evolve. But we acknowledge that today we are facing enormous challenges, but at the same time, tremendous opportunities. Chile has vast natural, economic and social resources, built on the value of its people. It is based on these resources that we can redefine ourselves as a country and offer the world our great potential. Seizing this opportunity means we have more capacity to understand, adapt and create.

The deployment of science, technology and innovation is not a magic solution that will solve the challenges we face. Nor does it pose a path free of conflict and tension. Nor is it a substitute for courage and political will. But we are convinced that, in order to have the opportunity to build a better society, we inevitably have to make more of an effort in science, technology and innovation than we are today.

This effort to improve our collective knowledge base and incorporate it more actively into all our activities goes far beyond the need to increase business R&D spending, number of patents or scientific publications. Of course, they are all important, but the complex

The deployment of science, technology and innovation is not a magic solution that will solve the challenges we face. Nor does it pose a path free of conflict and tension. Nor is it a substitute for courage and political will. But we are convinced that we inevitably have to make more of an effort in science, technology and innovation than we are today.

challenges we face in the multiple dimensions of our society, in a world marked by the impact of global change and rapid technological change, require much more.

The Presidential Science Advisory Committee for Development summarised this situation in two key questions: what are we going to live on? and how are Chileans going to live together?

All the committee members agreed that we are at a crossroads in our development, besides nuances or positions on specific issues, so the committee report was clear in defining the contribution of STI:

“Deepen and strengthen our democratic coexistence requires a dialogue between the social and natural sciences, humanities, the arts, engineering and technology, where, in a multidisciplinary and collaborative manner, they can help to identify the questions and enlighten the available paths. Expanding our capacity for critical reflection, opening and exploring new spaces for innovation in all areas of our society is the contribution we expect from further developing our scientific and technological capabilities.”<sup>1</sup> To this end, the Committee set as a priority goal that more people should systematically generate and use knowledge in their activities<sup>2</sup> in all areas of human endeavour and in the various spaces of our society,

so that Chile has an expanded capacity to lead and stimulate its development (see Annex 1).

As a Council, we support and adhere to the proposals in this report, as we share the conviction that strengthening and mobilising human talent is the State’s main contribution to promote STI.

1. Science Committee for Development (2015), “*Un sueño compartido para el futuro de Chile*”, CNID, page 12.
2. The OECD definition of researcher is used: Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and in the management of the projects concerned.

Source: OECD, 2015. Frascati Manual.



## PARTICIPATING AND COLLABORATING: CONDITIONS FOR STI IN A COMPLEX CONTEXT

Increasing and mobilising human talent is essential for Chile to enter this new development stage. We must also be able to focus our efforts consistently with recognising the complexity of development, and change the way we have traditionally understood the role and promotion of STI.

Today we agree that the importance of science, technology and innovation is much more than their contribution to economic dynamism. This does not reflect a dichotomy between research and innovation goals, but rather the cross-sectional aspect of each of their dimensions. For example, companies, as the main agent of innovation, currently need to innovate not only in terms of their profit goals, but also, and in some cases above all, to make their operations environmentally and socially sustainable.

On the other hand, those who do research have a critical role in ensuring that their work contributes to move towards the desired development, for which there are several channels. This is certainly valuable when new knowledge is used to solve problems or is transformed into new products or services. But when it also helps us to better understand our reality, as well as emerging phenomena,

enlightening our conversations and debates. There are many ways to connect research with the environment and each one is important.

This broad perspective on the role of STI must include an encounter of its different areas. This context of complexity requires us to establish collaboration as a key element of our actions. Of course, opting for the confluence of different disciplines, sciences and humanities, but also for all the actors of our society. Thus, the challenges and the opportunities that arise can be approached considering the different views, values and interests. Overcoming a dominant perspective is the path that will allow us to become aware of the richness and complexity of the phenomena, enlightening our understanding of them and creating opportunities for innovation. And it is here, in this process where we want to move forward; STI policies can be an essential element to promote an encounter. Above all, collaboration generates spaces of mutual knowledge and understanding, building trust and better social fabric.

Chile has a huge opportunity to build on what we already are. To know and promote the geographical and territorial singularities, our country's historical heritage provides us with the primary level on

Defeating a dominant perspective is the path that will allow us to become aware of the richness and complexity of the phenomena, enlightening our understanding of them and creating opportunities for innovation. And it is here, in this process where we want to move forward; STI policies can be an essential element to promote an encounter. Above all, collaboration generates spaces of mutual knowledge and understanding, building trust and better social fabric.

which opportunities for conservation, adaptation and innovation can flourish. For this reason, we choose to deploy STI across our territory and to include it in the different spheres of our society.

We believe that the key to success will be our ability to sustain long-term efforts that bring together different perspectives in a constructive dialogue based on intellectual honesty and respect.

This has been part of this Council's search and experience, and we are convinced there is broad agreement that can call for a collective effort to improve the use of STI for national development.

The proposals presented below aim to show in detail our perspective described in this document. These proposals are not intended to re-

place what is being done today, nor do they represent everything that will need to be done in the coming years to advance this transition.

These initiatives offer new spaces and new logics that open paths for our progress, and if implemented, not only do they have a high direct impact, but they also constitute a layer for other efforts in this same direction.



### **Mobilising resources to boost STI efforts: the challenging context where we will operate in the near future**

Investment in R&D is not a luxury, but a necessity to achieve development. Moreover, in the current context, it is essential to renew deployment of efforts and action in this field. We need to make more progress and we know that in countries such as ours, with natural resource-intensive economies, it is crucial for the government to take decisive action. Is the current rate of public investment sufficient? Where does that leave us in 2030?

According to OECD data, R&D expenditure between 2009 and 2014 (the only comparable data available) increased at an average annual rate of 5.8%, i.e., two points above the average GDP growth for the period (3.8%). This was the result of an average annual growth in public R&D spending was 4.8% and 10% in the case of private R&D spending. If average annual expenditure on R&D continues to grow by 5.8% and 3.8% of GDP, by 2030 we would only reach an expenditure of 0.58% of GDP. Thus, Chile would continue to be the OECD country that invests the least in R&D and it would perhaps widen the gap with the average of advanced countries.

If we want to reach 1% of GDP by 2030, with a moderate growth

in private spending (32%-40%), we must make a significantly greater effort than we have done so far. On the one hand, public spending should grow 8.8% per year and, on the other, private spending should grow 11% per year.

The current context of public spending commitments means that in the short term, the possibility of increasing public expenditures on R&D requires the reallocation of funds from other items. In the short term this can be seen as a zero-sum game, where what the STI gains is another sector's loss. However, investing in R&D can precisely reduce the need for current expenses and investment in areas such as health, infrastructure, natural disaster management, drinking water supply, etc. The challenge, then, is to improve the connection between R&D efforts and the needs of our society.

This type of public effort is undoubtedly a powerful message to the private sector, encouraging actors to innovate in order to address these challenges. But also, we need to be creative and develop new ways to promote private investment in R&D.

The proposals contained in this document recognise this challenging context, and they offer novel, but realistic ways to make the leap forward we need.

## Five proposals for a new transformational drive

We never get tired of repeating: Chile needs to make an even greater effort in science, technology and innovation than we have done so far.

It will not happen just because we say so. Nor is it enough to demand more resources from the State. Public budget projections indicate that in the coming years we will face a very restrictive situation, and committed costs will be considerably high. A significant increase in STI funding means giving it priority over other areas of need, as well as mobilising new funding sources.

Aware of this scenario, the aim of our proposals is to provide a creative response to the limitations we face in the short term.

The proposals have not been inspired by a few, but they reflect a shared learning through multiple dialogues and conversations, and are based on some fundamental convictions that we share as a Council.

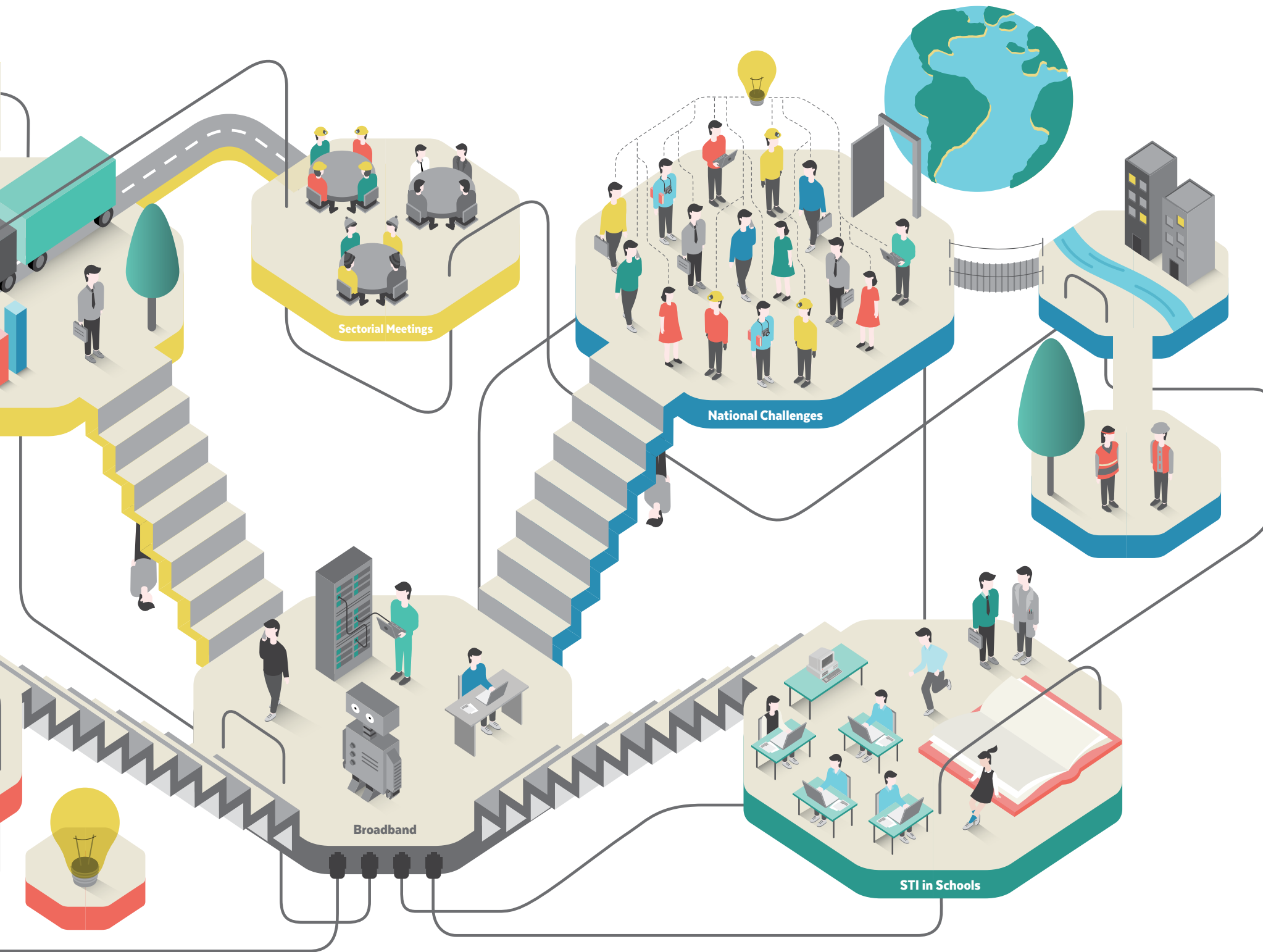
The first is that our goal as a country must be to move towards socially and environmentally sustainable development and, in this context, part of our learning is that rather than defining the exact path to follow, we must expand our capabilities to act in different settings, making STI a fundamental component of this process. Consequently, the main objectives of the project are to agree on mechanisms that will give a strong boost to na-

tional efforts in this area and to deploy the talent of our people. And together with these efforts to open spaces for everyone; we propose some focused transformative impulses where, in addition to proposing specific areas, which we believe are important, we focus on installing institutional mechanisms to enable us to create this capacity and sustain these options over time.

Furthermore, we assume the strategy's viability is based on the agreements reached during its preparation. The emphasis placed on dialogue and agreement building is reflected in the express support given by directly involved actors to measures that concern them. Thus, the very process of developing this strategy has made it possible to create the conditions so that the proposals have the critical support to materialise.

Finally, we are committed to a limited set of key proposals, rather than a long list of recommendations, focusing our attention and efforts on initiatives that really have a transformative impact and that make sense to citizens and their deepest concerns. We aim to reconcile ambition with reality, assuming we are developing capacities to travel on this new path.





## I. An invitation to be big: National Development Challenges

Agreeing on a procedure that, incorporating people's concerns, facilitates the selection of major challenges where STI can make a significant contribution, with at least a 10-year horizon.

In Chile we have had important differences about the role public policy could have in facilitating the deployment of new activities. These includes the risk that policies significantly vary from government to government, thus undermining the possibility of impact. Today we can agree on how to act in this area and send a clear message to the different actors in the system.

By agreeing that it is important to leave ample space for people to express their creativity and to take charge of a future we cannot predict, let alone control, we have also advanced in a broad agreement: given the size of Chile, we cannot claim to be excellent at everything. Some kind of focus should guide at least some of the efforts the public sector is making in this field. The call is to work out how to define that focus and what criteria should be used to guide public actions.

Traditionally, the discussion on how to exercise selectivity has focused on economic sectors. This immediately led to a clash over positions on the feasibility and legitimacy of the State "choosing winning sectors". Besides discussing the relative merits of each of these positions, today as a Council we propose a different approach to this issue.

We propose a paradigm shift: select national goals, not sectors. Thus, in addition to overcoming the old discussion about selectivity with which we have coexisted, we can connect and show the contribution of STI to the concerns that matter to us all, often connecting economic, social and environmental dimensions to cross-sector challenges.

These are major national goals that address unique problems and/or opportunities in this country. For example, natural disasters. We know Chile is the nation most affected by these events and that, as a result of climate change, they are increasing in frequency and intensity. Disasters directly affect people's lives and well-being, so disaster prevention and mitigation are objectives that bring us together as Chileans. This country has already achieved a leadership position in earthquake response, but we are also increasingly exposed to floods, landslides, wildfires and tsunamis. Then, why not be world leaders in the capacity to prevent, respond and recover from natural disasters,



and why not direct part of our STI efforts to this cause and from here we could address a key issue that affects our population and at the same time develop technologies and innovations that help the world to face this challenge?

This is just one example. There are other relevant goals that can be added to our condition, such as being leaders in environmentally sustainable mining, in clean energy generation (particularly, solar energy), or in solving childhood obesity which today is a serious problem.

In all these and other imaginable cases, we are faced with a challenge of public interest, anchored in some singularity of our territory or society, and where innovation, scientific research and technological development are critical. They all need public policies to be aligned, as well as public and private competition, from the world of companies and entrepreneurs, from very different sectors, and from civil society organisations. Mobilising these energies requires strong commitment to persevere in tackling a given challenge, as this is the basis for actors to naturally concentrate their efforts on this goal.

We have examples from a wide range of countries of how STI have been used to address major national challenges that are purpose-driven, enabling them to position themselves as world leaders in specific areas. This is the case of the Netherlands in water management, Denmark with renewable energies, or Israel with desert irrigation technologies. We can also follow this path.

In a way, the creation of the Strategic Investment Fund (SIF), under the auspices of the Ministry of Economy, pointed in this direction by establishing a scheme to finance interventions that tend to fall outside the priorities of the sectoral ministries, but are key to achieving complex objectives. Based on the lessons learned from this experience, we believe it is possible to design a scheme that will improve its operation and focus it on a more limited set of national challenges, projecting it over time.

Specifically, we propose to establish a procedure that, taking into account people's concerns, will facilitate the selection of a limited number of major national challenges that can be worked on, two with at least 10-year horizons and with a management that reports directly to the Presidency of the Republic. We propose that the implementation of the work programmes associated with the challenges should be financed by the Government, but that the bulk of the resources mobilised should come from the public departments and the related private actors. Furthermore, we propose that there be a billion-dollar resource fund, available to finance specific investments or activities necessary for the success of the programmes, but which cannot be implemented through the existing public channels. This fund would be a sort of continuator of the current Strategic Investment Fund (SIF).

Once approved, these goals should become a State policy to be assumed as a special responsibility by the ministries and services of

the different governments. The main task of the steering team would be to coordinate the efforts of public and private agents, thus taking on the main issue faced today in order to address complex challenges that exceed sectoral logic.

The process of selecting challenges, as well as monitoring progress, are particularly critical aspects of this initiative.

Therefore, as a Council, we propose that the challenge selection process should include the effective participation of citizens, guaranteed by a committee of renowned and diverse people, ensuring its independence and safeguarding the legitimacy of the process. The challenges to be addressed may be presented by public, academic, business or civil society bodies, demonstrating their importance.

The decision systems should have sufficient time and resources to analyse them, even considering complementary studies if required. Below are listed a few of the selection criteria that should be considered:

- ❖ Response to a condition specific to Chile
- ❖ Based on goals that respond to relevant problems or needs
- ❖ Have the potential to create value for the world
- ❖ Have a strong justification to require special public sector intervention
- ❖ Contribute positively to environmental sustainability and social cohesion, and this contribution is clearly measurable.

Addressing this challenge will require a clear but adjustable roadmap approved by the committee. Once a year, the implementation team should provide an accountability report, detailing progress on performance indicators and justifying programme maintenance. Apart from the resources to finance the implementation team work, the allocation of resources for specific projects will be made on a case-by-case basis by the Committee. All the above will be publicly accessible and it will have to be communicated through a specially dedicated website.

The process of designing the proposed procedure should be supported by international experts and benefit from the experience of the Strategic Investment Fund (SIF).

NEWS WE WOULD LIKE TO READ ABOUT THIS MOMENTUM

## **CHILE HAS MADE A TOURIST PARADISE OF THE DRIEST DESERT IN THE WORLD**

At a hostel on a small property near San Pedro de Atacama, Roberto Amaral and Constanza Montes receive tourists from all over the world and offer them an unforgettable experience. Fruits and vegetables grown in the area by their neighbours, handicrafts that rescue traditional culture, stary nights guided by professionals from the astronomical observatories, and a life that draws its energy from the Norte Grande sun.

At the beginning of the 21st century, Chile set itself the challenge to use solar energy to provide water to the driest place on Earth. Due to the scarcity of water and climate change, fruit trees were moved to the south, Chile used its knowledge and technology to make the Sun its main partner, recovering water from the sea and thus keeping the ecosystems in the area alive. Today this country is at the forefront of a series of developments associated with solar energy, the use of sea water, understanding the desert and engaging the communities to

keep customs, traditions and nature alive. In this context, Roberto and Constanza proudly built their business.

The joint work with research and technological centres, has not only created concrete solutions to ensure the survival and development of the families in that region, but it has also incorporated science into their daily lives, especially astronomy and knowledge about the desert with its specific life forms.

This project has attracted worldwide interest, given the combination of various scientific approaches at stake, the support it has gained from numerous public and private bodies, including several key ministries in the field, along with venture capital funds added early to this initiative that reports directly to the Presidency of the Republic.

## II. A way to act collectively: Business investment meetings for sectoral R&D&I

Design a compulsory contribution to carry out R&D&I activities focused on collective sectoral challenges, and managed by companies in the sector organised for this purpose.

In Chile, there are several incentives to encourage companies to innovate, including Corfo's support lines and the R&D tax incentive scheme. These mechanisms already have an important track record and are an effective aid for companies seeking to carry out innovation projects. Likewise, over the years a set of tools has been deployed to support the emergence and first expansion of new enterprises.

However, we do not have similar mechanisms to assist the R&D&I needs that companies collectively have as a business sector. The truth is that there are, and will increasingly be, a significant number of challenges that companies cannot take on individually, either because they are too costly and the benefits will be distributed very quickly among all the firms in the sector, or because the possibility of success requires all the firms to participate. The effects of climate change, the new environmental requirements and the transformational waves that are generating technological changes (e.g., smart industry, Internet of Things, and Big Data), are some of the elements in the current context that have made companies aware that they need to unite to address common challenges.

What kind? The challenges may consist of highly specialised personnel training, or R&D&I programmes and projects in key areas

for a sector (e.g., environmental problems, new varieties of pests or diseases, development of standards), creating technology transfer and service centres, and even training technology-based companies to provide essential goods and services for a sector.

However, acting collectively is a learning process which we have just started. Coordinating and bringing together all the firms in a sector is already a major challenge, which becomes even greater if we seek financial cooperation that will enable us to develop a common R&D&I agenda, which due to its nature has uncertain dividends.

The creation of public research and transfer institutes or centres has been one of the traditional ways to address this type of R&D&I challenge. Since the 1960s, several of these institutions have made important contributions to develop their sectors; however, they have also faced difficulties such as, ensuring resources are directed to the actual needs of their sectors, or inflexibilities inherent in public institutions and, above all, problems to secure funding to enable them to remain in operation. Although these efforts are valid and necessary, they are insufficient in relation to the magnitude of the challenges we face today.

Therefore, we propose a scheme that will facilitate the implementation of long-term collective sectoral R&D&I initiatives. This scheme requires all the companies that invoice more than 100,000 UF to contribute a percentage of sales. The amount collected is returned to the companies and which is then used to develop R&D&I programmes to collectively benefit a sector. This process is overseen by a representative meeting of all the companies in a sector.





In this scheme, the State intervenes to replicate, at a corporate-sector level, the best practices of the world's most innovative companies: indexing or allocating a percentage of sector sales to investment in R&D&I, by charging a parallel tax. This is the easiest and most transparent way of fulfilling its dual purpose: first, overcome coordination problems involved in collecting resources for R&D actions delivering wider benefits and, second, prevent larger beneficiaries, who do not contribute, benefiting from the results. The State also has a duty to monitor and ensure the spirit of the law is respected in terms of how the resources are used.

Whenever this sectoral tax is created, the law should set out the paying companies right to allocate the resources collected to the R&D&I Investment Board of their choice. In the event that they do not select an option, the resources would go directly to public funds.

The Boards should specify their objectives in advance and propose programmes with limited or renewable time horizons based on the results obtained. Obviously, by participating in the administration of the Investment Boards, the companies will adjust these programmes, but always based on public results<sup>1</sup>.

The logic of setting this contribution for larger companies, but permitting smaller companies in the sector to participate in the Investment Board management, is that the latter have more difficulties in implementing innovations that arise from the R&D processes and generate less benefits from innovation (see chapter 3), but their participation is important for operational efficiency across the sector.

As reference, if implemented at a rate of 0.1% of corporate sales, with a turnover of more than 100,000 UFs, this scheme would generate an additional US\$ 731 million for R&D<sup>2</sup>. This represents close to 0.3% of GDP and is equivalent to a 73% increase in Chile's total R&D expenditure. The proposed formula is inspired by Paul Romer's approach (1993), currently the World Bank Chief Economist, as a way of overcoming the problems that limit collective R&D&I, but through a mechanism that maintains market incentives to reward successful

initiatives and punish inefficient ones. The idea is that companies coordinate not to offer but to demand and finance payment for services provided by other specialised entities, such as technology-based companies, science and technology centres and universities. This implies that it must have a professional operation, capable of identifying and organising the requirements common to all companies, while presenting technically consistent projects.<sup>3</sup>

Several countries, many of them natural resource-intensive, have developed similar instruments or mechanisms. These include Norway, Argentina and Colombia (see table).

On the basis this proposal receives a favourable reception, which we have identified in the dialogues with various businessmen and business leaders, the Council proposes to establish an inter-ministerial committee, led by the Ministry of Finance. This committee will discuss these ideas and agree on a detailed proposal to legally implement this type of mechanism. The preparation of this legal mechanism should involve a wide range of representatives from the private sector, particularly from sectoral business associations. One way to progressively advance in this direction and improve the mechanism, would be to start in some sectors where this need is particularly felt by companies and they communicate this through their business association.

1. In the event that intellectual property is generated, the results should be made available to domestic companies and those operating in the country, and they may be licensed for global operations. The income obtained would be reinvested in the activities defined by the Board.
2. This calculation used the sales figures by company tranches reported by the SII.
3. See Romer, P. (1993) "Implementing a National Technology Strategy with Self-Organizing Industry Investment Boards", Brookings Papers: Microeconomics 2, 1993.

### Two experiences of collective R&D&I organisation

#### Norway

The Norwegian Seafood Research Fund was established in 2001, financed by a 0.3% levy on the fishing industry's exports (US\$18 million per year). This is a completely voluntary contribution, it is not part of the tax burden or national budget; this is to ensure it is not used for other purposes.

The board of directors responsible for the fund is made up of four fishing industry leaders, two trade union representatives and an observer from the Ministry of Science and Technology. It receives recommendations from fishing industry advisory committees, including artisanal fisheries, and closely monitors the industry's needs and preferences. Its purpose is to transform R&D into useful results for the industry, its motto being: "Research is the transformation of money into knowledge; innovation is the transformation of knowledge back into money."

#### Argentina

In Argentina there are several interesting experiences. One of them was driven by rice producers in the province of Entre Ríos who, faced with a decline in productivity in 1999, asked the provincial government to impose a tax allocated exclusively to finance STI at the Institute

of Agricultural Technology (INTA) in the Province. This initiative was very successful, because thanks to the development of a new variety they were able to not only reverse the drop in productivity, but also to become leaders in this field.

Another initiative was promoted by the chamber of the Argentine Association of Metallurgical Industry (ADIMRA), which consists of 35 associations and 24,000 companies. In 2001, they asked the government to impose a compulsory payment on companies in the industry to provide them with resources to use more technology in their operations. A decree established a compulsory payment between 1% and 2% of the payroll for companies in the industry to finance ADIMRA.

They started with training centres and now invest in technology centres that incorporate training and support new innovation projects that are submitted to public funds, and even the provision of technological services. In the latter case, they have invested in machinery and equipment that are too expensive for an SME to maintain. This is the case, for example, with 3D printers (which also require specialised personnel), or a camera that analyses the electromagnetic compatibility of equipment (US\$ 1 million). Similar initiatives have been promoted by the electronics industry in Córdoba and the agricultural machinery industry in Rosario (CIDETER).

ANOTHER NEWS ITEM WE WOULD LIKE TO READ ABOUT THIS MOMENTUM

## THE OPEN SECRET THAT DRIVES THE WINE INDUSTRY

In the last decade of the 20th century, when Manuel Espejo began his career in the wine industry, he knew a key element of the business was to be very careful not share strategic information with the competition. Thirty years later, this scenario has radically changed. Sharing information and creating joint plans and strategies has not only become important, but it is also an essential element of disruptive growth in this economic sector.

Using the Collective Sector R&D Law scheme, Viña Espejada is a small company member of the association of wine producers in the O'Higgins, Maule, Biobío and Araucanía Regions, which has managed to establish a (private) Investment Board that is managing a US\$10

million fund. In the past eight years, this fund has allowed them to apply the technological advances in biotechnology, genetics, bioinformatics and environment to develop an early detection kit to identify viruses and pathogens and improve resistant varieties that make a difference and adapt to the different *terroirs* of Chile.

Having a Pathogen-Free Bank as the main goal and early detection tools was a desire of many rural entrepreneurs to once again believe in this activity and contribute to the development of our regions. This challenge would have been impossible to face alone or in the short term.

This dream was possible thanks to the fact that they collectively organised with the State to give a boost to Chilean wine.

### III. Ability to look ahead: A State that understands and anticipates

To allocate a percentage of each ministry's total expenditure to finance R&D&I in response to long-term challenges and key public issues, agreed upon across the board.

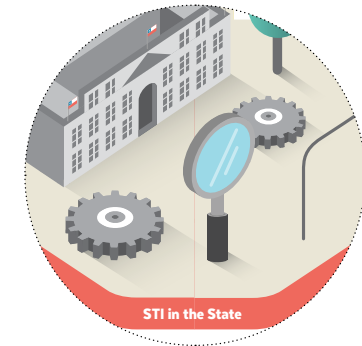
The current context of change also poses enormous challenges for the State. Moving through a scenario marked by a combination of technological and environmental changes that have complex and uncertain social impacts, with a population that is increasingly connected and demanding, presents enormous challenges for the way public action is carried out. There are certainly great risks and fear of the destabilising effects of this wave of transformations may have paralysing effects or keep the public sector desperately responding to the events imposed on it by this situation. The modernisation of the public sector is now more complex than ever before, as these new systems need more than just new technological devices, they also require changes in practices and cultures deeply rooted in the institutions, not to mention disruptive impacts on employment and occupational profiles.

However, this new scenario also opens up opportunities to transform the public sector and the way it operates. The new information and communications technologies not only provide citizens with a means of controlling and demanding State action, they can also be a tool for better understanding and integrating their desires and concerns and making them part of the solutions. The new scientific and technological knowledge, both local and international, may also be used to assess courses of action, and to better anticipate and prepare for the foreseeable effects of trends in global change.

In this context, we need a State with more capacity to understand, adapt and anticipate and, above all, more open to an intelligent and innovative society.

This is, undoubtedly, a process that has several sides and which needs us to radically rethink the way the State is organised and its relationship with its citizens. From our point of view, we firmly believe that whatever direction this adjustment takes, it must involve a greater and more systematic relationship between the public sector and the national centres of knowledge generation and technological development.

Through a closer relationship between the two parties, virtuous circles in the dynamics can be achieved, where public policy design



1. We used 2% of the final consumption expenditure (item 22 of the budget) as reference for the rate of expenditure required, but the idea is that each Ministry should be able to propose the source of funding.

and operation benefit from advanced knowledge, while it would also create incentives for some of the research to focus on public interest.

For this purpose, we propose that all central government ministries should be required to allocate a percentage of their annual budget for the procurement of R&D programmes, with at least a three-year time horizon. For instance, a percentage equal to two percent of each ministry's spending on goods and services, in the case of the 2016 budget, this would have meant an additional R&D investment of US\$ 84 million, equal to 8.4 percent of total R&D spending<sup>1</sup>. The social return on this effort cannot be less than the public activities in progress and, in fact, they can be higher, as shown in the calculations of returns on R&D investment in natural disaster prevention.

We propose that the programme objectives should be determined in consultation with an advisory committee composed of former government ministers from different political positions, together with scientists and members of civil society organisations.

Thus, we believe the ministries can promote R&D activities, developing new knowledge and innovations in the public interest that go beyond the current situation and emergencies they must respond to. This would enable Chile to anticipate the impact of the waves of technological change and emerging phenomena, as well as take advantage of the new knowledge and technology to promote public policy innovation. A collateral effect of this initiative is that the ministries will have to strengthen their ability to act as a counterparty

to those who develop the specific R&D&I projects or programmes, thus increasing the State's own capacities.

We propose that the process of identifying and implementing R&D projects should be advised by the future Ministry of Science and Technology. Likewise, the future Committee of Ministers of Science, Technology and Innovation should recommend how to approach common problems involved in modernising all the ministries, such as designing advanced digital strategies to optimise public spending on broadband infrastructure, cyber security and data centres, as well as on distributed services that can use various public services. It can also address cross-cutting issues such as, support strategies to ensure water availability and sustainability, address ageing and chronic diseases and experiment with smart solutions for a smarter and more transparent government.

We propose to move forward and implement this initiative, first by adding a gloss to the Budget Law limiting the number of ministries. Based on the lessons learned from this first initiative, it can be modified to involve all the ministries.

### **Experiences of scientific support to strengthen public policies**

#### **Australia**

The roles and responsibilities of scientific advisors in the Australian system vary according to the factors that explain their actions, such as the type of advice, individual, institutional or panel, the formality of the advice, the content and its audience, education, health, agriculture, environment, and the political context. For example, Australia's Scientific Advisor, established in 1989, had as a first challenge to coordinate the preparation of multidisciplinary responses to Global Climate Change and the need to keep scientific activity at the same level as the accelerated changes of international development. While, the Australian Academy of Science has a more informal science advisory role, by preparing scientific advice in response to specific Government and Parliament inquiries.

#### **Canada**

The requirements for scientific advice emanate mostly from science-based Departments and Agencies, such as agriculture, food, nuclear safety and defence. These bodies work with scientific experts who provide advice to design public policies. Likewise, other users of scientific advice include industry, transport, public safety and emergency preparedness.

Thus, scientific advice or expertise comes from the National Research Council and the Research and Technology Organisation. The Departments and Agencies also seek advice from external independent experts

who review the quality of the science performed by Government and provide recommendations on programmes and policies.

There are three independent organisations that provide scientific advice to the federal government. In the context of cabinet confidentiality, scientific advice contributes to areas of national interest, such as public health and safety, environmental protection, resource exploitation, wealth creation, and innovation.

#### **Finland**

Although there is no formal structure, like in Australia or Canada, the need for scientific advice has been recognised by the Prime Minister's office has resulted in some ministries setting up temporary committees to bring scientific knowledge closer to public policy design, which takes the form of Advisory Councils. For example, the climate panel at the Ministry of the Environment.

At the same time, institutional support is given, by research institutes which function under the guidance and funding of ministries, to develop related scientific activity. Their research agendas are variable, in terms of being policy relevant, and they do not cover all government areas.

ANOTHER NEWS ITEM WE WOULD LIKE TO READ ABOUT THIS MOMENTUM

## **INNOVATION POLICIES ENABLE MORE AND BETTER HEALTHCARE**

Rosalinda Amuncura has lived all her life in Seno Muerto, a small village in the Los Lagos municipality; it is in such a remote area that it still does not appear on many maps. To get to Seno Muerto you have to go through winding dirt roads, making it difficult to get there unless you have a special vehicle and, it is even worse if the trip is during the rainy months. During the last decades, the people who live here have become used to only receiving two regular visitors: Mario Barrera, the parish priest of the Futaleufú church, who makes biweekly visits during spring and autumn, and Albertina Larenas, general physician for this remote area, who tries to go every two months.

In May 2029, this was one of the small villages in Chile chosen to pilot this initiative, the Ministry of Health installed telemedicine devices in three of the 14 houses in Seno Muerto, training Mrs. Amuncura and two other neighbours how to use these devices. These devices enable healthcare providers to examine them at a distance, remotely accessing 70% of the diagnosis and follow-up medical examinations that Dr Larenas used to do, or which required them to travel for several hours to the Chaitén Hospital.

A year after the pilot was launched in the 6 most isolated villages in Chile, the results have surpassed all expectations, improving the quality of life of these people, while having a positive impact on different health indicators.

This project is part of the “2% Ministerial” plan, through which public bodies are dedicating this percentage of their budget to technological innovation and, in the case of the Ministry of Health (MINSAL),

to telemedicine. With proven innovative social and technological practices in telemedicine, artificial intelligence and advanced designs in logistics distribution networks, the MINSAL has founded the Agency (under Private Law) but with a Board of Directors in which the Minister Lorenza Ramírez participates, as well as outstanding scientists, NGOs and businessmen of this country.

To start up the Agency, it was determined that the initial 2% budget of the Ministry of Health, would be used to implement six pilots in the towns of Codpa (Arica), Pozo Almonte (Iquique), Vicuña (Coquimbo), Quillota (Valparaiso), Seno Muerto (Los Lagos), Coyhaique (Aysén) and Punta Arenas (Magallanes) to bring to the rural world and remote towns the most advanced health centres in the country, the best knowledge of health centres from around the world specialising in different healthcare areas. Affordable healthcare available to everyone 24/7.

In addition to enabling remote examinations, this ambitious plan aims to build an Uber-type network of doctors who want to provide services in remote centres. Furthermore, it involves the intensive use of artificial intelligence tools in alliance with the main health centres in the world and in Chile’s main cities. Redefining a healthcare network based on mobile devices and health centre location indicators is a reality thanks to this new flexible, coordinated and long-term space for R&D&I management.

#### IV. A condition for take-off: Broadband and digital government from Visviri to Cape Horn

Promote widespread digitalisation of government services, so as to create digital infrastructure conditions facilitating intense network deployment and their use by SMEs and citizens.

High quality digital broadband infrastructure is not a luxury of rich countries, but an enabling condition for the development and well-being of the entire population of this country. Today it is as essential to development as energy, water and transport infrastructures. In fact, increased productivity in traditional economic sectors, the emergence of new industrial and service sectors, as well as the modernisation of the State for the 21st century and being connected to the world in all areas, require a high-speed, high-quality, high-capillarity and highly resilient broadband infrastructure.

Chile has taken significant steps in its digital development. Today, almost everyone over the age of 15 uses mobile phones and more than 60% of households have Internet access (ECLAC, ITU), as do a large number of companies. However, more than levelling out the field of access to information and knowledge, or to allow the deployment of

creative capabilities, or to increase the productivity of SMEs in Chile, the Internet has been consolidated as a consumer good used preferably as a source of entertainment and as a personal communication platform.

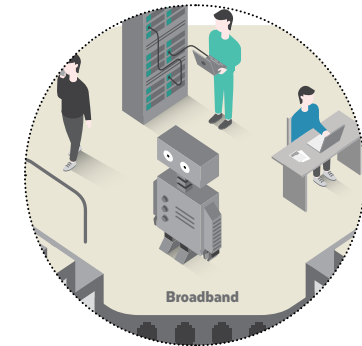
There is certainly nothing wrong with these demonstrations, but in Chile (as in the rest of Latin America) they are becoming dangerously disproportionate (ECLAC, 2016). Thus, not only is the growing transformative power provided by these technologies wasted, but the incentives for this country to develop the necessary investments to take advantage of the enormous impact that a massive deployment of broadband connectivity can have on our collective well-being are diminished. If we continue on this current path of progress, the opportunities and benefits of this process will be concentrated among higher income families and larger businesses.

As a result, progress in broadband deployment itself will slow down, as there will not be enough customers (traffic) to justify investments.

We can see how there are signs that this process is already underway in this country.

Firstly, there is a significant and growing gap with OECD countries. Less than 10% of businesses and 2% of households have high-speed Internet access ( $\geq 30$  Mbps).

Since 2009, the gap in Internet access speed has been widening with respect to OECD countries. And even though Chile has a per capita





income that is just over half the OECD average, prices for 15 Mbps per month (US\$ PPC) are 80% higher than the average in those countries.

Second, disparities in Internet access are very significant, both in terms of income and geography. Currently, more than 80 percent of households in the richest twenty percent have access to the Internet, compared to only 30 percent of households in the poorest twenty percent. In fact, the municipalities on the east side of Santiago have much more access than the more popular areas of the capital, the regional capitals and in rural areas. At the same time, businesses have extremely heterogeneous access to and use of the Internet.

These gaps show that Chile has structural and also institutional limitations to develop a digital infrastructure that favours innovation and knowledge-based development. At present, we do not have the infrastructure to take full advantage of the opportunities offered by the Internet of Things for production and logistics systems, advanced manufacturing for industry, ICT for precision agriculture and telemedicine in healthcare. Only wealthier households and large enterprises are able to pay for high-standard dedicated services.

The country risks missing out on the new waves of profound transformations that will occur over the next few decades, and the distance between social groups and between companies will increase. Access to quality digital infrastructure is emerging as one of the pillars of inclusion in the 21st century.

According to estimates by the Undersecretary of Telecommunications, in order to have a broadband Internet at the same level as in OECD countries with adequate national coverage, we require an investment of about US\$ 23 billion in the next ten years, which is equivalent to everything the telecommunication companies invested

in the last twenty years. Given the current types and intensities of network use, this investment is unlikely to materialise, since traffic projections do not make network operations profitable.

To meet this challenge, we propose to implement an ambitious programme operating simultaneously on two fronts. On the one hand, and as a fundamental focus, to generate the conditions to increase the use of the Internet with an impact on productivity and efficiency improvements in both the public and private spheres. On the other, to correct administrative and coordination problems that raise investment and network operation costs.

With regard to the first point, our proposal is to establish an ambitious plan for the digitalisation of services carried out by the State. This would have the direct benefit of reducing costs in public action and improving service quality and coverage, while substantially increasing network traffic, generating conditions that could support a more extensive network deployment.

An emblematic case is that both the cost and waiting time can be reduced through the use of telemedicine. Recent experiences applied to the case of ophthalmological examinations show savings of close to 60% in benefits and with greater opportunity, given the chronic shortage of such specialists. Applications such as Building Intelligent Manufacturing also allow major savings in the process of design, approval and construction of buildings. The Escritorio Empresa project, which brings together all the procedures associated with the creation of a company, is also an example of the type of action to be promoted. If we want to open wide opportunities to be part of the so-called Industry 4.0, we need a digital infrastructure of the highest standards.

Thus, the challenge is to move from one-off experiences to a strategy that is supported and driven at the highest level, with goals and incentives that are monitored with the support of the Ministry of Finance. All new public procedures or services should start at a digital level, and only residually operate in a face-to-face manner.

In addition, it is essential to strengthen the more intense and sophisticated use of information and communication technologies by smaller companies. In Chile such companies use these technologies in a very primary way. This situation is one of the direct causes of their low level of productivity and income. At the same time, since their activity is concentrated in the service and trade sectors, the opportunities offered by digitalisation are not very difficult to implement. The various public programmes for the dissemination and transfer of technology and business, as well as support for training and technical education, must incorporate this dimension more decisively into their actions.

However, training and transfer are not enough to bring small businesses into the digital world. It is also necessary to ensure low-cost digital operations. In Chile, for example, small retailers and farmers' market vendors shy away from using electronic means of payment because of the high fees they are charged, compared to large customers.

In the United States, this situation led to the passage of a special law regulating transaction charges (see Chapter 3).

The second line of action, complementary to the promotion of digitalisation, aims to facilitate the implementation of infrastructure works that allow network deployment. The approval processes involved need to be thoroughly reviewed, and efforts made to simplify and streamline them wherever possible. A clear example of unnecessary costs to be incurred is the lack of coordination on the part of municipalities when granting permits to install underground cables. The mere fact that all the companies were called upon to do this work would mean significant savings.

In short, it is about having a digital strategy that truly rises to the level of a major goal of national interest. To do so is to offer the vast majority of our citizens real participation in the gestation and enjoyment of the opportunities offered by a revolution that is already affecting our lives and will continue to do so.

ANOTHER NEWS ITEM WE WOULD LIKE TO READ ABOUT THIS MOMENTUM

## **CHILEAN FISHERMEN: FROM FISHING NETS TO GLOBAL DATA NETWORKS**

The development of broadband in Chile over the last 10 years has today, in 2030, enabled the current level of Internet penetration in Chile, reaching record levels in the region and the world. This is thanks to intense public-private work, reinforced by a research, development and innovation plan to promote key global initiatives such as “#BigDataOfThings” (BDOT).

One of the most striking examples of the local and global impact of these initiatives is being driven by artisanal fishermen.

Freddy Parra lives and works in the cove of Duao in the Maule region; however, he feels like a citizen of the world. He is a fourth-generation artisanal fisherman, and today he can access tools and networks allowing him to maintain traditions and share his expertise, while being connected to people, information and organisations elsewhere. “I feel part of a large community that lives around those of us who interact with the sea every day”.

He is a member of the Artisanal Fishermen of Caleta Duao Organisation in the central region of Chile and of the National Association of Artisanal Fishermen of Chile. In recent years, the latter with various government institutions have driven the Integrated Global Data Network and Marine Extractor Zone Alert, part of the BDOT project. These initiatives have been possible precisely because of the development of broadband in this country.

Like any fisherman, Freddy gets up very early and works long hours to catch the marine resources and then return to the coast to sell them. This work has been positively impacted by the use of Information and Communications Technologies, Big Data and the Internet of Things. Every day, before starting his workday, he uses his mobile phone to get information

about online marine monitoring of the area: he checks the current weather conditions and forecasts for his workday, SHOA and Port Authority alerts about tides, ecosystem balance and other events. If these institutions allow him to set sail, he checks fish/species prices, and the relationships with potential companies that could buy the day’s catch, among other data.

For Luis Contreras, president of the local network, the biggest advantage of this system is the local and global feedback. “The network allows us to be in contact with other extraction areas in Chile and the world. So, we can anticipate situations and be informed in real time of what is happening even when we are working out at sea,” he explains. He adds “with this we have managed to reduce the number of deaths and missing colleagues, and improve our quality of life. Now we are working with other organisations to further improve safety measures.

This style of work has been achieved thanks to the joint efforts of the Navy, Chile’s public and private ports, the Ministry of Transport and Telecommunications, the Industrial Fishermen and the Associations of Artisan Fishermen of Chile.

## V. An opportunity to continue flying high: STI at the heart of schools

In 5 years, we can take STI to all primary and secondary schools through meeting and co-designing spaces between the worlds of science and education.

The Council is committed to making STI part of the narrative about our national, diverse, and multicultural identity.

We propose to begin by developing in children and young people the ability to ask, research and experiment. These skills are provided by science, technologies and innovation, and are critical to the future.

In Chile there are significant cases that show these skills in the different spaces of life, for example: poetry has turned to mathematics; artisan and popular inventors apply principles of inquiry and problem-solving; and physics is revealed in the myths of native peoples.

Extending this possibility means participating in the school experience, at all levels, the development of scientific curiosity and a culture of innovation, taking advantage of a wealth of resources that exist in our territorial, cultural and knowledge diversity. Museums, national parks, zoos, archaeological and historical sites, research centres, communication and training platforms, technology companies, universities, technical centres and institutes distributed in every corner of Chile, have educational and cultural dissemination programmes

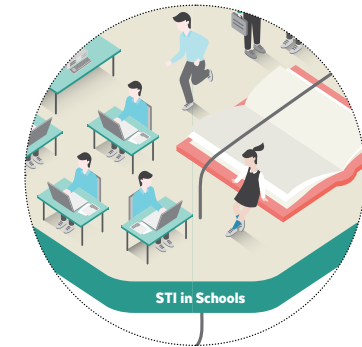
that connect us to the advances in science and technology, and these programmes can be multiplied.<sup>1</sup>

They can be partners in the education system, if we organise their proposals and support their entry into primary and secondary schools, incorporating them into the national curriculum frameworks, incorporating them into school planning and management, as well as into teacher training and education processes. But, above all, into the school experience of our children.<sup>2</sup>

To this end, we are committed to a peer-to-peer relationship with teachers, shaping these interventions in such a way as to support them in the performance of their teaching work, based on their own knowledge and experience.

It is essential to recognise that teaching is extremely demanding, it often takes place in socially and culturally deprived conditions, and it not merely to communicate knowledge, it is also a complex interaction process.

From this reflection, within the framework of the “Science for Development” Commission, the Council proposed to move forward with a pilot project that was implemented in 2016, coordinating the efforts of the different public institutions involved in this initiative. Thus, we aimed to establish a connection that would allow real joint work between teachers and those who seek to contribute with their knowledge and experience from the world of STI to adapt the curriculum and programmes of the available offers to support the educational needs of the students at each school.



1. Science Committee for the Development of Chile, “*Un sueño compartido para el futuro Chile*”. CNID, 2015. Appendix Subcommittee on Culture.
2. Science Committee for the Development of Chile, “*Un sueño compartido para el futuro Chile*”. CNID, 2015. Appendix Subcommittee on Culture
3. “*Un sueño compartido para Chile*.” Report to the President of the Presidential Commission on Science for Development CNID, July 2015 (p. 118).

### **Club Network: Getting down to business and cables**

Mixing design, art and technologies for prototyping in one workshop space, The Club, is a programme where young students from technical schools dress up as inventors and put their creativity into project development.

Useful devices that solve problems or useless objects that fulfil wishes, are created by students. This initiative is based on the assumption that learning emerges only when there is an emotional link between the subject and the object of study, so the aim is to have young people explore and discover by doing what makes sense to them. Thus, the club, its tools and the techniques (3D modelling, programming, electronics and carpentry) become a means of exploration.

The network component aims to confront young men and women with the diverse realities of Chile and, hence, broaden their understanding of the world where they live. Therefore, students in Cholchol, Temuco and Valparaíso, worked side by side with young offenders serving sentence and held at the semi-closed La Cisterna Centre.

After a pilot study was conducted at three high schools and a semi-closed centre run by Sename (Child Welfare Service), distributed across three regions, the first guidelines were created to begin building a nationwide club network.

This initiative, inspired by the dynamics of makerspaces and the project learning methodology, can be a powerful experience for children and young people to face the challenges of the 21st century, even for the advent of Industry 4.0.

More than a hundred teachers and 2,500 students participated in 23 initiatives in twelve schools in the Los Ríos and Metropolitan regions. The assessment revealed significant improvements in the students' "interest in science" and "attitudes towards science", based on the virtuous alliance between teachers and scientific proponents.

This programme will continue expanding and learning during 2017, by using the resources provided by the Conicyt Explora programme as well as the outreach resources included in projects funded by Conicyt and the Millennium Science Initiative. This positive experience has led some regions to replicate it using Regional CIF resources (Regional Competitiveness and Innovations Fund). The Ministry of Education plans to incorporate it into its lines of work as of 2018.

Based on this process we believe that the conditions are in place to provide children and young people in Chile with a new learning experience based on a more systematic contribution from science and innovation developed in Chile. For this reason, we propose to extend this programme and in a period of five years cover all the primary and

secondary schools across Chile. This system would require an investment of approximately \$70 billion per year, perfectly affordable using the available resources of the different participating institutions, together with those mobilised by the education reform.

This proposal aims to lay solid foundations at the heart of the education community to, permanently and jointly, build a culture of science, technology and innovation that will allow us to unleash talent and contribute to making Chile a country whose development we are proud of.

We already have a validated methodology that enhances the willingness and interest of researchers, teachers and students, based on a collaboration dynamics. There is no excuse for not moving forward and for "the children and young people of Chile to actively and creatively participate across the entire territory in creating and using scientific-technological knowledge and innovation as fundamental tools for understanding, developing and transforming the world in which they live."<sup>3</sup>

ANOTHER NEWS ITEM WE WOULD LIKE TO READ ABOUT THIS MOMENTUM

## **CHILEAN CHILDREN CO-CREATE QUESTIONS THAT ARE CHANGING THE WORLD**

Pedro is 13 years old and two years ago, in 2028, together with scientist Aurelio Escobar, created a system to provide reports on the impact each activity carried out by his family members, and the operation of his home, has on the carbon footprint, and not only in relation to the country's index, but also to those of the world.

Pedro asked the question: "How can we raise awareness at a domestic level about the impact of our actions on the environment? While searching for an answer, he worked with researchers at the Centre for Advanced Environmental Innovation at Universidad de Temuco, and also with his teachers at the Cunco Rural School, to co-create science, technology and innovation projects that would have local impact and, ideally, global potential.

The answers to the question and subsequent solution led by Pedro, have gone around the world; they were patented and the first tests are being conducted in Finland and Japan. Pedro, via teleconference, is providing advice on how to implement the system in homes and also involve children, teachers and scientists in those countries.

This experience is part of the "STI Culture at the Heart of the School; a journey through science, technology and innovation" programme,

which has allowed thousands of Chilean children to co-create questions that challenge the present and the future.

The Cunco Rural School hosted the meeting of school communities that have been in the programme for 10 years: "STI Culture has allowed us to meet, dialogue, and dream about education and the future. Additionally, year after year, we work and create with scientists, new knowledge for the children, but also new questions and challenges," says Mariana Araneda, a maths teacher at the school.

During the celebration activities, co-creation and agile prototyping workshops were held. Desks, stairs and even the floor, everything was transformed into a place of discussion about artificial intelligence, chemistry and recipes, volcanoes, art and digitalisation, woodlice and evolution. Children of all ages: 12- and 16-year-old students, and 14-, 7- and 17-year-old students.

History teacher and host René Letelier smiles: "After years of collaborative work with scientists and a new approach to learning with the education community, I knew that the results would be even bigger from Araucania to Chile and the world," he says emotionally.

## A NOTE ON THE TASKS OF THE NEW SCIENCE, TECHNOLOGY AND INNOVATION INSTITUTIONAL STRUCTURE



At the time this strategy was presented, a proposal to create a Ministry of Science and Technology is in its first phase of legislative discussion. The discussion on the objectives, competencies and areas of action of this new ministerial entity were discussed at length within the framework of the Presidential Advisory Committee on Science for Development. The different opinions on the direction the future ministry should take are set out in the report published in June 2016, but they will not be included here. It is in the legislative discussion that these differences will be processed, weighing up the plans and teams that were previously submitted, at the end of 2013, by another committee created specifically for this purpose and which resulted in the proposal of a Ministry of Science, Technology and Higher Education.

The intention is not to repeat the extensive debate that has taken place on the subject, and recognising that the proposal to create a Ministry of Innovation creates an opportunity to strengthen the efforts that we as a country carry out in STI, as the National Council of Innovation for Development. We would like to point out some of the challenges a new institutional framework should address, in line with the guidelines expressed in these pages.

The new institutional structure should be an effective contribution to improve the coordination and mobilisation of STI efforts for sustainable and inclusive development. At a public sector level, this means that whatever the new ministry's structure, it must be seen as a cross-cutting ally of the remaining government bodies that promote STI activities and contribution to Chile's development. The future Ministry should accompany and support an extended process for its use and promotion across the public sector. This would require the different departments to incorporate STI developments to improve

their performance and importance, and to also promote its progress by using the broad range of underused government regulatory and financial tools available. The main risk is if STI developments are considered the responsibility of the Ministry created for this purpose and not of the entire public apparatus.

Another institutional challenge is to ensure scientific, technological development and innovation activities are closely intertwined. Although each one is important, and there is not just one way of promoting their contributions, it is evident that to achieve certain development goals, we need to coordinate the different areas and actors. This coordination, in a scenario where there are more actors, will necessarily involve a higher authority to guide these efforts.

The passage of the law should also be an opportunity to review the corporate governance structure of the agencies involved in promoting STI, for example, more diverse representation of interests and views on the different boards. It would also be important to strengthen the operational capabilities of the agencies, particularly Conicyt, which have not kept pace with promotion funding increases, resulting in excessive administrative burdens on staff and delays. At this level, it would also be preferable to reach an agreement with the General Comptroller of the Republic, so that the law sets out the role and operation of agencies consistent with the flexibility imperative and reaction speed needed to support the actors in order to be effective.

Finally, we pose the challenge of ensuring an adequate dialogue between the central government and the regions, to reconcile national priorities with those deployed in locations across Chile, and not just the capital. In the context of a decentralising process promoting a significant transfer of functions to regions, this dimension must be looked after with great care.



## At the end of a document At the beginning of a process



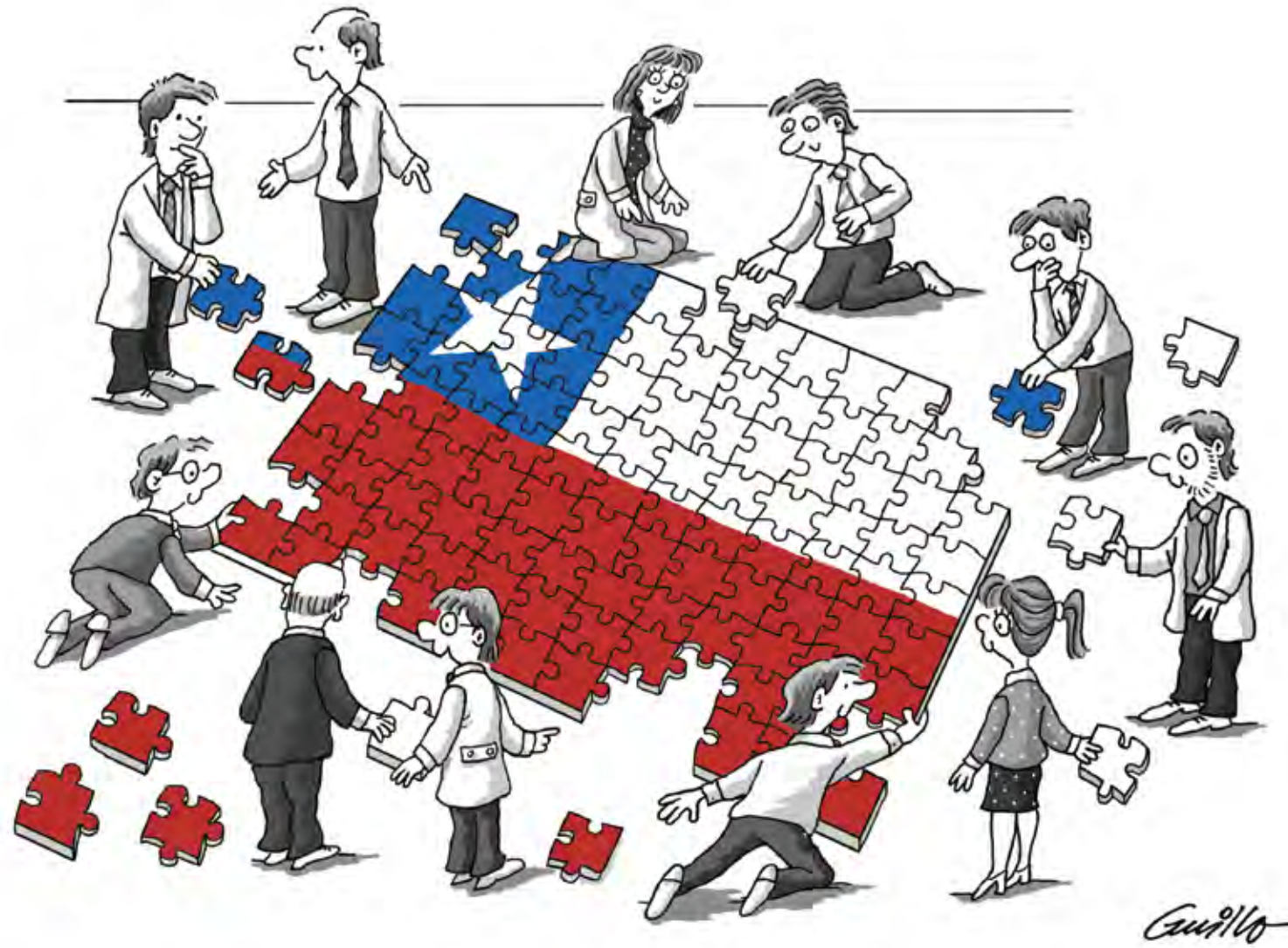
Although it pains us to admit it, in these ten years, progress in making science, technology and innovation an ally for our development has not been as expected.

In the light of this experience, today we believe this strategic exercise will be a space where we can hold meetings, reach agreements and increase the willpower to mobilise and maintain transformative projects to create the conditions for our dreams to come.

In these times of rapid change, complexity and uncertainty, this limited set of ambitious, but potential initiatives, open up spaces where our commitment to the country bear fruit.

Therefore, we want to contribute to creating transformative dynamics, i.e., a space for continuous learning, where we can design and test new ways to strengthen and take advantage of the science, technology and innovation capabilities to build a better future for Chile.





ANNEX I

## ANNEX 1



### **More researchers proposed by the Commission on Science for Development**

We currently have 16,000 researchers working part-time or full-time, representing nearly 50% of total staff dedicated to research and development (R&D). This means that Chile has around 0.97 active, full-time equivalent researchers per 1,000 employed, the lowest rate in the OECD as of 2014. Chile is evidently lagging behind when compared to China (1.97), Argentina (2.88), Turkey (3.46) and the OECD average (7.96).

This lack of researchers has a profound impact not only on Chile's scientific development potential, but also on the learning of imported technologies, on innovation based on science and technology, on the formation of advanced human capital, on the design of competitive business strategies, as well as on the design of public policies and on the development of the country's regions. Overcoming this gap is a strategic issue.

The trend of the last decade indicates that at this rate, Chile will double the number of researchers by 2030, maintaining its position as one of the OECD countries with the lowest number of researchers per 1,000 people.

If the country were to set a goal of at least tripling the number of R&D researchers and personnel between 2016-2030, i.e., the government would have to continue its efforts for another three lustrums, improving from 0.97 to 1.97 researchers per thousand inhabitants. Although this is still well below the current OECD average (7.96 per thousand inhabitants), it would cover part of this enormous gap our country has in this area, which is consistent with Chile exceeding 1% of R&D spending by 2030.

This strategic option must at least incorporate four criteria: new researchers should graduate from postgraduate courses of excellence; postgraduate training is not only demand-driven, but also prioritises disciplines in which Chile confronts major deficits, ensuring a harmonious balance between exact sciences, social sciences, arts and humanities; the new generations are educated with a culture based on the ethics of collaboration, inter- and transdisciplinary work and open dialogue with society; and they are incorporated into different spaces of society, not only into universities, especially ensuring to strengthen scientific and technological capacities in regions.

Achieving this means overcoming several barriers. In companies, particularly SMEs, part of the difficulty lies in the lack of scientific infrastructure and equipment, which can be addressed by contracting the services of science and technology centres or by forming alliances with technology-based companies. In the case of universities and scientific-technological centres linked to them, the proposal is to create a research career within universities themselves that opens up a route of promotion and recognition for people who are exclusively dedicated to this activity, and overcomes the fact that today the number of active researchers depends on increasing the number of staff, limiting its expansion and specialisation. And in general, it implies opening up to the world, as all developed nations have done, attracting talent to Chile and fostering global networks that incorporate Chilean researchers working abroad.



## ACKNOWLEDGEMENTS



This proposal is the result of ten years' learning experience, since the Council was set up. In keeping with this, it has not been conceived as a process culminating in the publication of a document. On the contrary, our aim is to make it available to the community as a starting point.

We would like to thank everyone for their suggestions and comments to enrich this proposal. Elías Arce, María Eliana Arntz, Bernardo Broitman, Juan Claro, Andrés Couve, Carlos Montes, Alejandra Mustakis, Sonia Pérez and Klaus Schmidt-Hebbel, took the time to read the entire document and send us their insights and comments. Of course, any errors or omissions are not their responsibility.

Likewise, there is a group of professionals who contributed from their areas of expertise to enrich the process of reflection and support the statements and proposals contained in this document: Marcela Angulo, Manuel Araya, Pamela Arellano, Paula Astudillo, Alex Berg, Fernando Bustamante, Paulina Carvallo, Raúl Ciudad, Pelayo Covarrubias, Hernán Cheyre, Sofía Del Sante, Jessy Echeverría, Rocío Fonseca, Nils Galdo, Antonio Gartner, Aldo González, Mariana Herrera, Rodrigo Krell, Gastón L'Huillier, Guillermo Larraín, Juan Felipe López, Claudio Maggi, Claudia Marró, Claudia Mery, Juan Cristóbal Moreno, Claudio Muñoz, Inti Núñez, Mónica Paz, Sandra Peralta, Ma. Teresa Ruiz, Isabel Salinas, Enrique Sepúlveda, Tomás Schuster, Pedro Sierra, Lucas Sierra, Osvaldo Urzúa, Mariangeles Véliz, René Villegas, Andrés Zahler. We also appreciate the comments made by participants at meetings organised by the Institute of Engineers, the Productivity Dialogue of Universidad del Desarrollo, the Centre of Public Studies, the National Productivity Commission.

We would like to give special recognition to the young people who participated in the Emerging Innovation Agents Table who were able to bring new voices and perspectives: Marisol Alarcón, David Alvo, Marcel Augsburg, Ignacio Brescia, Patricio Canales, Marco Carcuro, Victoria Corti, Komal Dadlani, Rodrigo Echeopar, Mariana Fulgueiras, María José García, Eduardo Guzmán, Bruno Grossi, César Fuentes, José Tomás Labbé, Juan Carlos Lara, Maitetxu Larraechea, José Tomás Lobo, Joaquín Meliñir, María José Montero, Nicolás Morales, Paloma Núñez, Macarena Pola, Jaime Peña, Javiera Roa, María Paz Ramos, Nicolás Riquelme, Marco Rivera, Matías Rojas, Carla Silva, Tadashi Takaoka, Francisco Torrealba, Claudina Uribe, Fernando Valiente, Pablo Viollier.

## Credits

This publication was prepared by the National Council of Innovation for Development and its Executive Secretariat.

### Address

Gonzalo Rivas G.

### Coordination

Katherine Villarroel G.

### General edition

M. Soledad Ugarte M.

### Editorial Committee

Gonzalo Rivas G.

Katherine Villarroel G.

M. Soledad Ugarte M.

Álvaro Díaz P.

### Research

Jaime Álvarez G.

Oriana Avilés M.

Juan Pablo Contreras

Xaviera de la Vega P.

Álvaro Díaz P.

Raúl González

Alexander Hazbún R.

Rodolfo Lauterbach

Verónica Luco

Aldo Medina Z.

M. José Menéndez

Cristián Moreno

Leonardo Muñoz

Dan Poniachik

### Communications

Pablo de Buen N.

Paloma Baytelman

Virginia Herrera

### Administrative support

Ana Luisa Véliz

Paola Valdenegro

Marcos Rubio

### Art Direction

Ximena Rosselló

### Graphic design

Ximena Rosselló

Aldo Medina Z.

Antonia Necochea

José Tomás González

Camilo Zúñiga

### Illustrations

Guillermo Bastías (Guillo)

Julie Carles

Nicolás Carrasco

### Editorial production

### and printing

BYWATERS

---

In this book, Chilean fonts were used: Texta and Texta Narrow, designed by Daniel Hernández Sánchez and Miguel Hernández Montoya, and Australis Pro, designed by Francisco Gálvez Pizarro.

This work is licensed under the Creative Commons Attribution- Noncommercial- NoDerivative 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

You are free to copy, distribute the work in any medium or format. This is on the condition that you give credit to this work in an appropriate manner, providing a link to the license, and indicating whether changes have been made. You may do so in any reasonable way, but not in a way that suggests that you or your use is endorsed by the licensor. In addition, you must ensure that the material is not used for commercial purposes and that no derivative works are produced on the original work.



---

Santiago de Chile, June 2017. Second edition.



*“This text is an invitation to leave the con-fortune zone where we find ourselves: short-termism. It is easier to navigate in the immediacy, than to try to collaborate to project sustainable actions in the long term. It is a matter of no more and no less than regaining confidence that we can govern change.*

*The merit of the proposal is that it brings us closer to dealing with the issues that concern us so much, such as climate change or low productivity. It does so, moreover, by taking up a long-awaited demand from civil society, which seeks to give greater legitimacy to decisions on public affairs. In short, it addresses the confidence deficit, which is undoubtedly the greatest challenge we will face as a society in the coming decades.*

**María Eliana Arntz**  
Director Casa de la Paz Foundation

*“A multi-faceted analysis that identifies various economic and social factors that influence the productivity needed to advance along the path of development. In the competitive environment in which companies operate today, innovation is no longer an option but a necessity to sustain growth capable of creating more quality jobs and to stop social problems from waiting. I think that both the diagnosis and the proposals included in this report invite us to work side by side to promote initiatives that are necessary to improve the quality of life of all Chileans”.*

**Juan Claro**  
Director of the Centre for Public Studies Former  
President of the Confederation of Production and  
Trade (CPC)

*“It is a very valuable document not only for what it proposes but for the information it holds. It presents real examples of STI for social welfare, not unicorn dreams. They are possible if we stop looking at what is good outside and what we lack inside, to start valuing the science we have in Chile now. Since I am very excited that the CNID is so honest about this reality and the need to move from promises to concrete actions. Something that is clear from beginning to end is that it reflects the work of a group with a sincere intention of approaching and improving the development of STI in our country.*

*It gives me hope to see that there are others who dream. It takes courage to persist in this attempt.”*

**Olga Barbosa**  
Researcher at Universidad Austral President of the  
Ecological Society of Chile

*“The generation and application of knowledge was fundamental in the origins of the Republic. And although historically our policies have not been very systemic, the bridges that have begun to be rebuilt between science, technology and innovation, and that trace the story of this document and the recent history of the CNID, offer us a new opportunity to address the comprehensive development of Chile in a scenario full of uncertainty. The invitation is to be great, to strengthen those bridges by combining country challenges and collective capacities. If we add this proposal to the construction of a diverse disciplinary base, essential for understanding nature, we may find the elusive key to improving competitiveness and consolidating our cultural identity.*

**Andrés Couve**  
Professor at the Faculty of Medicine, University of  
Chile Director of the Millennium Institute of Biomedical  
Neuroscience (BNI)

*“This excellent report from the CNID develops strategic directions for the future of the CTI, which should play a much more important role than the one it has played until now, to ensure that our country moves more decisively along a path of integral development. The report presents good comparative data and a descriptive but balanced diagnosis of the achievements and shortcomings of STI in Chile. It culminates with five concrete public policy proposals that, in large part, should generate a consensus for their eventual implementation. The future challenge is an ex ante evaluation of the impact of these innovative proposals, as well as ex post evaluations of the effects of traditional state instruments in support of STI”.*

**Klaus Schmidt-Hebbel**  
Full Professor at the PUC of Chile Former Chief  
Economist of the OECD

*“The collaborative way in which the CNID built this strategy and the innovative nature of its proposals are an invitation for science, technology, innovation and entrepreneurship to work together for a better Chile.*

**Alejandra Mustakis**  
President of the Chilean Association of Entrepreneurs

*“Our country needs to expand and energize the productive matrix to continue growing. The primary export and financial income model has been exhausted. The CTI can help us make the leap we need. This document analyzes precisely our weaknesses and challenges in this area. It invites us to think about how to combine STI policies with productive and industrial development actions. It analyzes comparative experience, showing that in successful countries the public sector has had and still has a decisive role in STI. Many advances emerged from an entrepreneurial State that opened up paths to the private sector. Finally, it proposes five strategic initiatives whose implementation requires a broad political and technical consensus”.*

**Carlos Montes**  
Senator

*“The country’s problems that are visible here are a good sign of the urgency that CNID gives to its strategy. An urgency that, if not recognized in its social value, will be more of a setback than an advance, as the policy proposed here warns.*

**Sonia Pérez**  
Professor of the Department of Psychology and  
Director of Research at the Faculty of Social Sciences,  
University of Chile