Regional endogenous development in Chile: a simulation analysis of two models of allocation of public funds

Desarrollo regional endógeno en Chile: Análisis mediante simulación de dos modelos de asignación de fondos públicos para el desarrollo productivo

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Abstract: This paper analyses, through simulations, two regional development models to contrast their potential to promote endogenous development in two Chilean regions (Antofagasta and Coquimbo). The models were developed with the SocLab social simulation platform, which is based on the theory of Organized Action Systems. The models' input was generated by interviews with stakeholders closely involved in the allocation of public funds for innovation and productive development. The results show that Antofagasta's decentralised model promotes endogenous development by permitting a high degree of influence and coordination among local actors, while presenting a better state of critical resources for this purpose. For the Coquimbo region, the centralised model presents greater dominance and autonomy of a single actor (central government) over other actors who should respond to the local interest. The models were compared by using a qualitative approach. The novelty of the paper relies on the application of a simulation platform based on the Organized Action System theory to model and simulate two systems of actors responsible for regional endogenous development. The proposed approach helps to better understand and compare different development models which contribute to policy making.

Keywords: Regional development; endogenous development; decentralisation; SocLab; Chile.

Resumen: Este artículo analiza, a través de la simulación, dos sistemas de desarrollo regional en dos regiones de Chile (Antofagasta y Coquimbo), para contrastar su potencial para promover el desarrollo endógeno. Los modelos se elaboraron con la plataforma de simulación Social SocLab, la cual se basa en la teoría de los sistemas de acción organizada. El modelo se nutre de información proveniente de entrevistas con las partes interesadas, estrechamente relacionadas con la toma de decisiones en la asignación de fondos públicos para la innovación y el desarrollo productivo. Comparando los modelos con un enfoque cualitativo, los resultados muestran que el modelo descentralizado de Antofagasta tiene mayor potencia para promover el desarrollo endógeno, al permitir un alto grado de influencia y coordinación entre los actores locales y presentar un mejor estado de recursos críticos para este propósito, mientras que el modelo centralizado de Coquimbo presenta un gran dominio y autonomía de un solo actor (gobierno central) sobre otros actores locales, que de esta manera corren el riesgo de desvincularse del interés regional. Este documento es original y es pionero porque aplica con éxito una plataforma de simulación basada en una teoría social bien conocida (sistema de acción organizado) para modelar y simular dos sistemas de actores responsables del desarrollo endógeno regional, a fin de comprenderlos mejor, compararlos a la luz de algunos atributos para el desarrollo endógeno y luego elaborar algunas políticas de mejora en este sentido.

Palabras clave: Desarrollo regional, desarrollo endógeno, descentralización, SocLab, Chile.

1. Introduction

In Chile, Law 20.390 of October 16th, 2009, incorporated a constitutional reform on Regional Government and Administration. However, few changes have occurred in practice: i) the creation of autonomous regional councillors (CORE) in 2013; ii) the Constitutional Organic Law on the Transfer of Competences (approved in 2014) iii) the creation of three new divisions in the Regional Governments (GORE), one of them being the Productive Development and Industries division (2016) and iv) the implementation of decentralisation in the allocation of funds to promote innovation and productive development (2015) with pilot experiments in three regions of Chile (Antofagasta, Biobío, and Los Ríos). As part of this, the Regional Productive Development Committee (CDRP) was created, a territorial development unit with powers to allocate funds for productive development with autonomy. The latter is the largest experience of decentralization in Chile, which is why it will be the subject of comparison in this research. The other thirteen regions, including Coquimbo, continued with the centralised system for allocating public funds. This allocation of funds for innovation and productive development to companies is made through deconcentrated institutions with offices in each of the regions named CORFO and SERCOTEC (deconcentrated entities). These elements will make the main difference between the cases to be considered: Coquimbo and Antofagasta.

There is in this experience an interest in decentralization and institutional change (creation of the CDPR), i.e., in fostering participation of local actors for promoting local and regional development. Decentralization and promotion of local and regional actors is linked to a certain kind of development: endogenous development. Given all this, we are interested in understanding better how endogenous development has been promoted in two case studies (Coquimbo's and Antofagasta's). We will use a qualitative approach evaluate in which of these cases endogenous development has been more achieved.

There are diverse approaches for local and regional development (Pike et al. 2017), from top-town to bottom-up approaches, including combinations of them. The first one suggests that local and regional development should be directed from the national level, while the second one emphasizes the need for the participation and strengthening of local actors. Pike et al. (2017) argue that no one of these is always better. Given the national interest shown by the above Chilean policies aiming at promoting regional development by means of strengthening local actors, we evaluate (via simulation) how such experiences have fostered endogenous development, a kind of bottom-up development.

On the other hand, the creation of the CDPR in the Antofagasta's case represents a change of the governance, i.e., an institutional variation, as part of the effort for strengthening local participation. Though the effects of institutional variation in local governance for local and regional development is ambiguous and not well understood (not always effective as expected), as pointed out by Rodríguez-Poce (2020), well directed institutional changes towards decentralization are a promising strategy, and thus suggested, from the perspective of endogenous local and regional development.

Though no form of local and regional development is always the best, there are good experiences with endogenous development. An adequate institutional framework is necessary to implement public policies for innovation and technological development (Angelelli et al., 2006). In this context, it is important to emphasise regional development and decentralisation through resources such as the capabilities and potential of all the actors in each locality (Ochoa & Pilioneta, 2006). It is precisely the endogenous development approach that seeks to promote development based on regional actors and productive factors (Tödtling, 2020).

In the above backdrop, the main objective of this study is to compare the relationships between the actors linked to the regional productive development system of Coquimbo (non-decentralised) and Antofagasta (pilot region of decentralisation) to determine and measure the differences in the level of local cooperation in the allocation of public funds for innovation and productive development in two regions with different degrees of decentralisation. Though Coquimbo has a deconcentrated model: we will call it "centralised model".

We study the behavior of the system by carrying out social simulations. (Axelrod, 1997; Squazzoni, 2012). We use the SocLab framework which has been used to the study of concrete and ideal forms of organization (see e.g. Sibertin-Blanc et al., 2006; El-Gemayel et al., 2011; Sibertin-Blanc et al., 2013a; Terán et al. 2015) on the basis of sociological inquiries. Pike et al. (2017) and Rodríguez-Pose (2020) suggest to learn from case studies in order to understand better the complexities of local and regional development. Social simulation is useful to comprehend better real situations by virtual experimentation of case studies, complementing real case studies. The present paper aims at generating additional knowledge about two case studies by virtual experimentation.

The results of the simulation allow validating that the pilot decentralisation model (Antofagasta) has better conditions of articulation and cooperation between local actors, that is, promotes endogenous development, by allowing a high degree of influence of local actors and presenting a better state of critical resources for this purpose.

The research presents evidence regarding the relevance of the decentralisation process in decision-making to promote and strengthen the endogenous development of the regions, through greater autonomy and coordination in the allocation of public funds for innovation and productive development, to promote the development of the regions with their own particularities by their local actors who best know the potentialities and shortcomings of their region. Additionally, this is pioneering research in terms of the method used, which was through simulation based on the theory of organised action systems.

The rest of this paper is organised as follows. The second section extends the theoretical framework of the paper given in the introduction. Section three describes the case studies. Section four examines the methodology, i.e., the SocLab simulation platform. Section five describes the model. The next section presents the results and their implications for regional endogenous development. The last section offers some conclusions.

2. Theoretical framework

Pike et al. (2017) examine diverse approaches for local and regional development, from top-town to bottom-up approaches, including a combination of them. The first one suggests that local and regional development should be directed from the national level in a centralized form, while the second one emphasizes the need for the participation and strengthening of local actors. We use a qualitative approach to evaluate the simulation models in terms of their contribution toward favouring endogenous development, a form of bottom-up development. Below, we will review Pike et al. (2017)'s and the endogenous perspectives of local and regional endogenous development, briefly comparing them. Additionally, we will refer to the qualitative and quantitative levels of approaching local and regional development.

2.1 Regional/local development

Pike et al. (2017) expose the complexities regarding local and regional development. They define development as the enactment of conditions and institutions that promote the concretion of the potential of the capacities and faculties of people, communities and places in a cohesive and sustainable project, reducing disparities and inequalities between and within localities and regions. Based on worldwide experiences, they suggest a holistic, progressive and sustainable approach, a three principles based method, to guide local and regional development. These principles should consider the context and particularities (in time and space) of the case. The holistic domain argues in favour of recognizing the close inter-relations among economic, social, political, ecological and cultural dimensions of local and regional development. Regional development is connected to social issues such as notions of well-being and quality of life beyond the region, and inside the region, such as familiar income and productivity. The progressive domain suggests to promote certain principles

such as spatial justice and equality by a more uniform development, as well as democracy, solidarity and cohesion stressing the role of diverse social agents, including the state, private and community actors. Finally, the sustainability principle claims for promoting health, well-being and quality of life, considering an integrated understanding of the relations among the economic, political, social, ecological and cultural dimensions of sustainability. Additionally, the authors stress the political character of local and regional development, therefore it is fundamental to make explicit issues such as the kind of development to be promoted and for whom. The authors suggest to indicate clearly who are the beneficiaries, and how diverse actors and communities participate on the diverse moments of the development process and benefit from it. Local and regional actors must participate in the whole development process, including the definition of development, and the determination of where it would occur and who would benefit from it. Finally, the authors indicate the importance of institutions in order to enable articulation, deliberation, participation, representation and resolution of the local and regional actors. In this respect, Rodríguez-Pose (2020) reviews progress in academic comprehension regarding the role of institutions in promoting regional development. Parallelly, both Pike et al. (2017) and Rodríguez-Pose (2020) recognize the complexity and uncertainty of local and regional development, and the need for further research and recognition of the particularities of each locality and region.

2.2 Regional/local Endogenous development

Endogenous development is a development strategy that emerged in the 1970s, which seeks to promote development based on regional actors and factors, considering the local situation (Tödtling, 2020). It is aimed at satisfying the needs and objectives of the local population by emphasising the regional potential, such as resources, know-how, productive capacities, and potential of local actors (Ochoa and Pilioneta, 2006), entrepreneurial skills and education in general (Sharifzadegan et al., 2011). Endogenous local and regional development must mobilize local and regional potential (Pike et al. 2017), in a bottom-up context strategy. For Pike et al. (2017), sustainability is a key element of endogenous development. Particular attention should be given to the capacity, knowledge, autonomy and resources afforded to local and regional actors within multi-actor and multi-level government and governance structures.

Therefore, endogenous development has as a condition and an objective the validity of the decentralisation processes (González & Micheletti, 2021). That is, the process requires involving all relevant actors, according to the local situation, capacities, and potentialities. This should lead to the construction of local activities in an autonomous manner, promoting collective welfare (Ochoa & Pilioneta, 2006). It requires the strengthening of identity (Arocena, 2002) and social capital, understood as a set of norms and common values that form a network of relationships between the different actors where collaboration and cooperation prevail, to achieve the proposed development objectives (Pisani & Micheletti, 2018).

According to Tödtling (2020), there are still pending issues in enhancing the development of many regions that have used top-down models. Endogenous development is considered a good strategy for decentralisation and empowerment of localities based on their intrinsic potentialities, duly articulated. Also promote some of the following creations: industrial districts, regional entrepreneurship and development, regional learning, and regional innovation systems (Tödtling, 2020). For Gonzalez and Micheletti (2021), endogenous development requires an empowered local society, with relationships between the different agents/actors to generate endogeneity in the process.

In summary, regional endogenous development proposes a systemic or holistic perspective of regional growth, considering globally the situation, specificities, capacities, environment, objectives, etc., of the region and promoting the autonomy of regional activities without generating national contradictions. It must go hand-in-hand with the strengthening of regional, provincial, and municipal governments (González and Micheletti, 2021).

We find many similarities between Pike et al. (2017)'s general perspective of local and regional development and the particular view of endogenous local and regional endogenous development. Both stress the importance of inclusion and participation of local and regional actors in the development process.

Pike et al. (2017) rise the question regarding which kind of local and regional development and for whom. Our answer is that, following the interest of the Chilean experience explained above, and its coincidences with Pike et al. (2017)'s perspective about local and regional development, we chose endogenous development. For endogenous development, the participation of local and regional actors is fundamental, thus not only national actors but also local and regional actors must benefit from and participate in the development process (what answers the "for whom" question).

2.3 Quantitative and qualitative dimensions of local and regional development.

Following Pike et al. (2017), the quantitative dimension of local and regional development refers to a numeric measure, e.g., per capita growth indexes or new created enterprises; while the qualitative dimension is bothered with the nature and character of local and regional development, for instance, the political, economic, social or ecological sustainability or the distribution of power among actors. The qualitative approach focuses on more subjective issues regarding the particularities of a locality and region. It is related with the systemic or holistic properties of the locality or region. Pike et al. (2017) recognizes that these qualitative and quantitative dimensions can be integrated but are not always correlated or coincidental. It is possible to find cases where following a quantitative approach development increases, while simultaneously there is a quantitative variable that contradicts such improvement. The qualitative dimension has become increasingly important in recent years regarding new holistic concerns, e.g., sustainability.

3. The cases of study: Coquimbo and Antofagasta

The regions of Coquimbo and Antofagasta have been chosen to carry out this study, they are territories located in the northern macro-zone of Chile. The Coquimbo Region is characterized by having a diversified economy, standing out for its contribution to GDP, the sectors associated with mining (26.7%), personal services (12.5%), financial and business services (11.2%), construction and housing and real estate services (17.4%), also highlighting agriculture, fishing, tourism and commerce (CORFO, 2022). Antofagasta, for its part, is mainly based on mining activity linked to copper and lithium (52.6%), a sector that is not only the economic engine of the region, but also a fundamental pillar in the country's economy. Following in proportion to regional GDP are the financial and business services sector and the construction sector, both with a 10.3% share of the region's economy (Yáñez, 2019).

The main regional authorities in each region are three: i) intendants, ii) Regional Council (CORE) and iii) Regional Government (GORE). The Intendants, a senior administrative figure in the regional governments, must answer to the President of the Republic. This position is in charge of allocating the budget to the regional governments, as well as managing the investment funds. This is a position of trust of the president, therefore, if he does not comply with the task entrusted to him, he is removed from his position, generating uncertainty in the management of the region. The Regional Council (CORE) is a public collegiate body with powers over regional government and administration. They oversee effective citizen participation in the regional government. Since 2014, the councillors are elected by universal suffrage, in direct voting, for periods of four years, and can be re-elected. The councillors, together with the intendants, comprise the regional government (GORE).

This paper contrasts two approaches to regional development in Chile. On the one hand, the traditional centralist model (Coquimbo case). On the other hand, a form of decentralisation oriented towards regional endogenous development, creating a territorial development unit with certain attributions (CDRP in Antofagasta case).

In the case of Antofagasta, the approach to decentralisation of productive development was achieved in two ways: i) the legislative way that emphasised the creation of regional development services, and ii) the administrative way that proposed a model of decentralisation of national services or agencies through programmes. Under this structure, a hybrid of legislative and administrative approaches was created. This change gives political responsibility for productive development to the GORE (Regional Government) and leaves the execution of regional policies to specialised executing agencies called Regional Productive Development Committees (CDPR). This institution should define priorities for productive development at the regional level and the budget allocations necessary to implement regional policies in this area and play an articulating role in regional and national policies.

There are currently two models for the allocation of public funds for innovation and productive development in Chile: i) one in which resource allocation decisions are made by public institutions at the central level (CORFO and SERCOTEC), which, for this research, will be called the centralised model, represented by Coquimbo region; and ii) the regions where a CDPR has replaced the functions of CORFO and SERCOTEC in fund allocation decisions, which for this study, is the case of the decentralised model of Antofagasta.

CORFO and SERCOTEC are deconcentrated public services dependent on the Chilean Ministry of Economy, whose mission is to support the development of smaller companies through subsidies and technical assistance. In Coquimbo's case, the administrative organization of the two main entities that support productive development in the territories depends on the Central Government and, as pointed out by Ferreiro et al. (2019, p. 79), this reality implies that their deconcentrated public services with national coverage respond directly to the national directors and ministers located in the centre. On the other hand, in Antofagasta, while the CDPR (replacing local CORFO and SERCOTEC dependencies) is decentralized.

The criteria for decision-making of officials designated by the central government: CORFO and SERCOTEC in Coquimbo, as well as the Intendant (head of GORE) both in Coquimbo and Antofagasta, is importantly aligned with that of central government. Members of the regional deconcentrated units of CORFO and SERCOTEC's decision making is very similar to that of members of these entities in Santiago − officials of both are designated by the central government −. On the other side, as the central government is supported by, and comes from, a certain political party or by a certain political coalition that usually includes several political parties, all these somewhat aligned functionaries could have certain political bias in relation to these political entities. This possible bias was implicitly captured or included in our models when identifying the relations and actors, as well as when defining the effect functions of the relations on the actors, the interest of the actors on the relations, and the solidarities between actors.

4. Methodology

The research methodology consists of virtual experimentation with a model developed on the SocLab platform. The SocLab framework (Sibertin-Blanc et al. 2006, 2013a, 2013b) has been developed into a formalisation of the Sociology of Organized Action (SOC) of Crozier and Friedberg (1980). In SOC, the authors studied how social organisations are regularised, as a result of counterbalancing processes involving power relationships between social actors. Social organisations may include community interaction similar to that occurring in systems of regional development, as studied here.

In SOC, power relationships are based on the actors' mastering of certain resources needed by others. This theory recognises that actors have bounded rationality, and that their environment is complex and shapes their behaviour (Simon, 1982). Consequently, the behaviour of each actor is strategic in the social game defined by their interaction with others. As a meta-objective, every actor adjusts his/her behaviour to obtain a satisfying level of capability to reach his/her goals, which is a balance of the aims assigned to his/her role within the organisation or social interaction, and of his/her particular objectives. The end of a social game is to reach a stationary state, i.e., a configuration where no actor has reasons to change his behaviour, i.e., where for all actors, the satisfaction of the actor is larger than his/her aspiration.

The management of a resource determines how it can be used by others so that it is the base of a *relationship* between the manager and the users of the resource. The dependency of an actor on a resource is expressed by its *stake* and *effect function*, as shown in Table 1 for our base model. The stake of an actor on a resource expresses how much it depends on this resource, on a *scale null = 0, negligible = 1,... , significant = 5,... , critical = 10*. Each actor has 10 stake points to distribute on the set of all resources.

The effect function of a resource on an actor expresses to what extent the management of the resource, by the actor controlling this resource, impedes or supports the actor in the achievement of its goals.

The impact of a resource r having the management m upon an actor a, i.e., the capability it provides to this actor to achieve its goals, is the value of the *effect$_{r,\,a()}$* function applied to m, weighted by the stake of a on r. Consequently, an actor gets some satisfaction, as an aggregation of the impacts it receives from the resources it depends on, weighted by the solidarities it gives to other actors, and, conversely, it exerts some influence, as an aggregation of the capabilities it grants to actors who depend on the resources it controls (Sibertin-Blanc et al. 2006, 2013a, 2013b). Formally, it can be said that, when a system of organised action is in a configuration m = (mr)$_{r \in R}$, the capability received by an actor a is defined as:

$$capability(a, m) = \sum r \in R \; stake(a, r) * effect_{r,a}(m_r) \tag{1}$$

From this, we can define the satisfaction of a as (calling A the set of all actors):

$$satisfaction(a, m) = \sum b \in A \; solidarity(a, b) * capability(b, m) \tag{2}$$

Conversely, the influence exerted by actor a over actor b is defined as the sum of the capabilities it supplies to the actors, towards which b has solidarity by the management of the resource*(s)* it controls, that is:

$$influence(a, b, m) = \sum c \in A \; solidarity(b, c) * capability(a, c, m) \tag{3}$$

Finally, the influence of a is the sum of the influence of a on all actors:

$$influence(a,m) = \sum b \in A \; influence(a, b, m) \tag{4}$$

Table 1: Stakes, effect functions, and relevance of each resource for the Coquimbo and Antofagasta cases.

Effect	Coquimbo Model					Antofagasta Model				
	CorfoSercReg	CORE	GORE	CentralGob	Relevance	CDPR	CORE	GORE	CentralGob	Relevance
ManagCap	**2.0**	1.0	1.0	1.0	5	**2.0**	1.0	2.0	2.0	7
OperatDesignCap	**1.0**	1.0	1.0	1.0	4	**2.0**	2.0	2.0	1.0	7
NegCapWithGORE	1.0	**1.5**	1.0	0.0	3.5	1.0	**2.0**	1.0	2.0	6
DecRecParticLevel	1.0	**1.5**	1.0	0.0	3.5	1.0	**2.0**	1.0	0.0	4
NegCapWithCORE	1.5	1.5	**1.5**	2.0	6.5	1.0	1.0	**2.0**	2.0	6
NegCapWithCentralGob	1.5	1.5	**1.5**	2.0	6.5	1.0	0.0	**1.0**	1.0	3
FinancAllocation	2.0	2.0	3.0	**4.0**	1.1	2.0	2.0	1.0	**2.0**	7

Actors seek to maximise their satisfaction. The linear relationships between the variables assumed in Equations (1)-(4) are explained in (Sibertin-Blanc et al., 2006). Firstly, the introduction of the linearity is in line with the Sociology of Organized Action (SOC) of Crozier and Friedberg (1980): In all equations we added the value due to each involved actor or relation; for instance, in equation (1), the capability given to actor a per each relation r the actor manages is added (this particular capability is proportional to the stake of a on r and the effect of relation r on actor a), while in equation (2) the satisfaction that actor a receives from each actor b he has solidarity with is aggregated (the satisfaction a receives is proportional to the solidarity a has towards b, and the capability b achieves). Secondly, the operation of the model requires to normalise diverse variables, e.g., the sum of the actors' stakes and then to attribute to each one the same amount of stake points to be distributed on the relations he participates. This normalization grants the same investment to each actor, i.e., the same possibility of personal implication in the game. It makes possible to quantify several concepts of the SOA by numerical values belonging to the same scale of values, and thus to compare them. For instance, the relevance of a resource could be estimated as the sum of the stakes placed by the whole population of actors on the relation supported by this resource, as those stakes reflect the importance of these relations for the actors (in section 5.2 the relevance of the resources in our model is given). Similarly, by calculating other variables (equations (1)-(4)) using linear relations, facilitates maintaining in a comparative scale these other variables of the model (satisfaction, etc.). The SocLab decision-making algorithm is described in Sibertin-Blanc et al. (2013b), and El-Gemayel et al. (2011).

The output variables, e.g., influence and satisfaction, indicating the situation of the actors can help us in evaluating the degree of endogeneity of local and regional development in the simulated cases (Coquimbo and Antofagasta). Particularly, uneven values of influence: low values for some actors and high levels for other actors imply that the first actors have week power, low capacity to participate with relevant impact in the game, and likely low potential for autonomy, since the game depends on powerful actors, what means that the game is unfair (some actors are too week, while other are too strong). This is an unfavourable situation for endogenous development, given that it requires good participation and autonomy of all actors. Additionally, sustainability, a property of local and regional development in accordance to Pike et al. (2017), and by the theory of endogenous development, requires effective participation of all actors. Thus, the distribution of influence of actors gives us a qualitative approach and criteria (following Pike et al. 2017) measuring and comparing endogeneity of the models representing two case study. Other similar criteria could be defined, e.g., based on the distribution of satisfaction of among actors.

5. Simulation Model

The information to develop the model was obtained through interviews conducted virtually through the Zoom platform, from May to June of 2021, that is, before the newly elected authorities (Regional Governors) took office and replaced their predecessors, the Regional Intendants. Since mid-July the highest authority in both regions analysed is the Governor. To include the vision of diverse actors (SERCOTEC, Intendant, etc.) the interviewed met the following requirements: i) work in CORFO, SERCOTEC or another government institution, ii) has held public office and iii) knows well the public system.

Four interviews with thematic script of guided open questions were conducted with two people in Antofagasta and two in Coquimbo. It was necessary to conduct the interviews in four moments or stages, each one having the following characteristic: i) the objective of the paper and the elements of the simulation model were explained.; ii) open questions were asked, and meaning and examples of key concepts, e.g., solidarities were given; iii) information was verified; and, iv) answers were validated with other external experts. Regarding point iii), validation, it was done through expert judgement (interview with two experts) with extensive experience in the public sector. Our way of collecting information was a variant of that presented in Sibertin-Blanc et al. (2013a).

A model with four actors was elaborated. The first actor is in charge of the analysis and allocation of public funds for innovation and productive development. In the case of the Coquimbo Region, there are two autonomous agencies: CORFO and SERCOTEC, which we will call CorfoSercReg. For the Antofagasta Region, this role is fulfilled by the Regional Productive Development Committee -CDPR, created for this purpose within the framework of the decentralisation process previously described. The second actor is the Regional Council (CORE). The third actor included in the analysis is the Regional Government, (GORE). The fourth actor is the Central Government (CentralGob), which includes all the authorities that issue guidelines from the city of Santiago, where the government authorities are located. Each actor controls the following resources.

CORFO/Sercotec (Coquimbo's case) - CDPR (Antofagasta's case):

- ManagCap: Capacity to manage resources at the national level (central government and central CORFO) and at the regional level (GORE) to implement development programs with an impact on the territory.

- OperatDesignCap: Capacity to design and operate in an effective and coordinated manner relevant development programmes focused on regional development and aligned with regional and national strategies and policies.

CORE:

- NegCapWithGORE: Capacity to negotiate with the GORE for the financing of Regional Public Policies for Productive Development.

- DecRecParticLevel: Level of participation in resource allocation decisions for projects to be executed in the territory.

GORE:

- NegCapWithCORE: Negotiating capacity with CORE.

- NegCapWithCentralGob: Negotiating capacity with the Central Government to define the level of resources for productive development.

CentralGov:

- FinancAllocation: Allocation of funding for proposals in regions through executing agencies (CORFO, SERCOTEC, and CDPR).

5.1 Solidarities

Solidarities among the actors are shown in Table 2. Each cell indicates the solidarity from the actor in the row towards the actor in the column. Given the space limitations, we will only explain the solidarities of one actor for each model: CorfoSercReg or CORFO/Sercotec of Coquimbo´s case and its equivalent in Antofagasta, the CDPR:

Solidarities of CorfoSercReg towards all other actors in Coquimbo:

- CorfoSercReg has higher levels of solidarity towards itself and the central government than towards the other actors, given that the head of the regional actor and members of CorfoSercReg are appointed by the central level. These two actors complement each other and have common interests. The solidarity of CorfoSercReg with CORE Coquimbo and GORE Coquimbo is, however, relevant, given their shared and complementary interest in regional development. It is

possible to understand this solidarity, given that both CorfoSercReg and GORE members are also appointed by the central political administration.

Solidarities of CDPR towards all other actors in Antofagasta:

- The CDPR being quite autonomous in Antofagasta, this actor presents a high degree of solidarity with itself and with the local actors of the Antofagasta region (CORE and GORE) and a little less with the entity external to the region: The Central Government. The CDPR shows an important degree of autonomy concerning the central level in terms of decision-making and it is in its interest to maintain a close relationship at the local level with actors like the GORE and the CORE.

Table 2: Solidarities between actors.

Solidarity	Coquimbo's Case			
	CorfoSercReg	**CORE**	**GORE**	**CentralGob**
CorfoSercReg	0.3	0.2	0.2	0.3
CORE	0.2	0.5	0.2	0.1
GORE	0.2	0.2	0.3	0.3
CentralGob	0.1	0.0	0.1	0.8
Solidarity à	Antofagasta's Case			
	CDPR	**CORE**	**GORE**	**CentralGob**
CDPR	0.4	0.25	0.25	0.1
CORE	0.25	0.4	0.25	0.1
GORE	0.25	0.25	0.4	0.1
CentralGob	0.3	0.15	0.15	0.4

5.2 Stakes and effect functions

The dependency of an actor on a resource is expressed by its stake and an effect function (see Table 1). For instance, CORE's distribution of stakes would reflect the order of importance of the resources for their goal of getting the best benefits for the region. On the other hand, given the domain of possible values of a resource, the effect function indicates the effect of the resource on the actor, for each value in its domain, which could be positive or negative. For instance, a high negotiating capacity of CORE with GORE (row 3 in Table 1) would have a strong negative effect on GORE in Coquimbo's model, but a relatively high positive effect on GORE in Antofagasta's case.

Distribution of stakes

The stake of the actor who controls the relationship is in bold characters. The relevance column indicates the sum of stakes put on each resource. The relation controlled by CentralGob has a much higher value in Coquimbo's model (11) than in the Antofagasta model (7). This value is related to the potential to achieve influence - in accordance only with this element, the influence potential of CentralGob in Coquimbo is higher than that of CentralGob in Antofagasta. On the other hand, CORE and GORE's controlled relations have a stronger relevance in Antofagasta than in Coquimbo.

Effect functions

The shape of the effect functions shows a conflict between some actors in Coquimbo, e.g., CORE and GORE, because of the opposing impact on them of the relations NegCapWithGORE, DecRecParticLevel, and NegCapWithCORE, and between CORE and CentralGob because of the different impacts on them of the relation NegCapWithCORE. In Antofagasta, these conflicts do not occur. The only actors with certain (low) conflict in Antofagasta are CORE and CentralGob because of the different effects of the function OperatDesignCap, for the positive values of the resource[1].

5.3 Preliminary analysis of the model structure

In Antofagasta, the resources are more balanced in terms of relevance, while in Coquimbo, the resource managed by the central government is much more important than the others, and unimportant are those managed by the CORE, followed by those managed by the CDRP (see Table 1). In the Antofagasta model, the least valued resource is the negotiating capacity of the GORE with the central government. Accordingly, the central government would be expected to have high influence in Coquimbo, while CORE, followed by GORE would have low influence. The resource negotiation of the GORE with the central government would also be expected to bring little influence to the GORE in the Coquimbo model. However, the GORE manages a second resource: negotiation with the CORE, which is better valued than the first.

In terms of effect functions, the effects of the following resources are quite different in the cases: OperatDesignCap, NegCapWithGORE, DecRecParticLevel, NegCapWithCORE. These differences show a greater conflict between the actors in the Antofagasta case, except for the OperatDesignCap resource. More specifically, it is observed that OperatDesignCap (resource managed by CorfoSercReg) has an effect on the central government that is more opposite (in the sense that the effect function has a positive slope for some, and a negative slope for the others) vis-a-vis the effect on the other actors in the Coquimbo model, than in the Antofagasta one. The opposite occurs in other cases (as Table 1 illustrates), i.e., the effect is the opposite concerning most of the other actors in the Antofagasta case.

6. Results of the simulations

From the results, we must indicate the level of coordination and articulation between the actors to see what conditions are in place to promote the achievement of endogenous development in each case, to compare the performance of both cases. A good level of endogenous development and sustainability requires, mainly, a sufficient influence of the local actors, in accordance to the above defined qualitative approach for evaluating endogenous development, or at least a balance of forces between the actors, so that local actors have good influence on decisions, and participate effectively in decision-making in the definition, control, and evaluation of development policies and actions. Equally, but less important, local stakeholders must have at least an average level of satisfaction. Thus, mainly the CORE, a popularly elected actor, in both cases, and the CorfoSercReg committee in Coquimbo, should have a good level of influence (above average), and not have low satisfaction, which should be at least at the same level as the other actors– close to average. It would be desirable for these stakeholders to have high influence, the highest among all stakeholders. On the other hand, for the system to be democratic, the other actors should have equal participation, and in the case of alliances between actors, these should not have more power than that exercised by other actors. The GORE and the central government in both systems, and the CDPR in Antofagasta, are appointed by the central government, either totally (GORE, by appointing the intendant) or partially: CorfoSercREg (by appointing a significant number of its members, either directly or through its influence in the GORE).

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1 Due to space constraints, the justification of the distribution of stakes of each actor on the relations, the effect functions and the solidarities is not presented in this paper, but it can be required to the corresponding author.

On the other hand, strengthening endogenous development requires that the following resources, which are directly related to the financing and implementation of endogenous development actions, have a high value: ManagCap, OperatDesignCap, DecRecParticLevel, and FinancAllocation.

6.1 Simulation of the two cases

The results of the simulations are presented in Table 3, 4 and in the seventh column for each case (Coquimbo and Antofagasta) of Table 5. Table 3 presents the means and standard deviation of satisfaction and influence of the actors, as well as the number of steps of the simulation, while Table 5 presents the state of the resources (column for each case Sim) for 100 simulation runs/ replications. The low values of the standard deviations shown in Table 3 per each model indicates that the differences between the means resulting per each model are statistically significant. The intervals of confidence for any result will be very narrow considering that we have performed 100 simulation replications (means behaves as a t-student whose value converges to the real value after 30 samples (much less than the 100 replications we have performed)). It can be observed that some resources are in a lower state in the Antofagasta case than in the Coquimbo case, e.g., ManagCap (managed by CDPR), CapNegWIthCORE (managed by GORE), and NegCapWithGORE (managed by CORE). This is basically because there is more conflict among the actors in the Antofagasta model.

One of the most striking differences between the two models is shown by the satisfaction of the actors. The satisfaction of the central government is relatively lower than that of the other actors in the Antofagasta case, unlike what is observed for the Coquimbo case, which has a slightly higher satisfaction than the other actors. On the other hand, in terms of influence, in the Antofagasta case, the order of influence is CDRP, CORE, GORE, CentralGob; that is, the local actors have much more influence than the others, while in the Coquimbo case, local actors CorfoSercReg and CORE, have less influence than the other actors, especially the autonomous local actor CORE. This issue is highly significant as it reflects the low level of importance of local decision-making, represented by the CORE, in the Coquimbo case, as opposed to the much higher relevance it has in Antofagasta.

Finally, regarding the number of steps in the simulation (last row of Table 5), the Antofagasta case model requires more steps to achieve the regulated state, which reflects the greater conflict between the actors in the system.

Table 3: Satisfaction, influence, and the number of steps for the two cases.

	Actors	Satisf Averages	Satisf Deviations	Influence Averages	Influence Deviations
Caso Coquimbo	CorfoSercReg	52.12	1.26	61.34	2.33
	CORE	54.52	2.85	3.83	0.84
	GORE	51.9	1.76	75.21	3.11
	CentralGob	55.63	0.95	74.16	4.03
Simulation steps	895.3				
	Actors	Satisf Averages	Satisf Deviations	Influence Averages	Influence Deviations
Caso Antofagasta	Comité	77.1	4.68	115.71	4.38
	CORE	78.99	5.22	77.5	11.72
	GORE	78.69	5.15	58.79	7.11
	GobCentral	61.51	4.01	44.7	4.36
Simulation steps	1167.7				

Table 4 presents the percentage of satisfaction and influence that the actors offer in the simulation configuration, vis-a-vis the total they can obtain in the model. It can be observed that the CORE has already obtained a good percentage of the total influence it can offer, 79.7%, which indicates a strong structural constraint concerning this characteristic; that is, the CORE will not be able to increase its (already low) influence much beyond the present value (to reach 100%). In fact, the maximum possible value of influence that the CORE can achieve, with the structure of the Coquimbo model, is 9.3. This structural constraint does not occur in the Antofagasta model, where already in the regulated state configuration (simulation), this actor achieves a relatively high level of influence (the second-highest, after the CDRP).

Table 4: Percentage of total satisfaction and influence in the simulation for Coquimbo's case.

	CorfoSercReg	CORE	GORE	CentralGob	Satisfaction
CorfoSercReg	98.6 %	57.9 %	98.3 %	99.0 %	95.8 %
CORE	99.0 %	94.7 %	91.4 %	92.6 %	94.5 %
GORE	99.0 %	38.6 %	99.0 %	95.9 %	94.9 %
CentralGob	98.7 %	12.7 %	99.2 %	98.7 %	95.9 %
Influence	99.0 %	79.7 %	98.6 %	97.6 %	

Note: The table shows the percentage of total satisfaction received in columns (respectively, total influence given in rows) by an actor, vis-a-vis the total the actor can receive (resp. give), both from (resp. to) each other actor, and the total general in the penultimate rightest column (resp. penultimate row).

Implications for regional endogenous development

The main drawback for endogenous development is the unfair distribution of power in Coquimbo, where CORE achieves a too low level (see Table 3). Using our qualitative approach for evaluating endogenous development, there are better conditions for endogenous development in Antofagasta than in Coquimbo. More specifically, considering the levels of achievement of local actors and resources that promote endogenous development, as indicated at the beginning of this section, we have:

(1) Local actors in Antofagasta (CORE and CDPR) have the two highest levels of influence among all actors, while in Coquimbo, the only autonomous local actor, CORE, has an extremely low level of influence (see Table 3). Additionally, Table 4 shows a strong structural constraint for the CORE to increase its influence in the Coquimbo's case. Concerning satisfaction, the levels of local actors are not too different to the average and to that of the other actors in both cases (Table 3).

(2) The resources ManagCap, OperatDesignCap, and DecRecParticLevel show higher values in Antofagasta than in Coquimbo, while the resource FinancAllocation presents very similar values (see Table 5, column Sim).

Thus, in terms of endogenous development, the Antofagasta regional development

system is in a better condition than that of Coquimbo.

6.2 Analysis of the structure of the models

From Table 5, as it occurs for the regulated configuration, several resources for the maximum global satisfaction and Nash equilibrium configurations take lower values in the Coquimbo case than in the Antofagasta case. In particular, the resources

controlled by the CORE and the GORE take lower values. It is to be noted that to achieve the global maximum, the resource DecRecParticLevel managed by the CORE should be at its most negative possible level (-10); that is, the CORE should have zero participation in the decisions related to the allocation of resources for projects in the territory. Additionally, only by maintaining this resource at such a level can the CORE achieve the maximum possible value of influence indicated above: 9.3.

On the other hand, we can observe more difference between the global satisfactions in the maximum global satisfaction and Nash equilibrium configurations in the Coquimbo case (232.8 and 213.9, respectively), than in the Antofagasta case (317.1 and 313.3, respectively). This indicates that the simulation of the Antofagasta case is more stable, as all these configurations are closer to one another.

Additionally, among the configurations for which the satisfaction of each actor is maximised, the satisfaction of the central government is the farthest from the state of maximum global satisfaction in both models. In the case of Coquimbo, the difference between these two configurations is much wider, that is, the central government assumes a position farther away from that which maximises the maximum global satisfaction. On the other side, in Antofagasta, the configuration that maximises the satisfaction of the CORE coincides with the one that maximises the satisfaction of the GORE, so that these actors have a certain circumstantial alliance, which is in favour of decentralisation and regional autonomy.

The fact that, in Coquimbo, CORE's action is required to be cancelled to increase the maximum global satisfaction indicates a certain similar position and alliance among the other actors to the detriment of the CORE. While this alliance could be partly circumstantial, in the real system the Intendant who occupies the leadership in the GORE and several members of the CorfoSercReg are appointed by the central government, which implies a certain real alliance between these actors, or perhaps a certain submission of the CorfoSercReg and the GORE to the strategic guidelines of the central government. This is consistent with the results of the simulation and the analysis of the structure of the models.

6.3 Implications concerning endogenous development

The results of the simulation and the structure of the model permit us to affirm that there are conditions that favour and promote endogenous development. In the case of Coquimbo, the CORE, an authentic local actor (elected by popular vote), has a very restricted influence, achieving its maximum value when it overrides its actions in the allocation of resources for projects in the local territory. Additionally, an alliance of the other actors is noted, which goes against the actions of the CORE and responds to the interest of the central government. Thus, the key of the problem regarding the power game in Coquimbo is related to the CORE, in how little its position matters for the other actors, rather than in the Committee. However, when compared to the case of Antofagasta, the problem is partially solved by giving more autonomy to the CorfoSercReg, since this allows breaking the dominance of the central government, offering a more appropriate context for action to the CORE, even a circumstantial ally.

In Coquimbo the dominant actor is the central government, to the detriment of the CORE's actions. This situation is different in Antofagasta, where the creation of the autonomous CDPR actor, replacing the CorfoSercReg actor (strongly dependent on the central government in Coquimbo), generates a more balanced development system, with high influence of the local actors CDPR and CORE. This situation favours sustainability, what is good for local and regional development, not only following the criteria of endogenous development, but also that more general criteria of Pike et al. (2017). In particular, in accordance to our cri approach to evaluate endogenous development, the fairer distribution of power in the Antofagasta's model implies that this case presents better conditions for endogenous development. Thus, the structural and simulation analysis allows us to conclude in favour of Antofagasta's decentralisation experience and the institutional change conveyed by the creation of an autonomous regional development entity (the CDPR).

Table 5: State of the relations and satisfaction for several configurations of the model.

	Coquimbo								Antofagasta							
	Max-Glob	Min-Glob	CorfoSercReg-Max	CORE-Max	GORE-Max	GobC-Max	Sim.	Nash-eq.	Max-Glob	Min-Glob	CDPR-Max	CORE-Max	GORE-Max	GobC-Max	Sim.	Nash-eq.
ManagCap	4.0	-10.0	4.0	5.0	4.0	3.0	5	4.0	10.0	-10.0	10.0	10.0	10.0	10.0	9.4	10.0
OperatDesignCap	10.0	-10.0	10.0	10.0	10.0	4.0	8.4	10.0	10.0	-10.0	10.0	10.0	10.0	10.0	9.8	10.0
NegCapWithGORE	6.0	-10.0	4.0	10.0	2.0	-3.0	8.8	10.0	10.0	-10.0	10.0	10.0	10.0	10.0	9.3	10.0
DecRecParticLevel	-10.0	10.0	-10.0	10.0	-10.0	-10.0	7.9	10.0	10.0	-10.0	10.0	10.0	10.0	10.0	8.7	10.0
NegCapWithCORE	3.0	-10.0	3.0	-1.0	5.0	8.0	5.6	5.0	10.0	-10.0	10.0	10.0	10.0	10.0	9.5	10.0
NegCapWithCentral-Gob	10.0	-10.0	10.0	10.0	10.0	4.0	9.5	10.0	10.0	-10.0	10.0	10.0	10.0	5.0	7.2	10.0
FinancAllocation	10.0	-10.0	10.0	10.0	10.0	4.0	7.1	4.0	8.0	-10.0	8.0	10.0	10.0	5.0	7	5.0
CorfoSercReg / CDPR	59.5	-83.0	59.6	52.7	59.3	47.1	52.1	52.6	82.4	-93.2	82.4	82.1	82.1	80.2	77.1	81.4
CORE	54.3	-65.3	53.4	63.6	51.3	28.5	54.5	54.4	84.9	-94.4	84.9	85.7	85.7	81.7	79.0	82.7
GORE	59.9	-81.2	60.1	52.6	60.4	47.6	52.0	50.5	84.6	-94.4	84.6	85.1	85.1	81.1	78.7	82.9
CentralGob	59.1	-97.0	59.4	49.7	60.1	62.7	55.6	56.4	65.1	-83.2	65.1	63.0	63.0	67.2	61.5	66.3
GLOBAL	232.8	-326.5	232.5	218.6	231.1	185.9	214.2	213.9	317.1	-365.2	317.1	315.9	315.9	310.2	296.3.	313.3

Note: The table shows the state of the resources (seven five rows), the satisfaction of all actors (rows 8 to 11), and global satisfaction (row 12), for the following configurations of the Coquimbo and Antofagasta's cases (in columns): state of maximal and minimal global satisfaction (columns 1 and 2), actor's maximal satisfaction (columns 3-6), regulated state (column 7), Nash equilibrium (column 8).

7. Conclusions

This work has made it possible to compare through simulation modelling two endogenous development systems, concluding that the decentralised regional development system of Antofagasta (as a pilot) supports endogenous development much better than the regional development system of Coquimbo. The decentralization in Antofagasta has involved an institutional change: the creation of the CDPR, a regional autonomous actor, which strongly supports endogenous development. This represents a case of institutional change favouring regional development (Rodríguez-Poce 2020 indicates that not always institutional changes prompt local and regional development). We have compared the models regarding their potential for endogenous development, by using a qualitative approach based on the fairness of the distribution of power, autonomy and participation of local actors, as well as sustainability of the development system.

Our research follows Pike et al. (2017)'s suggestion in relation to make explicit the kind of local and regional development chosen and for whom. We have chosen endogenous development, which in turn includes in the process and benefits the local and regional actors, in addition to national actors (the national government).

Both, the simulation analysis and the analysis of the model structure show the better state of Antofagasta's regional development system. In particular, of the autonomous local actors CORE and CDPR of Antofagasta have great influence in the system, which allows local control of decisions, at the political, strategic, and execution levels, as well as control of results. In contrast, in the case of Coquimbo, with a development system dominated by the central government, the CORE, an autonomous local actor, has very little influence. Moreover, the structural analysis of the model shows that this actor has major structural limitations; that is, with the current structural configuration of the system, this actor will not be able to have a significant influence on the regional development system. This is corroborated by the dependence of the other actors, GORE and CorfoSercReg, on the central government, forming with it a block in conflict with the CORE. Additionally, for the current situation represented by the simulation, the critical resources for endogenous development (ManagCap, OperatDesignCap, and DecRecParticLevel) present a better level for the Antofagasta case than for the Coquimbo case. The situation in Antofagasta is better than that in Coquimbo, not only under the perspective of endogenous development, but also under the viewpoint of Pike et al. (2017), given that it promotes: i) sustainability, since it favours participation and strengthening of local and regional actors, rather than only the central government; ii) progressivist, as it pretends to improve social conditions by changing the political situation, in particular, the distribution of power among actors, including an institutional change (creation of the CDPR); and, iii) holistic, given that it not only considers the standpoint, goals, and benefit of the central government, but also that of the local and regional actors.

Consequently, to promote endogenous development, a structural and institutional change of the local development system in Coquimbo is necessary, which would be achieved with the creation of an autonomous local development centre, CDPR, to complement and strengthen the local autonomous action of the CORE, and, simultaneously, subtract influence from the other actors strongly committed to the central government.

The paper has achieved its goal of generating additional knowledge about two case studies by social simulation and virtual experimentation, what is in line with Pike et al.'s (2017) suggestions regarding the use of case studies in local and regional development research. This research also brings to the discussion the relevance of the quality of institutions in contributing to the development of regions (Rodriguez-Pose, 2020).

Given the recent changes in certain levels of political-institutional decision-making in Chile (e.g., the highest regional authority is the Governor), which could configure new decision-making situations that will take some time to stabilise, our future work will be aimed at updating the models presented here, to better understand the new situation taking shape, and the opportunities for endogenous development that such political-institutional changes will offer.

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