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Territorial Infrastructure Support Index (ISIT): A theoretical and empirical contribution to the analysis of lag zones in Chile

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Abstract. Through a review of the literature on infrastructure, a study of international experiences, expert knowledge, and the elaboration of a Territorial Infrastructure Support Index (ISIT), this paper provides a comparative analysis of the development conditions – regarding infrastructure and services – for the location of productive economic activities, at the regional and provincial level in Chile. The results show contrasts between regions and within them, revealing the state of the current situation for each of the six dimensions: Water, Energy, Telecommunications, Roads, Logistics, and Resilience, as well as for their synthetic indicator ISIT. The results of the ISIT have been contrasted with the recent definitions made by the Government of Chile regarding the definition of lag zones, finding important coincidences at the provincial level that allow validating the ISIT as a tool for the analysis of gaps in infrastructure and equipment for development of economic and productive activities in Chile.

Key words: Infrastructure, region, lag zones and indicators

1 Introduction

The objective of this work is to investigate the possible impacts that infrastructure has on socio-territorial development in Chile, for which it is posed as a question how the gaps in productive economic development are related to the declared lag zones in the country. In particular, an index called Development of the Territorial Infrastructure Support Index (ISIT) is applied, which considers six dimensions: Water, Energy, Roads, Telecommunications, Logistics, and Resilience at a provincial scale and is contrasted with the geostatistical results provided by the information on lag zones.

The hypothesis of this work is that a lag zone is deprived of infrastructure for socio-territorial and productive development, deepening the conditions of isolation and widening the gaps with respect to zones that are provided. Although geographical conditions that isolate a territory are decisive for the definition of a lag zone, we believe that infrastructure represents the opportunity to overcome these conditions and improve the quality of life of its inhabitants and the productivity of their economic activities.

For this purpose, two work objectives are proposed: (1) Analyze and compare the gaps in infrastructure for the economic-productive development existing in the country in a multidimensional way based on the ISIT; (2) Compare the level of coincidence with the definition of lag zones established by the Chilean state.

First, the article provides some background on the theoretical and empirical framework used, from the review of international literature and working documents of the Chilean state. Then, what characterizes the lag zones is defined and it is explained how the ISIT was elaborated, to subsequently analyze its cartographic representation at a provincial scale and its contrast with the resulting cartography of the lag zones. Finally, some conclusions are delivered that reflect on its scope in terms of decentralization and regionalization in the current context of political and institutional transformations in which the country finds itself.

2 Theoretical framework

The economic literature on infrastructure began with research efforts to explain the positive correlation between infrastructure development and rapid economic growth of the industrial economies (Banerjee et al. 2020). Agénor (2010) suggests that an increase in the share of public spending on infrastructure leads to a steady high growth state. This is because infrastructure affects the production and public services such as health and, therefore, labor efficiency.

In this direction, different authors have argued that infrastructure reforms geographic connectivity and contributes to the agglomeration of economic activities (Fujita, Krugman 2004). Likewise, infrastructure reduces costs and trade flows, thus positively influencing economic development (Cohen 2010). Therefore, prosperity and regional growth depend primarily on the indirect effects of infrastructure (Chen, Haynes 2015).

Recent studies have shown that infrastructure provides the necessary services that support economic growth by increasing the productivity of labor and capital, thereby reducing production costs and increasing profitability, output, income, and employment. (Zolfaghari et al. 2020). Additionally, it is increasingly recognized that infrastructure plays a vital role in promoting growth and reducing poverty in under-developed countries (Gramlich 1994).

Empirical evidence on regional inequality and investment in infrastructure has shown, for example, that improving road infrastructure can help increase labor force participation to reduce income inequality (Calderon, Servén 2004). Similarly, other types of infrastructure, such as communications, drinking water, and electricity networks, can promote income growth in rural sectors and reduce the gap between rural and urban areas (Wan, Zhang 2015). Similarly, Straub (2008) points out that investment in infrastructure directly affects the increase or decrease of the gaps between rich and poor regions within the same countries.

Based on these facts, governments, institutions, and the research community recognize the importance of infrastructure in economic and territorial development. However, the distributional effects of infrastructures have not been sufficiently explored (Wan, Zhang 2015), revealing that one of the main problems is the unequal distribution of infrastructure provision in the territories (Zhang et al. 2017).

The infrastructure is relevant to connect all kinds of territories, especially those lagged or with peripheral conditions. These zones usually are isolated from other zones because of physical and human factors (Farole 2013, Hanks 2011). In other words, they are separated from the leading zones and circuits both physically and economically (Brad et al. 2015). The infrastructure represents a critical opportunity for improving lagging conditions, allowing more accessibility to and from the lag zones.

In the case of Chile, although there has been significant increase of infrastructure development in recent decades, some gaps continue to be observed in the form of regional inequalities, quality of local infrastructure, and the population's exposure to negative externalities derived from economic growth (OECD 2017), such as the contamination, and decrease of hydric resources due to the mining industry. Additionally, it is still necessary to overcome existing infrastructure deficiencies (MOP 2007) and contribute to a more homogeneous distribution of their provision, particularly in terms of roads, telecommunications, and water reserves. In this sense, the Ministry of Public Works

(2007) indicates that it is necessary to increase the country's competitiveness, improve the population's quality of life, and concentrate public investment in sectors and territories where social profitability[1] is higher, with social and territorial equity. This vision is inserted in the Infrastructure Director Plan 2010-2025.

Chile is a unitary and centralized country, (OECD 2017), in particular, concerning the issues of decentralization and public investment, Orellana Ossandón et al. (2021) argue that when clear and transparent rules do not regulate the criteria that control the allocation of these types of public investment, they do not have a significant impact on the final result. Additionally, the distribution of territorial infrastructure in Chile is dominated by non-programmatic logic, in which the politicians in charge of the distribution make use of discretion to improve their electoral results (Orellana Ossandón et al. 2021). Chile's subnational investment in infrastructure is mainly framed in transportation and public works, decided centrally by the sector ministries (OECD 2017).

Faced with this situation, one of the main challenges faced by political systems to advance towards sustainable urban development, lies in defining established technical criteria that direct the thematic and geographical prioritization of public investment in territorial infrastructure on standards of territorial equity or economic efficiency (Orellana Ossandón et al. 2021). This is necessary to counter possible relationships between election results and public investment spending, as has happened in Greece, where ruling parties have tended to reward constituencies that return them to power (Rodríguez-Pose et al. 2016).

In the same way, it is crucial to value private investment. According to the Critical Infrastructure for Development Report (2018), developed by the Chilean Chamber of Construction, more than 60% of the total investment in infrastructure for the next decade requires the participation of the private sector. In fact, 32% could be provided entirely and directly by the private sector if the correct incentives and institutional frameworks are created, and another 29% could be provided under a mixed regime (with public and private financing) (CChC 2018).

Studies in line with the Keynesian vision show a complementarity between public and private investment, arguing that this effect is because public investment is generally limited to goods and services that the private sector will not produce in optimal quantities (Ouédraogo et al. 2020). In this sense, public investment in infrastructure tends to complement private investment because it facilitates the implementation and realization of investment plans by private agents (Martinez-Lopez 2006). Along the same lines, Abiad et al. (2016), using a simulation model, highlighted that increased public investment increases production, both in the short and long term, and increases private investment.

3 Marginal territories

The advanced marginality is concentrated and isolated in delimited territories. It is often associated with territorial stigmatization from the outside and inside (Wacquant 2007). Also, there is a loss or dissolution of the "place" itself because of the physical and socio-economic conditions, which disadvantage the territory resulting on dependency over other territories (Tort 2003). In this line, the functional relationship between a center and its periphery determines the marginality of the region because they are distant, dependent, and different (Ferrão, Lopes 2004 in Vecchio 2022).

They are distant in a physical and/or in an economic view, where rural and non-productive territories, for example, are left aside from infrastructure development and financial flows. Also, they are dependent because of the lack of labor markets and a sustainable commerce of goods and services in the territory. Finally, they are different because of their own conditions of disadvantage which make them unattractive. Territorial marginality is related to a specific space and location, including the participation, or its lack thereof, in the economic dynamics (Vecchio 2022). There is often an absence

[1] It refers to a project evaluation and prioritization criterion that Chile has used to allocate public resources since 1975, which compares investment at social prices with the number of direct beneficiaries impacted by the project, pointing to purely economic issues and not the beneficiary end (society)

Table 1: Percent of susceptible districts to be lag zones by region in Chile

Region	Total number of district	Number of susceptible districts	Percent of susceptible districts in the region
Arica y Parinacota	4	0	0.00%
Tarapacá	7	3	42.9%
Antofagasta	9	7	77.8%
Atacama	9	3	33.3%
Coquimbo	15	8	53.3%
Valparaíso	38	4	10.5%
Metropolitana de Santiago	52	12	23.1%
Libertador General Bernardo O'Higgins	33	7	21.2%
Maule	30	10	33.3%
Ñuble	21	8	38.1%
Biobío	33	15	45.5%
La Araucanía	32	9	28.1%
Los Ríos	12	6	50.0%
Los Lagos	30	17	56.7%
Aysén Del General Carlos Ibáñez Del Campo	10	6	60.0%
Magallanes Y De La Antártica Chilena	10	5	50.0%
TOTAL	345	120	39.0%

Source: SUBDERE, 2022

of institutions that could benefit the inhabitants or promote new developments through investment in infrastructure. Some of these territories do not have a minimum population which justifies the investment from a cost-benefit perspective. Eventually, this ends in a vicious circle where marginality remains.

Marginal territories are related to the concept of accessibility. This concept has produced a paradigm shift in various research fields, from transportation studies to digital human interactions, as well as in multiple disciplines such as engineering and geography, to name a few (Greco 2018). Accessibility is understood as the potential to access a specific activity. Said potential depends on the ease or difficulty of reaching different points in space and the level of attractiveness or magnitude of the opportunities. In other words, it implies integration over the space of possibilities, weighted by the ease of interaction (Miller 2018). In this sense, due to their peripheral nature, marginal territories lack this potential due to the difficulty of access due to lack of means (infrastructure) and low attractiveness. Investment in infrastructure in these territories tends to be considered inadequate to cover their demand because their population is small and dispersed, making it difficult to justify this investment (Vitale Brovarone, Cotella 2020).

In the case of Chile, an adequate approximation to define this condition of marginal territories is possible from the definition of what, from the field of public policies, is called "lag zones". According to the Subsecretaría de Desarrollo Regional (SUBDERE), it refers to the existence of territories that live in conditions of lag with respect to the country average, for which the program proposes to reduce social and economic gaps prioritized participatively by the public and private actors of each lagging territory. The methodology for defining lag zones considers the district[2] as a unit of territorial analysis. Among the analysis variables that it contemplates are: level of isolation due to geographic or climatic conditions or availability of connectivity infrastructure; travel time to education and health facilities; travel time to services (financial institutions, among others). Table 1 shows the percentage of districts in each region that are susceptible to be classified as lag zones.

4 Approach of the research and methodological application

This work poses as research question: To what extent are the existing gaps in infrastructure for economic-productive development related to the condition of lag zones in the

[2]District is the smallest territorial unit in administrative political terms in Chile.

country? For this purpose, it is maintained as a working hypothesis that, although the lag zones determined by public policy in Chile are limited to aspects related to factors related to the level of isolation of human settlements in terms of connectivity, access to health, education and services, there is a close relationship between endogenous factors (geographical and climatic) with exogenous factors (public and private investment in infrastructure) which together explain the existing gaps between Chilean regions.

4.1 Development of the territorial infrastructure support index (ISIT)

Public and private investment decisions that favor the economic and social development of the country, expanding the geography of opportunities, require indicators that allow establishing the pre-existing conditions of the territory as a source of resources and supporting activities. Thus, based on the report on Critical Infrastructure for Development 2018-2027 prepared by the Chilean Chamber of Construction (CCHC), we carried out a detailed and systematic analysis of investment requirements in fourteen critical sectors for sustainable development in Chile, including water resources, energy, telecommunications, interurban roads, urban roads, airports, ports, railways, logistics, public spaces, hospitals, prisons, education, and resilience.

Subsequently, we organized workshops with Chilean infrastructure and land planning experts to collect recommendations on infrastructure measurement. Also, we reviewed international experiences at a subnational scale (whether regional or interurban) about measuring and comparing aspects related to critical infrastructure for the development of the economic-productive system of a country, such as the Index of Logistics Performance of the World Bank, logistics observatories and indicators of regional integration of Economic Commission for Latin America and the Caribbean, the World Competitiveness Index developed by the International Institute for Management Development Competitiveness Center, among others.

Concerning this, there is a need to exploit, for example, the potential of accessibility indicators as a support tool in infrastructure planning tasks aimed at efficiency and territorial cohesion (Ortega et al. 2014). Likewise, the medium or long-term investment plans, which include indicators of infrastructure gaps and focus on a territorial basis, could play a key role in moving towards a territorially inclusive country (Orellana Ossandón et al. 2021). In addition, a system of indicators highlights territorial inequalities (e.g., greater or lesser coverage of drinking water) and the existing elements that support local communities' social and economic development (Vișan 2019). Other authors, such as Sherval (2009), also point out that constructing a quantitative indicator for specific territorial contexts, (like urban and rural territories), is crucial to guide decision-makers in distributing public subsidies for disadvantaged regions.

Based on the review of various experiences in the development of indicators (Steiniger et al. 2020), such as the System of Indicators and Standards of Urban Development (SIEDU)[3], Rural Life Quality Indicators System (SICVIR)[4], and Urban Quality of Life Index (ICVU)[5], we elaborated the Territorial Infrastructure Support Index (ISIT). The ISIT refers to the territorial aptitude relative to network infrastructures and services for the development and competitiveness of the various activities of the national economic-productive system at the provincial level. Based on the indicators systems mentioned above, we established six dimensions of the ISIT: water, energy, telecommunications, roads, logistics, and resilience. Each one is briefly explained below:

- Water; provision, and coverage of drinking water and sewerage in urban and rural areas, as well as rainwater.
- Energy; related to the provision in the territory of electricity, fossil fuels, and the use of renewable energies.
- Telecommunications; coverage, and quality of fixed and mobile telephone services, and internet in urban and rural areas.

[3] https://www.ine.cl/herramientas/portal-de-mapas/siedu/
[4] https://www.ine.cl/herramientas/portal-de-mapas/sicvir
[5] https://estudiosurbanos.uc.cl/documento/indice-de-calidad-de-vida-urbana-icvu-2021/

- Roads; coverage, and quality of the interurban road infrastructure network on primary and secondary roads.
- Logistics; coverage, and proximity of equipment and services required to support economic-productive development in the territory.
- Resilience; provision of equipment and services to respond to exposure to socio-environmental risks.

For example, on issues of water resources, Ali et al. (2020) developed a regional drought indicator, which provides sufficient evidence for establishing effective drought mitigation policies and early warning strategies. In the case of Chile, the main objective of investments associated with water resources for the next decade is to have infrastructure works that allow the progressive supply of all kinds of demands, both for drinking water service and for environmental, ecological, and productive uses (CChC 2018).

Regarding energy development, Yang et al. (2020) suggest that an effective infrastructure investment strategy could optimize the reallocation of energy resources (e.g., more finance on renewable energies instead of carbon or oil), promote coordinated development between regions, and reduce regional development inequality. Likewise, investment in energy infrastructure can improve social welfare for the poor people's demand for vital energy resources, such as gas and electricity (Li et al. 2018). Also, Gunnarsdóttir et al. (2020) argues that sustainable energy development is a political objective that requires solid indicators. Often, indicators emphasize the economic impacts of energy developments (Allan et al. 2014, Black et al. 2014, Lekavičius et al. 2019) and little or no recognition of environmental or social impacts.

It is essential to highlight the telecommunications infrastructure's role as a driver of GDP and the greater demands for data traffic expected in the future. Although Chile presents high penetration values for residential and mobile internet in the regional context, the country reaches only 70% of the average mobile internet penetration in OECD countries (CChC 2018). Internet access is a challenge in Latin America and the Caribbean, requiring continuous and specific public policies to achieve universal coverage (Serebrisky, Suárez-Alemán 2019).

Concerning these last three dimensions, the input-output matrices[6] illustrate, for example, that water resources, electricity, and telecommunications are used in the production process of almost all sectors, while transport is a transversal input to all of them (Zolfaghari et al. 2020). Indeed, improvements in transport infrastructures positively impact regional development and significant repercussions on the economy and affect many processes (Ortega et al. 2014).

Transport infrastructure is a vital social and economic resource and provides access to current economic and social opportunities (Richardson 2005). Investment in the construction and maintenance of transport infrastructure is enormous, and its repercussions can be seen in all areas of society (Hildén et al. 2004). Regarding this, the road infrastructure supply for better mobility and transportation performance is generally used as an indicator and can be measured from four perspectives: state of the pavement, traffic capacity, safety, and accessibility (Alavi et al. 2016, Dong, Huang 2015, Song et al. 2020). In terms of interurban roads, the importance of roadways in the entire national infrastructure is evident. The geographical configuration of Chile and the scarcity of road alternatives in many parts of the territory means that inland highways and roads take a leading role in the transportation networks of people and goods (CChC 2018).

Logistics is considered the necessary infrastructure to make the freight transport value chain more efficient (CChC 2018). The needs at the national level are associated with improving the efficiency in the treatment of cargo and the transitions between means of transport, following the complete value chain of the merchandise, from its origin to its destination (CChC 2018).

[6] input-output matrices of the central bank of Chile, available at https://si3.bcentral.cl/estadisticas/-Principal1/Excel/CCNN/cdr/excel.html.

4.2 ISIT Selected Variables

The selection of variables to calculate the ISIT involved a procedure that combined two stages. In the first stage, we preselected around 70 indicators distributed in the six dimensions based on national (SIEDU, SICVIR, ICVU) at a territorial scale superior to the city scale or international (OSD, OECD) measurement experiences (Steiniger et al. 2020), published studies, and expert knowledge through interviews and a workshop with members of the infrastructure committee of the Chilean Chamber Construction (CChC). In a second stage, 43 indicators were selected (see Annex 1), based on three critical considerations: availability of official sources to prepare the ISIT periodically and obtain comparable results for the Chilean case, geographical and climatic conditions[7] of each province to make a valid relative comparison, always making sure that each indicator has the 56 provinces.

Further information on the indicators (including all ISIT dimensions with 8 Water dimension indicators, 6 Energy indicators, 5 Telecommunications indicators, 7 for Roads Network indicators, 8 Logistics indicators, and 9 Resilience indicators) is available in the Annex 1. The calculation formula, the institutional source, and the update year are established for each indicator by dimension.

4.3 Indicators by dimensions and synthetic indicator

For the elaboration of the ISIT, from the 43 indicators and their six dimensions, a Principal Component Analysis (PCA) was applied to enable the construction of a synthetic indicator for each dimension evaluated in the ISIT (Shahabi et al. 2012).

Before performing the PCA, all the variables will be normalized between 0 and 100. In addition, the scale of those variables whose original value scale is negatively or inversely proportional to good support of the territorial infrastructure was inverted. Therefore, 0 is considered the minimum or least favorable value for all variables, and 100 is the maximum or best value for supporting the territorial infrastructure.

Each Principal Component (CP) obtained from the analysis is a linear combination of all the indicators, where each one obtains a specific coefficient or weight (eigenvalue). The analysis yields several CPs equal to the number of indicators, and where each CP explains a certain percentage of the total variance.

To generate indicators by dimension, the weights obtained in the PCA are reduced to a single coefficient per indicator. First, the absolute value of each indicator's weight in each dimension, relative to each PC, is multiplied by the percentage of the variance that explains said PC. This process is repeated for each indicator, considering the CP values (see equation 1). After obtaining a single coefficient per variable, a cut-off value (benchmark) is established to select the indicators that make up the final index. The criteria for choosing the cut-off value will be discussed at the work table; however, as an initial criterion, it is suggested to select a benchmark that leaves a minimum of 2 to 3 variables per area. Then, all those indicators with coefficients higher than the benchmark are chosen.

$$Cv_{comp1} = PVar1_{comp1} * \%S^2_{var1} \tag{1}$$

where

$comp1$ … Component 1,
Cv … Final Variable Coefficient,
$PVar1$ … Variable Weight 1,
S^2 … Variance.

Subsequently, for the final calculation of each dimension, the coefficients obtained are scaled for the selected indicators to add up to 100 in each area. Then, the provincial values of each indicator (previously normalized) are multiplied by the coefficient and added by dimension. Therefore, the province that has the maximum score in all the indicators of a dimension will have a score of 100 in that dimension.

[7] Some indicators are available only for coastal zones or specific climatic zones (presence of vegetation, among other characteristics).

Table 2: Population and area distribution by region in Chile

Region	Population	% Population	Surface	% Surface
Arica y Parinacota	226,068	1.3%	16,873	2.2%
Tarapacá	330,558	1.9%	42,225	5.6%
Antofagasta	607,534	3.5%	126,049	16.7%
Atacama	286,168	1.6%	75,176	9.9%
Coquimbo	757,586	4.3%	40,579	5.4%
Valparaíso	1,815,902	10.3%	16,396	2.2%
Metropolitana	7,112,808	40.5%	15,403	2.0%
O'Higgins	914,555	5.2%	16,387	2.2%
Maule	1,044,550	5.9%	30,296	4.0%
Ñuble	480,609	2.7%	13,178	1.7%
Biobío	1,556,805	8.9%	23,890	3.2%
Araucanía	957,224	5.4%	31,842	4.2%
Los Ríos	384,837	2.2%	18,429	2.4%
Los Lagos	828,708	4.7%	48,583	6.4%
Aysén	103,158	0.6%	108,494	14.3%
Magallanes	166,533	0.9%	132,297	17.5%
TOTAL	17,573,603	100.0%	756,097	100.0%

Source: Own elaboration, according to INE data, 2022

4.4 Classification for comparative analysis

Given that there is no possibility of comparing the ISIT with any national or international reference that would allow recognizing specific standards in some dimensions, four levels were determined; High, Medium-High, Medium-Low, and Low, based on the results obtained from the statistical processing itself. So then, the territorial aptitude of the ISIT or some dimension would be:

HIGH (dark green) : When the indicator by dimension or synthetic for a province is above the average plus mean standard deviation. $x > \bar{x} + \sigma$

MEDIUM-HIGH (light green) : When the indicator by dimension or synthetic for a province is between the average plus the mean, standard deviation, and the average. $\bar{x} < x < \bar{x} + \sigma$

MEDIUM-LOW (light brown) : When the indicator by dimension or synthetic for a province is between the average and the average minus the mean, standard deviation. $\bar{x} - \sigma < x < \bar{x}$

LOW (dark brown) : When the indicator by dimension or synthetic for a province is below the average minus the mean, standard deviation. $x < \bar{x} - \sigma$

The results for each dimension and the ISIT are represented cartographically, a question that allows observing the differences between regions and within them, showing the contrasts that exist to make the location of some economic-productive activities more feasible depending on what affects them in each dimension.

5 Analysis of results

The regions that conform to the continental territory of Chile present an uneven distribution in terms of their surface and demographic terms, as can be seen in Table 2, organized from north to south.

To better visualize the contrasts existing in the country, in demographic and territorial terms, Table 2 shows that while the Metropolitan region concentrates 40,5% of the population, it only occupies 2,0% of the continental surface. In contrast, the Magallanes region only concentrates 0,9% of the population and occupies 17,5% of the national territory. Regions such as Antofagasta in the north and Aysén in the south present the same pattern as Magallanes.

The latter reinforces the centralist and unitary character of the Chilean state, as can be seen in Graph 1 were, from north to south, between the regions of Valparaíso and Biobío (5 regions of 16 regions), 73,5% of the population is concentrated, only occupying 15,1% of the national territory. It is crucial to point out that in the OECD report on Chile (OECD 2017), it is stated textually, "Chile has opted for a mixture of two models: on the one hand, a liberal economic model that relies on the ability of the market to distribute resources and tends to limit public intervention. And, on the other hand, a 'centralist model of political administration' is understood as a way to maintain stability, protect national unity, and contribute to economic efficiency and social redistribution. This model places Chile in a unique situation compared to other OECD countries, with low total public spending (as a percentage of GDP) as well as a low level of subnational spending (as a percentage of total public spending)" (p. 8).

The combination of models has made it possible to develop exports focused primarily on the primary sector, with an estimated US$50 billion in exports. This sector is mainly concentrated in mining (50,8%), fruits (9,4%), forestry (7,1%), and aquaculture (6,5%). Mining activity is concentrated in the northern area and the rest are located in the country's southern area, while in the Metropolitan region where the country's capital is located, the commerce and services sector prevail far above the percentage of the population with just over 70,0%.

6 ISIT provincial results

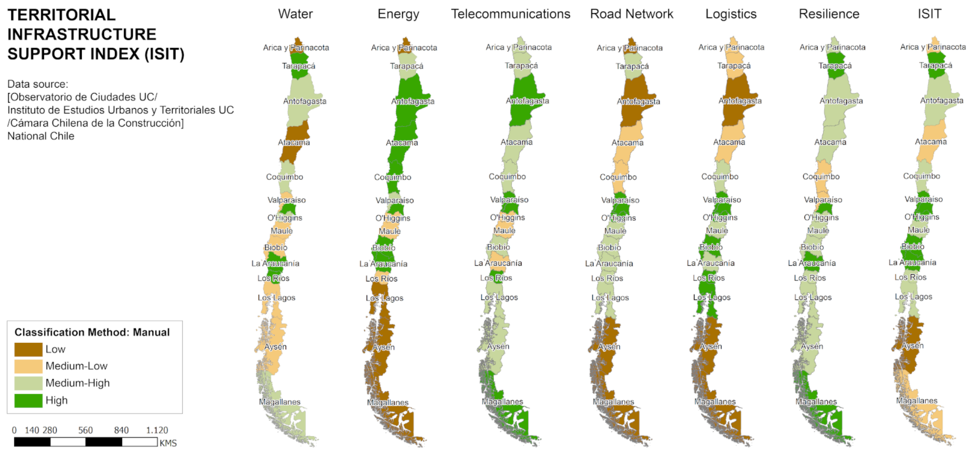
The results of the preparation of the ISIT are presented below, considering two scales of analysis; interregional and intraregional. The interregional analysis allows comparing the ISIT and its dimensions between the different regions of the country. And, the intraregional analysis will enable us to verify the existing contrasts within each region from the results that are represented at the provincial level.

6.1 Interregional Analysis

The interregional analysis is shown in Figure 1, where the results obtained for each region are presented, once applied in PCA and selected the 25 indicators that express the most significant variance, considering a distribution of water with three indicators, energy with four, telecommunications with four, roads with five, logistics with five and resilience with four.

In general, the interregional maps show that the different dimensions of the ISIT in the central macro zone of the country are more favorable compared to the north and south of the country, particularly concerning the southern zone (regions of Aysén and Magallanes), in contrast to a High and Medium-High level of territorial aptitude for the Metropolitan region in almost all dimensions, exceptionally in the telecommunications dimension. Then, the Biobío, Valparaíso, and La Araucanía regions present results with a High and Medium-High level in all their dimensions, although with a greater tendency towards a Medium-High level of territorial aptitude and other Medium-Low. The rest of the regions of the central macrozone, such as the O'Higgins and Maule regions, mainly present a territorial aptitude at a Medium-High level. Both also show a low level in the telecommunications dimension.

Figure 1 also shows a significant level of contrast between dimensions in the extreme north of the country. On the one hand, while the energy dimension is presented with an excellent territorial aptitude, especially in regions with a significant presence of large copper mining such as Tarapacá at the Medium-High level, Antofagasta and Atacama at the High level, which has promoted private investment in terms of development, the supply and diversification of energy sources, mainly through solar and wind energy. And, on the other hand, in the roads and logistics dimensions, territorial aptitude is presented at a Low and Medium-High level, most likely due to the high concentration



Source: Own elaboration, 2022

Figure 1: Interregional comparison by dimension of the ISIT

of the population in its regional capitals and the low level of development of its smaller cities without good alternatives for transportation of workers to mining sites.

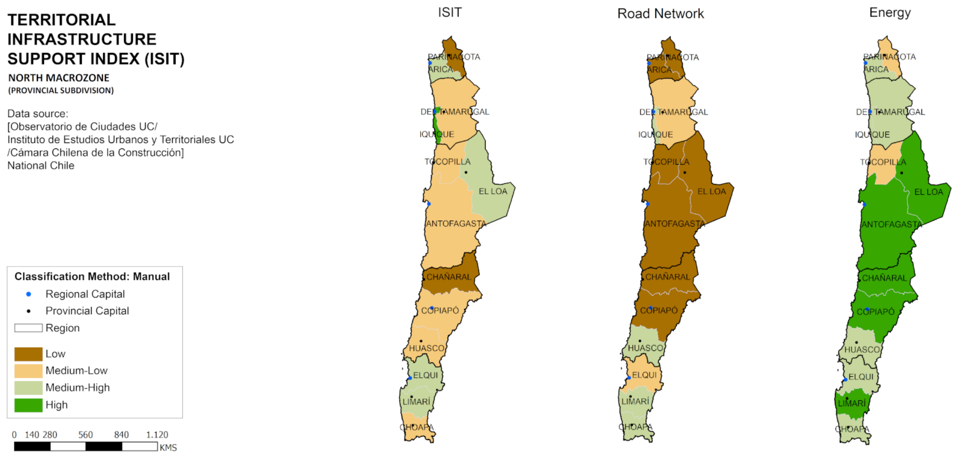
And, in the extreme south, from Los Ríos Region towards the southern zone, the regions show a deterioration in most dimensions, where they mostly reach a Low or Medium-Low territorial aptitude, except for the telecommunications and water dimensions. Figure 1 also shows the characteristics of a territory with rugged geography from the region of Los Lagos to the south, making surface connectivity especially complex in Aysén and Magallanes. In addition, it is an area with historically low population occupation. These two regions cover a third of the country's continental surface but only account for 1,5% of the national population.

Lastly, the ISIT, as a synthetic indicator that results from the average of the six dimensions, shows that only the Metropolitan and Valparaíso regions reach a High territorial aptitude. This situation deteriorates towards the north, reaching a low ISIT level in the Arica and Parinacota Region. In contrast, to the south between the O'Higgins and Los Ríos regions, a Medium-High territorial aptitude predominates, then the Los Lagos, Aysén, and Magallanes regions present an ISIT at Low level. In conclusion, in interregional terms, the country presents critical imbalances in infrastructure and equipment for economic-productive activity that limits its growth and economic development potentials, already warned by the OECD (2017) report and other similar studies.

6.2 *Intraregional Analysis by Macrozone*

Based on the interregional results, this section reviews the results obtained at the provincial level, considering an analysis based on macro zones. Four macro zones will be considered: The North (regions of Arica and Parinacota, Tarapacá, Antofagasta, Atacama, and Coquimbo); the Central North (Valparaíso, Metropolitana, and O'Higgins), the Central-South (Maule, Biobío, Araucanía, and Los Ríos), and the South (Los Lagos, Aysén, and Magallanes). The intraregional analysis is conducted from north to south for the 55 provinces defined in the continental territory.

The presented analysis shows the contrast between those dimensions where there is greater contrast in the results. That is, where provinces tend to be concentrated in a Low or Medium-Low aptitude versus that of a more favorable dimension, where the provinces are concentrated in the High and Medium-High levels. Likewise, the result of the synthetic index obtained by the provinces of each respective macrozone is presented.



Source: Own elaboration, 2022

Figure 2: ISIT of provinces of the northern macrozone

6.3 Analysis of Provinces of the Northern Macrozone

Figure 2 shows the results by province of the five regions that belong to the northern macrozone. Of all the provinces that conform to this vast territory, only the province of Tamarugal in the Tarapacá Region achieves an ISIT at the High level. However, the province of Iquique, which is in the same region, only reaches the Medium-Low level. For the other regions, the ISIT shows an important contrast between the Arica and Parinacota Region provinces but less prominent between the Regions of Antofagasta, Atacama, and Coquimbo.

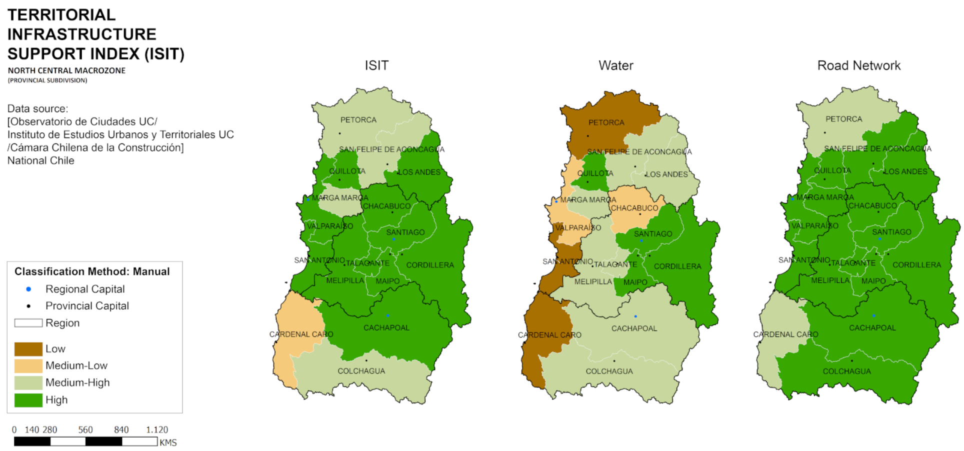
This contrast also shows a significant disequilibrium between dimensions. For example, the Antofagasta region has a good energy performance, derived from mining activity, but poor connectivity, considering the distances. The opposite occurs in the province of Tamarugal, where the indicators are more homogeneous among the different dimensions, allowing the province to stand out with the best overall infrastructure indicator.

6.4 Analysis of Provinces of the Central-North Macrozone

Figure 3 shows how all the provinces of the Metropolitan Region have a High ISIT level, being the only case among all the regions of the country. While in the case of the Valparaíso region, there are contrasts among its seven provinces, where Petorca, Marga-Marga, and San Felipe de Aconcagua reach an ISIT at a Medium-High level, the rest of the provinces have High levels. And, in the case of the O'Higgins region, there is a greater diversity of situations concerning the ISIT, because while the province of Cachapoal reaches a High level, the province of Colchagua obtains Medium-High and the province of Cardenal Caro obtains Medium-Low.

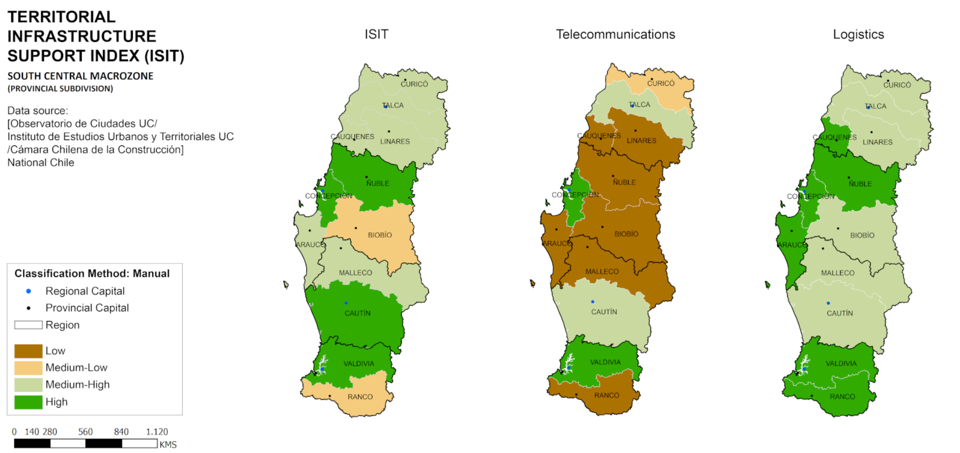
Then, the greatest contrasts between provinces by dimension in the case of the central-north macrozone are in the water dimension where a greater number of provinces obtain Low and Medium-Low levels, particularly in the province of Petorca and San Antonio in the region from Valparaíso and in the Cardenal Caro provinces in the O'Higgins region. Now, although there are provinces with a High and Medium-High level in territorial aptitude in the water dimension, it is crucial considering that the province of Santiago, Maipo, and Cordillera, contain 40,0% of the country's population. There are also provinces in the Medium-Low levels such as Valparaíso and Chacabuco.

In contrast to the previous dimension, in the roads dimension, this macrozone presents its best territorial aptitude, since except for Petorca and Cardenal Caro, which reach a Medium-High level, the rest of the provinces obtain a High level in this dimension. It must be considered that the three regions (of central-north macrozone) that make up



Source: Own elaboration, 2022

Figure 3: ISIT of provinces of the central-north macrozone



Source: Own elaboration, 2022

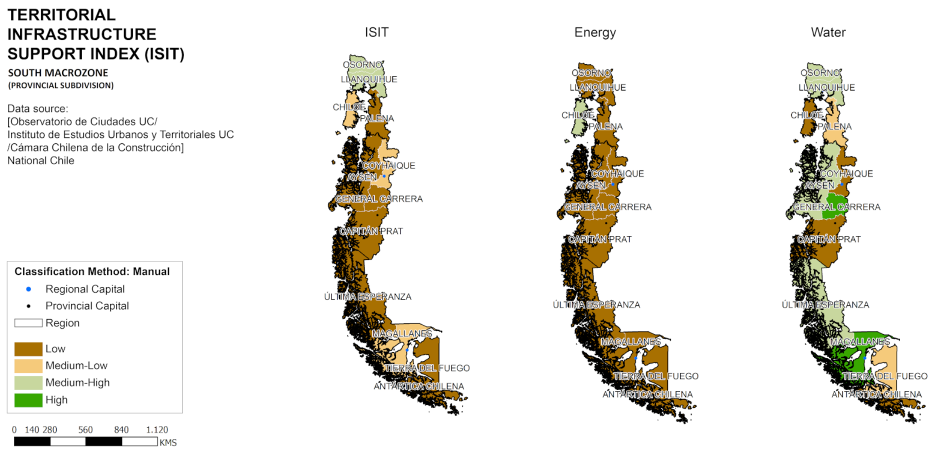
Figure 4: ISIT of provinces of the central-south macrozone

what for this study we have defined as the central-south macrozone, it covers only 6,6% of the country's territory. However, it contains at the same time 56,0% of the country's population, a territory where there are also ports located in the provinces of San Antonio and Valparaíso, that move slightly over 50,0% of the country's cargo, as well as the main international airport in the province of Santiago.

6.5 Analysis of Provinces of the Central-South Macrozone

In Figure 4, the results are positive, given that the ISIT presents most of the provinces in the High and Medium-High level in terms of territorial aptitude, where only the province of Biobío in the Biobío Region and the province of Ranco in the Los Ríos region reach only a Medium-Low level. Maule region's homogeneity in the ISIT is particularly noteworthy, and the greatest contrast is in the Los Ríos Region.

The Telecommunications dimension is where this macrozone presents the fewest advantages, as shown in Figure 4, and more significant contrasts within the regions that comprise it. The most remarkable contrast occurs in the Biobío region given the fact that while the province of Concepción reaches a High level, the other provinces reach a



Source: Own elaboration, 2022

Figure 5: ISIT of provinces of the southern macrozone

Low level. The Los Ríos region holds the same level of contrast. And, in the case of the Maule and Araucanía regions, the contrasts are lower; however, it also accounts for regions where telecommunications do not reach the same coverage and quality standards.

In contrast, the logistics dimension for this central-south macrozone is where the results are most favorable since all the provinces reach a High or Medium-High territorial aptitude, the Los Ríos region is the only region with all provinces at High level.

6.6 *Analysis of Provinces of the Southern Macrozone*

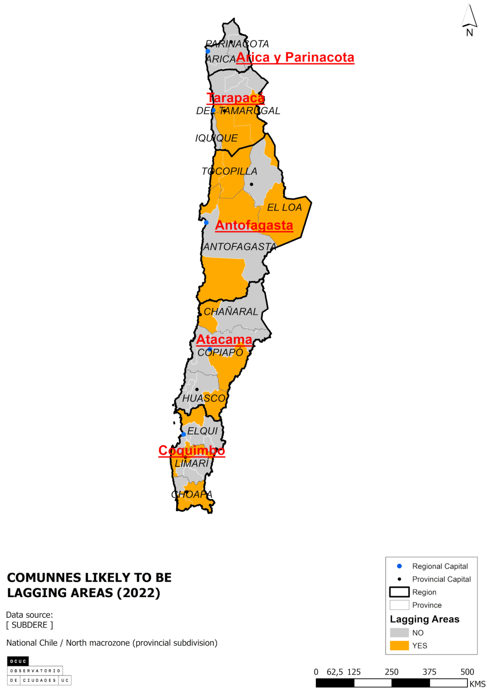
The ISIT for the southern macrozone shows in Figure 5 that the provinces mostly reach a Low level in their territorial aptitude, except for the provinces of Osorno and Llanquihue, which reach a Medium-High level. As noted above, the ISIT shows a greater precariousness in infrastructure and equipment for the Aysén and Magallanes region provinces. It is essential to highlight the interconnected electrical system and the main road reaching the north to the border with Peru, to the south end in Puerto Montt, Llanquihue Province, Los Lagos Region.

When analyzing the most significant contrasts between dimensions, in the southern macrozone, the dimension that presents the worst results is energy, as shown in Figure 5, where all the provinces present a Low level, except for the province of Chiloé (Insular territory of Los Lagos region). The previous shows that in this dimension, there is also a high level of homogeneity between provinces.

Lastly, although there are essential contrasts between provinces in the water dimension for the southern macrozone, it is also the best dimension in terms of results. This question is logical considering it is an area where higher levels of rainfall are recorded, however, there are significant deficiencies in drinking water and sewerage services, and a storage deficit.

7 ISIT analysis regarding lag zones

The lag zones can be considered as marginalized territories, being possible to contrast the results obtained in the maps obtained from the ISIT with the results shown in Table 1. Thus, in the case of the northern macrozone, made up of four regions; Arica and Parinacota, Tarapacá, Atacama, and Coquimbo, which account for 34,4% of the country's surface (see Table 2), where the lag zones are concentrated mainly in the Antofagasta (77,8%) and Coquimbo (53,3%) regions. In the case of the Antofagasta region, where the communes present an ISIT at a low or medium-low level, it coincides with the character of a lag zone of the communes of the province of Tocopilla (see Figure 6), and reaches



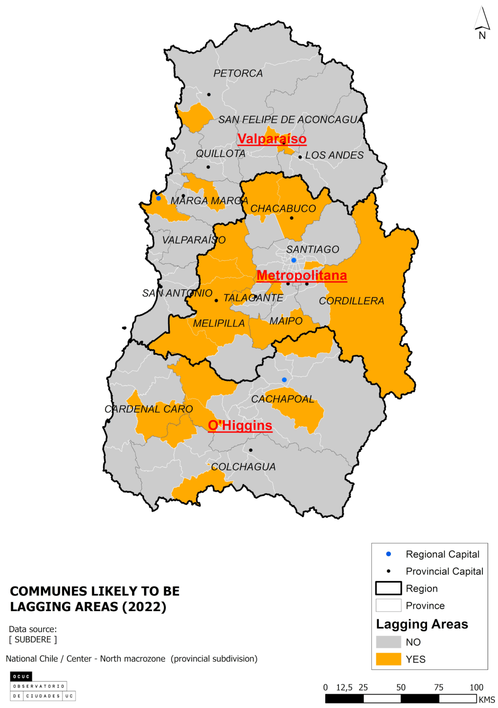
Source: Own elaboration, SUBDERE, 2022

Figure 6: Lag zones by district and province of the northern macrozone of Chile

16,7%. of the surface of the country, only below the Magallanes region (see Table 2). And, in the case of the Coquimbo region, the ISIT result coincides with the communes of the Choapa province. In the case of the Atacama region, where the percentage of lag zones reaches 33,3% of the communes, the coincidence is partial in the case of the province of Chañaral, with only a significant contrast, and in the case of the province of Tamarugal, which shows an ISIT at a High level, while 2 of 5 communes are considered lag zones. In conclusion, the result of the ISIT reaches an important but not total coincidence with respect to the definitions of lag zones.

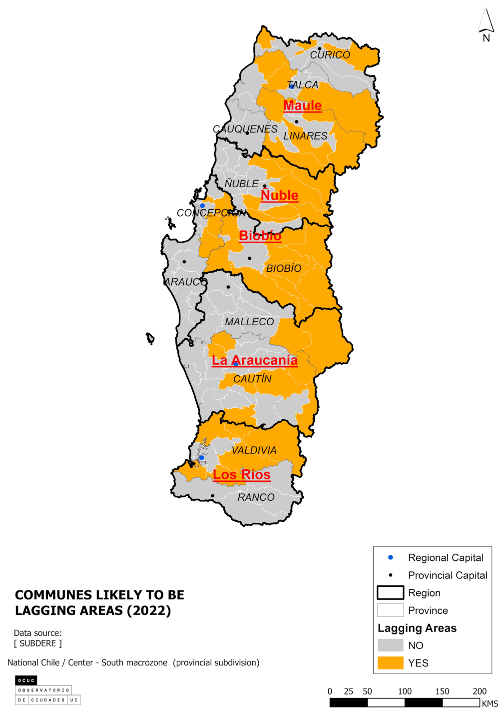
In the case of the central-north macrozone, made up of the Valparaíso, Santiago Metropolitan and Libertador General Bernardo O'Higgins regions, the ISIT results are the same for almost all the provinces (see Figure 3 compared to Figure 7), because the percentages of communes likely to be considered lag zones do not exceed 25,0% for the three regions, being the lowest percentages of all the country's macro-areas. Additionally, it should be considered that this southern macrozone contains 56,0% of the country's population (see Table 2), but the lowest percentage of the country's surface (6,4%). In conclusion, there is a high coincidence between the results obtained from the ISIT with respect to the declared lag zones.

Now, for the case of the regions of the central-southern macrozone, made up of the Maule, Biobío (includes Ñuble), Araucanía, and Los Ríos regions, where 25,1% of the country's population is concentrated (Table 2), the Los Ríos region reaches 50,0% of districts that can be declared as lag zones and then the Biobío region with 45,5%, concentrates the highest percentages (see Table 1). In contrast, the Araucanía region presents the lowest percentage with 28,1%. When comparing these results with those obtained by the ISIT (see Figure 4 compared to Figure 8), it coincides that the provinces of Biobío in the region of the same name and the province of Valdivia in the Los Ríos region, where districts are concentrated as lag zones, present a medium-low level of ISIT. With regard to the rest of the regions, although there are districts that can be declared lag zones, they do not exceed 40,0% of the total number of districts. In conclusion, the result of the ISIT reaches an important but not total coincidence with respect to the definitions of lag zones.



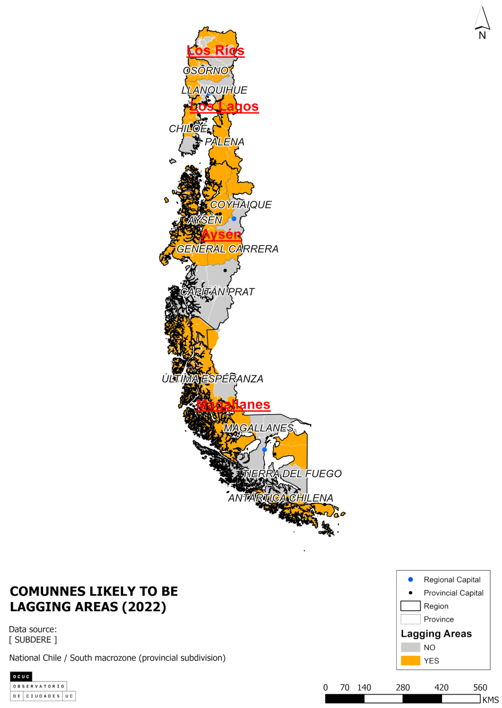
Source: Own elaboration, SUBDERE, 2022

Figure 7: Lag zones by district and province of the central-north macrozone of Chile



Source: Own elaboration, SUBDERE, 2022

Figure 8: Lag zones by district and province of the south central macrozone of Chile



Source: Own elaboration, SUBDERE, 2022

Figure 9: Lag zones by district and province of the southern central macrozone of Chile

And, finally, regarding the results compared to the southern macrozone that integrates the regions of Los Lagos, Aysén, and Magallanes, where only 6,2% of the country's population is concentrated in a total area of 38.2% of the country, a territory characterized by a very low density, particularly in the two extreme regions, where the vast majority of the provinces are likely to be declared as lag zones (see Figure 9). Table 1 shows that among the three provinces, more than 50,0% of communes are in this condition, being particularly high in the Aysén region with 60,0%. This result coincides with that shown by the ISIT (compare with Figure 5), where all the provinces of the Aysén and Magallanes region are at a low or medium-low level. In conclusion, there is a high coincidence between the results obtained from the ISIT with respect to the declared lag zones.

7.1 Conclusions

The ISIT constitutes the first effort in Chile to develop a multidimensional tool to analyze and contrast the state of the infrastructure and equipment needed for the economic and productive development of the country. Chile maintains a political-administrative structure of regions defined in 1974 during the military dictatorship, where later, since the return of democracy in the early 1990s, the reforms in terms of political, administrative, and fiscal decentralization have been insufficient, leaving the country with the lowest level of fiscal decentralization among the OECD countries (OECD 2017) with weak public policy attributions for elected authorities at the regional level (Orellana Ossandón et al. 2020). The latter emphasizes Chile's condition as a unitary and centralist country (OECD 2017), where decisions regarding public investment have concentrated the development of infrastructure and equipment in the central macrozone, mainly where more than two-thirds of the country's population live.

Notwithstanding the previous, Chile's export model, that has enabled participation in international markets, is concentrated in primary and secondary activities located in the north and south of the country, where the ISIT accounts for the existing deficits and high contrasts within the regions themselves. At the same time, this work has made it possible to demonstrate that the results obtained through the ISIT fit the definitions and identification of lag zones in Chile, where the highest levels of isolation and socio-territorial gaps are concentrated in the extreme north and south of the country. testing the hypotheses.

The ISIT, based on geographical, climatic, and demographic considerations, allows to establish that each region and province has more significant advantages and disadvantages at the national level, to facilitate the location of economic and productive activities. At the same time, it reveals crucial contrasts between regions and within them. From this perspective, this study and its results contribute to visualizing the country's challenges in terms of infrastructure and equipment to reach a development threshold that allows solving the current socio-territorial inequalities in Chile.

The results of this work are consistent with the theoretical and empirical background presented, in relation to the fact that the stock of infrastructure in its different dimensions is decisive in the existing gaps in terms of territorial development in our country, especially in what it says in relation to the connectivity networks associated with some specific dimensions of the ISIT (Roads, Telecommunications, and Logistics, mainly). In particular, the lag zones that are close to the concept of marginal territories for the Chilean case, turn out to be the determining infrastructures in terms of accessibility to public and private goods and services for a significant number of urban and rural localities scattered throughout the national territory.

Regional governors have recently been elected for the first time and the significant demands for greater decentralization on decisions on public investment, planning, and management of their territories, are all aspects that are possibly going to be included in the country's future constitution, a document which will be subject to voter's approval or rejection in September of this year. Therefore, the contribution of this study and its results are transcendent because it seeks to establish an integral – and up-to-date – diagnostic of the infrastructure conditions on the continental territory.

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References

Abiad A, Furceri D, Imf PT (2016) The macroeconomic effects of public investment: Evidence from advanced economies. *Journal of Macroeconomics* 50: 224–240

Agénor PR (2010) A theory of infrastructure-led development. *Journal of Economic Dynamics and Control* 34: 932–950

Alavi A, Hasni H, Lajnef N, Chatti K (2016) Continuous health monitoring of pavement systems using smart sensing technology. *Construct Build Mater* 114: 719–36. CrossRef

Ali Z, Hussain I, Grzegorczyk MA, Ni G, Faisal M, Qamar S, Shoukry AM, Wahab Sharkawy MA, Gani S, Al-Deek FF (2020) Bayesian network-based procedure for regional drought monitoring: The seasonally combinative regional drought indicator. *Journal of Environmental Management* 276: 111296. CrossRef

Allan GJ, Lecca P, Mcgregor PG, Swales JK (2014) The economic impacts of marine energy developments: a case study from Scotland. *Marine Policy* 43: 122–131. CrossRef

Banerjee A, Duflo E, Qian N (2020) On the road: Access to transportation infrastructure and economic growth in China. *Journal of Development Economics* 145: 102442. CrossRef

Black G, Holley D, Solan D, Bergloff M (2014) Fiscal and economic impacts of state incentives for wind energy development in the Western United States. *Renewable and Sustainable Energy Reviews* 34: 136–144. CrossRef

Brad S, Mocan B, Brad E, Mocan M (2015) Economic development of peripherial/lagging zones through smart innovation. *International Journal of Transitions and Innovation Systems* 4: 201–220. CrossRef

Calderon CA, Servén L (2004) The effects of infrastructure development on growth and income distribution. Available at SSRN 625277

CChC – Cámara Chilena de la Construcción (2018) Informe de infraestructura crítica para el desarrollo 2018-2027

Chen Z, Haynes KE (2015) Regional impact of public transportation infrastructure: A spatial panel assessment of the US Northeast megaregion. *Economic Development Quarterly* 29: 275–291

Cohen F (2010) What makes critical infrastructures critical? *International Journal of Critical Infrastructure Protection* 2: 53–54. CrossRef

Dong Q, Huang B (2015) Failure probability of resurfaced preventive maintenance treatments: Investigation into long-term pavement performance program. *Transport Research Record: Journal of the Transportation Research Board* 2481: 65–74. CrossRef

Farole T (2013) The internal geography of trade: Lagging regions and global markets. The World Bank, Washington, DC

Ferrão J, Lopes R (2004) Understanding peripheral rural areas as contexts for economic development. In: Labrianidis L (ed), *The Future of Europe's Rural Peripheries*. Routledge, London. CrossRef

Fujita M, Krugman P (2004) La nueva geografía económica: pasado, presente y futuro. *Investigaciones Regionales* 4: 177–206

Gramlich EM (1994) Infrastructure investment: A review essay. *Journal of Economic Literature* 32: 1176–1196

Greco G (2018) The nature of accessibility studies. *Journal of Audiovisual Translation* 1: 205–232

Gunnarsdóttir I, Davidsdottir B, Worrell E, Sigurgeirsdóttir S (2020) Review of indicators for sustainable energy development. *Renewable and Sustainable Energy Reviews* 133: 110294. CrossRef

Hanks RR (2011) *Encyclopedia of Geography: Terms, Themes and Concepts*. ABC-CLIO, Santa Barbara

Hildén M, Furman E, Kaljonen M (2004) Views on planning and expectations of SEA: The case of transport planning. *Environmental Impact Assessment Review* 24: 519–536. CrossRef

Lekavičius V, Galinis A, Miškinis V (2019) Long-term economic impacts of energy development scenarios: The role of domestic electricity generation. *Applied Energy* 253: 113527. CrossRef

Li Y, Wang G, Mclellan B, Chen SY, Zhang Q (2018) Study of the impacts of upstream natural gas market reform in China on infrastructure deployment and social welfare using an SVM-based rolling horizon stochastic game analysis. *Petroleum Science* 15: 898–911. CrossRef

Martinez-Lopez D (2006) Linking public investment to private investment: The case of Spanish regions. *International Review of Applied Economics* 20: 411–423. CrossRef

Miller E (2018) Accessibility: Measurement and application in transportation planning. *Transport Reviews* 38: 551–555. CrossRef

MOP – Ministerio de Obras Públicas (2007) Plan director de infraestructura 2010-2025. Gobierno de Chile

OECD (2017) *Brechas y estándares de gobernanza de la infraestructura pública en Chile: Análisis de Gobernanza de Infraestructura.* OECD Publishing, Paris. CrossRef

Orellana Ossandón A, Arenas F, Moreno Alba D (2020) Ordenamiento territorial en Chile: Nuevo escenario para la gobernanza regional. *Revista De Geografía Norte Grande* 77: 31–49. CrossRef

Orellana Ossandón A, Díaz D, Irarrázaval F, Moreno D (2021) Descentralización e inversión pública en infraestructura: Propuestas para priorizar brechas de desarrollo territorial a nivel subnacional. *Temas de la Agenda Pública* 16: 1–10

Ortega E, Otero I, Mancebo S (2014) TITIM GIS-tool: A GIS-based decision support system for measuring the territorial impact of transport infrastructures. *Expert Systems with Applications* 41: 7641–7652. CrossRef

Ouédraogo R, Sawadogo R, Sawadogo H (2020) Private and public investment in sub-Saharan Africa: The role of instability risks. *Economic Systems* 44: 100787–00. CrossRef

Richardson BC (2005) Sustainable transport: Analysis frameworks. *Journal of Transport Geography* 13: 29–39. CrossRef

Rodríguez-Pose A, Psycharis Y, Tselios V (2016) Politics and investment: Examining the territorial allocation of public investment in Greece. *Regional Studies* 50: 1097–1112. CrossRef

Serebrisky T, Suárez-Alemán A (2019) La provisión de servicios de infraestructura en América Latina y el Caribe: ¿Puede la región hacer más y hacerlo mejor? Vol. 758. Inter-American Development Bank

Shahabi H, Ahmad BB, Mokhtari MH, Zadeh MA (2012) Detection of urban irregular development and green space destruction using normalized difference vegetation index (NDVI), principal component analysis (PCA) and post classification methods: A case study of Saqqez city. *International Journal of the Physical Sciences* 7: 2587–2595. CrossRef

Sherval M (2009) Native Alaskan engagement with social constructions of rurality. *Journal of Rural Studies* 25: 425–434. CrossRef

Song Y, Thatcher D, Li Q, Mchugh T, Wu P (2020) Developing sustainable road infrastructure performance indicators using a model-driven fuzzy spatial multi-criteria decision-making method. *Renewable and Sustainable Energy Reviews*: 110538. CrossRef

Steiniger S, Wagemann E, de la Barrera F, Molinos-Senante M, Villegas R, de la Fuente H, Vives A, Arce G, Herrera J, Carrasco J, Pastén P, Muñoz J, Barton J (2020) Localising urban sustainability indicators: The CEDEUS indicator set, and lessons from an expert-driven process. *Cities* 101: 102683. CrossRef

Straub S (2008) Infrastructure and growth in developing countries: Recent advances and research challenges. World bank policy research working paper, (4460). CrossRef

Tort J (2003) Toponimia y marginalidad geográfica. los nombres de lugar como reflejo de una interpretación del espacio. *Scripta Nova: revista electrónica de geografía y ciencias sociales* 7: 133–156

Vecchio G (2022) Cuidar el territorio que envejece: Envejecimiento demográfico y marginalidad territorial en Chile. *EÍDOS Revista Científica de Arquitectura y Urbanismo* 19: 3–12. CrossRef

Vișan M (2019) Spatial and territorial development planning: Digital challenge and reinvention using a multi-disciplinary approach to support collaborative work. *Procedia Computer Science* 162: 795–802. CrossRef

Vitale Brovarone E, Cotella G (2020) Improving rural accessibility: A multilayer approach. *Sustainability* 12: 2876. CrossRef

Wacquant L (2007) La estigmatización territorial en la edad de la marginalidad avanzada. *Ciências Sociais Unisinos* 43: 193–199

Wan G, Zhang X (2015) Who gains more from which infrastructure in rural People's Republic of China? ADBI working paper 540. CrossRef

Yang F, Zhang S, Sun C (2020) Energy infrastructure investment and regional inequality: Evidence from China's power grid. *Science of the Total Environment* 749: 142384. CrossRef

Zhang X, Wan G, Wang X (2017) Road infrastructure and the share of labor income: Evidence from China's manufacturing sector. *Economic Systems* 41: 513–523. CrossRef

Zolfaghari M, Kabiri M, Saadatmanesh H (2020) Impact of socio-economic infrastructure investments on income inequality in Iran. *Journal of Policy Modeling* 42: 1146–1168. CrossRef

A Appendix:

Table A.1: List of indicators

DIMENSION INDICATORS	DESCRIPTION
Water	
Drinking water coverage	Percentage of provincial population with drinking water coverage
Sewerage coverage	Percentage of population with sewerage coverage
Total Population by rural drinking water (APR in Spanish)	Relationship of the total provincial population with respect to the number of APR
% Beneficiaries over Rural Population	Percentage of APR beneficiaries with respect to the total population
Annual rainfall deficit	Average annual rainfall of the last four years compared to the historical average
Concessioned urban area	Sanitary concession surface with respect to the provincial urban area
Coverage of operational territories	Area operational territories with respect to the provincial surface
Average water price	Water price per m^3 [No Peak (winter)]
Energy	
Price Benzine 93 Octane	Average price per liter of gasoline 93
Price Benzine 95 Octane	Average price per liter of gasoline 95 octane to the consumer
Price Oil	Average price of oil to the consumer
Total power generation	Sum of energy capacity available by province (Biomass, hydroelectric, wind, thermal and solar)
% Self-Generated Power	Percentage of self-generated power (biomass, wind, solar), with respect to the total power
Electrical Substations	Number of substations SIC/SING/SEM/SEA
Telecommunications	
Successful start calls	Percentage of Successfully Established Calls
Successful term calls	Percentage of Calls Completed Successfully
Fixed networks	Number of Fixed Network connections per thousand inhabitants
inhabitants per telecommunications antenna	Number of inhabitants per telecommunications antenna
Internet connection	Number of Internet connection per 1,000 inhabitants
Road Network	
% Double carriageway paved network	Percentage of dual carriageway paved network
% Paved main network	Percentage of main network paved
% Paved secondary network	percentage of paved secondary network
kms on intercity motorway	Distance to interurban highways, from the centroid or point with the best connectivity in the province
Paving network with respect to surface	Paved network with respect to the provincial surface
mins to intercity highway	Time (mins) to interurban highway, from centroide or point with better connectivity in the province

continued on the next page

Table A.1: List of indicators (continued)

Dimension Indicators	Description
Total network with respect to operational area	Provincial road network with respect to the operational area
Logistic	
Territorial coverage by Post Office (Hás)	Post offices with respect to the provincial area
Coverage of Service Stations (Hás)	Service stations with respect to the provincial surface
Territorial coverage branches of the State bank (Hás)	Banco Estado branches with respect to the provincial area
Distance to airport network (kms)	Distance (kms) to airport network, from centroide or point with better connectivity in the province
Distance to airport network (minutes)	Time (mins) to airport network, from centroide or point with better connectivity in the province
Distance to maritime terminals (kms)	Distance (kms) to maritime terminals, from centroide or point with better connectivity in the province
Distance to maritime terminals (min)	Distance (mins) to maritime terminals, from centroide or point with better connectivity in the province
Distance to service stations (kms)	Distance (kms) to service stations, from centroide or point with better connectivity in the province
Resilience	
% Area risk erosion	Percentage of the territory with Risk of Erosion class Severe or Very Severe
Average isolation hours	Average access (hours) to provincial capital
Kms of average isolation	Average distance (km) to provincial capital, from centroide or point with better connectivity in the province
Primary health distance (kms)	Average distance (km) to Primary Health centers, from centroide or point with better connectivity in the province
Distance to primary health (min)	Average distance (min) to Primary Health centers, from centroide or point with better connectivity in the province
Territorial coverage of Carabineros de Chile (Hás)	Carabineros barracks of Chile with respect to the provincial surface
Disaster Recurrence	Sum of the number of disasters per year (fire, landslides, tsunamis, volcanic activity, storm surges, floods, seismic activity)
Local coverage of the company of firefighters (Hás	Fire companies with respect to the provincial surface
Population per aérodrome	Provincial population with respect to the number of aerodromes