How to maximize the Chilean government's revenue with the National Lithium Strategy?

Francisco Olivares [a]

(Corresponding author)

Vicuña Mackenna 4686, 7820436, Santiago, Chile

fjolivares@uc.cl

Gustavo Lagos [a]

Vicuña Mackenna 4686, 7820436, Santiago, Chile

Marcos Singer [a]

Vicuña Mackenna 4686, 7820436, Santiago, Chile

[a] Pontificia Universidad Católica de Chile

Highlights:

- Investment alternatives to consider when implementing a lithium tax regime.
- An ad hoc tax regime for each lithium project can increase government revenues.
- The ad valorem tax rate that maximizes lithium tax revenue is up to 27%.
- The government shareholding that maximizes lithium tax revenue is up to 32%.

Abstract

One of the goals of the Chilean Government's National Lithium Strategy is to increase tax revenue, which can be accomplished through levying an ad valorem tax or via government ownership of projects. A key consideration when designing the tax system is the Laffer curve, which demonstrates that although higher taxes lead to more revenue per project, the tax burden can reduce the number of projects undertaken.

We computed the ideal revenue for Chilean salt flats based on cost estimates for both operating and capital expenses, utilizing data from various salt flats worldwide. Our analysis indicates that if it is not possible to discriminate by project, the optimal ad valorem tax rate and government participation rate are 10.94% and 15.97%, respectively, generating about US$ 3,600 million per year in revenue for the government. If a separate rate is applied for each project, the total amount increases to US$ 4,355 million, irrespective of the mechanism type. If both mechanisms are implemented simultaneously, the collection does not increase in relation to the amount already obtained from each system separately.

This research demonstrates that if the Chilean government persists in demanding a majority stake in the partnerships engaged in the exploitation of lithium, it is probable that few agreements will come to fruition in the following years. Consequently, Chile could forfeit its position as the world leader in lithium production despite possessing the largest reserves globally.

Keywords: Lithium; Laffer curve; Tax system; Government shareholding; Ad valorem tax.

1. Introduction

It is estimated that there is a risk of a shortage in the lithium market in the next decade (Han et al., 2023), which will require the development of new lithium extraction and production projects. In this market, Chile plays a fundamental role as it is the country with the largest lithium reserves and the third largest lithium resources (U.S. Geological Survey, 2023). For example, Hu et al. (2023) noted that Chile's lithium supply constraints pose a risk to global commercial lithium battery networks (Hu et al., 2023). Despite this potential, the country has no mining projects under construction as of 2023. Given that any project that starts construction in 2023 will not enter production before 2030 (Bajolle, Lagadic & Louvet, 2022), Chile's future leadership in the global lithium industry is being challenged by the emergence of projects in China, Argentina and Africa (Bloomberg Linea, 2023). One way to overcome the constraints that impede the development of the industry in Chile and other countries is through the implementation of a national lithium strategy that allows the creation of an articulated strategic vision among the relevant stakeholders operating in the country, which should be the result of a collaborative process between the government, the private sector and the scientific community (Obaya, López & Pascuini, 2021).

In this announcement, the Government of Chile revealed the National Lithium Strategy (NLS) with the goal of positioning Chile as the world's top lithium producer while safeguarding the environment and the welfare of communities residing around the salt flats and lakes (Government of Chile, 2023a). The remarkable feature of the NLS is the significant involvement of the State in the complete lithium value chain, with the intention of maximizing tax revenues. This would enable the financing of social, technological and productive investments (Government of Chile, 2023b).

The primary method of revenue collection entails the imposition of income tax on individuals and businesses in Chile. Nonetheless, mining corporations may also be subject to a sales or profits royalty rate. At present, enterprises operating in the Salar de Atacama region undergo a progressive income tax and a sales leasing rate that functions similarly to a royalty. The rate will differ between 6.8% and 40% contingent on the prices of lithium products like lithium carbonate and hydroxide.

One option for the state to generate revenue is to participate in the shareholding of productive companies through public-private partnerships. Due to the lack of financial and technical resources required for exploring and exploiting minerals, full government shareholding is not feasible (Cervantes & Garduño-Rivera, 2022). If a corporation has a majority shareholding of a company, it may also seek to control operations. There is currently no indication that the Chilean government is contemplating investing funds in potential ventures through public-private partnerships regarding the NLS.

This paper addresses two crucial questions on NLS: What is the maximum level of state shareholding that makes the exploitation of lithium in each salar economically viable? And, what is the optimal royalty fee for the exploitation of lithium in each salar? These questions are important since the tax regime for potential public-private partnerships remains unspecified in the NLS (Government of Chile, 2023a; Government of Chile, 2023b).

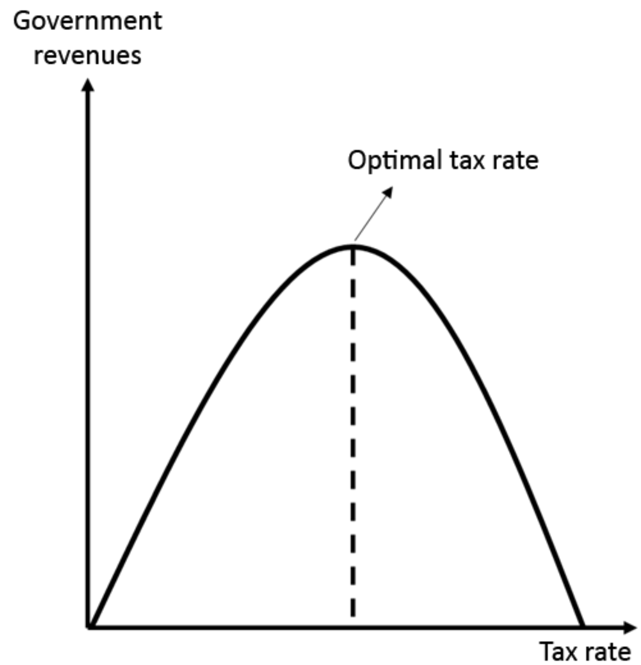
This study aims to identify tax and participation mechanisms that maximize tax revenue. It objectively outlines the factors on which tax revenues rely, analyzes the differences between royalty and corporate participation collection, and explores the optimal combination of corporate participation and royalty application. The study does not address additional tax objectives, such as the implementation of Pigouvian taxes to account for the externalities of mining extraction, including ecosystem damage (Roa, Navrud & Rosendahl, 2023).

The paper is structured as follows. Section 2 highlights the significance of incorporating the economic theory of the Laffer curve. Section 3 details a model for approximating the production expenses of the projects that may be leveraged by the NLS. Section 4 assesses the revenue generated by each of the revenue collection mechanisms. Finally, Section 5 concludes the study.

2. Laffer Curve

Imposing a higher tax rate does not always result in higher tax revenues. This is due to the fact that taxes can cause prices and costs to increase, which in turn discourages both consumption and investment, thus shrinking the revenue base. Put simply, while an increase in the tax rate may yield more revenue per unit sold or produced, it may also lead to a reduction in revenue by virtue of fewer units being sold or produced. The disparity in effects on government revenue is known as the Laffer curve in economic literature (Lin & Jia, 2019). The curve suggests that there exists an optimal tax rate that results in the maximum possible tax revenue. Figure 1 demonstrates the relationship between tax rate and revenue proposed by the Laffer curve.

Figure 1. Effect of tax rates on government revenues.



Source: Own elaboration.

In the context of this study, a higher ad valorem tax rate [1], like a sales royalty, or passive government shareholding [2] results in increased costs of domestically produced lithium products, such as lithium carbonate. We assume that demand determines the price irrespective of the tax regime imposed in the country. Our analysis is predicated on projections indicating a sustained surge in demand for lithium products, primarily propelled by the rise of electromobility (McKinsey & Company, 2023), and intensified competition in the global lithium market (Bloomberg Line, 2023). Consequently, the proposed Laffer curve receives validation from the supply side, through two distinct mechanisms:

1) Production Costs: In contrast to a profit tax, a sales tax, like the lease tax charged at Salar de Atacama, boosts the cost of producing lithium. For a mining venture to be

[1] For the purposes of simplicity and thoroughness, the sales royalty referenced in the introduction will be referred to as the ad valorem tax throughout this document.

[2] Passive shareholding that does not contribute capital to the investments.

successful in the long run, the cost of producing one ton of lithium carbonate equivalent (LCE) must fall below its selling price. Therefore, an increase in the tax rate may lead to a reduction in mineral production. Based on the current costs of lithium production via brine and the long-term mineral price estimate (Jones, Acuña & Rodríguez, 2021), it is projected that this limitation will not be active in the medium term.

This study considers both operating costs (OPEX) and capital expenditures (CAPEX) as production expenses. Since the State's passive corporate participation in a company does not involve contributing capital for construction, the private company collaborating to extract lithium can regard this participation as a cost.

2) Opportunity Cost: Investment decisions depend not only on the monetary production costs of projects but also on the available investment alternatives at the time of decision making. Projects with the lowest production costs (including taxes on profits or corporate shareholdings) are preferred for the same sales price.

   Currently, Australia is Chile's primary competitor in the lithium industry, holding 76.92% of the world's lithium production (U.S. Geological Survey, 2023). However, it is anticipated that by 2030, China, Argentina, and Africa will exceed Chile's share (Bloomberg Line, 2023). The implementation of a successful NLS will enable Chile to launch several new lithium mining projects, but most of them are projected to start production after 2030. If the NLS fails to trigger new investments, Chile will lose importance in the global market after 2030 even though it possesses the world's largest reserves of lithium, according to the U.S. Geological Survey (2023).

   Due to the abundance of lithium-producing opportunities in other countries, private investors considering investing in potential NLS projects have numerous alternatives worldwide. Thus, only Chilean salt flats with a production cost below a specific threshold, relative to the production costs of possible alternatives, will be deemed attractive for investment purposes. For simplicity, we will assume this threshold to be equivalent to the industry's average global cost[3].

In conclusion, for the government to optimize its revenue from the NLS, it must factor in both production costs and potential investors' opportunity costs when devising the revenue collection mechanism.

3. Cost Model

The previous section highlights the significance of calculating production costs for each potential project governed under the NLS. As reported by the Government of Chile (2023b), the country has 63 saline environments[4], including 45 salt flats and 18 salt ponds, each with unique physicochemical and hydrogeological traits. Therefore, it is unfeasible to generalize production costs for all possible projects. Through the first half of 2023, the NLS acknowledges 18 salt flats with geological potential for lithium extraction, as discovered by Troncoso et al.'s (2013) study, which did not evaluate production costs. This same study seeks to assess not only costs associated with these salt flats, but also evaluate potential extraction in other saline environments throughout the nation.

The first step is to determine the factors that influence the costs of lithium production from brine. The main factors are:

[3] The average cost of the entire industry is analyzed, encompassing both brine and mineral projects.
[4] The term saline environments encompass all brine deposits, including salt flats, saline lakes, hydrothermal springs, oilfield brines, and geothermal brines (Steinmetz & Fong, 2019).

- Lithium concentration: A higher concentration of lithium in the brine obtained from salt flats enables the extraction of a larger quantity of lithium per cubic meter of processed brine.
- Surface area of the salt flat: In addition to determining the maximum amount of brine to be extracted, this method enables capitalizing on existing economies of scale.
- Ratio of lithium to other minerals: A greater magnesium and boron ratio in the brines, in relation to lithium, raises the expense of refining the lithium products required by the market.
- Climatic conditions: Since evaporation ponds are utilized for obtaining concentrated lithium solutions, regions with arid weather conditions enable a shorter duration of production.

Risacher, Alonso, and Salazar (1999) conducted a comprehensive study on various saline environments in Chile, analyzing samples from 53 locations. This exceeds the scope of Troncoso et al.'s (2013) study and allows for a more in-depth examination of potential projects in the country. Specifically, the study focuses on the 39 saline environments where information on the salt flat surface is available. The analysis excludes the Salar de Atacama due to its operational status, resulting in the opportunity cost of investing in another project being a sunk cost[5]. The physical characteristics of these saline environments are summarized in Appendix A.

Due to the large number of samples collected from each saline environment in the study by Risacher, Alonso, and Salazar in 1999, it is imperative to establish specific criteria for sample

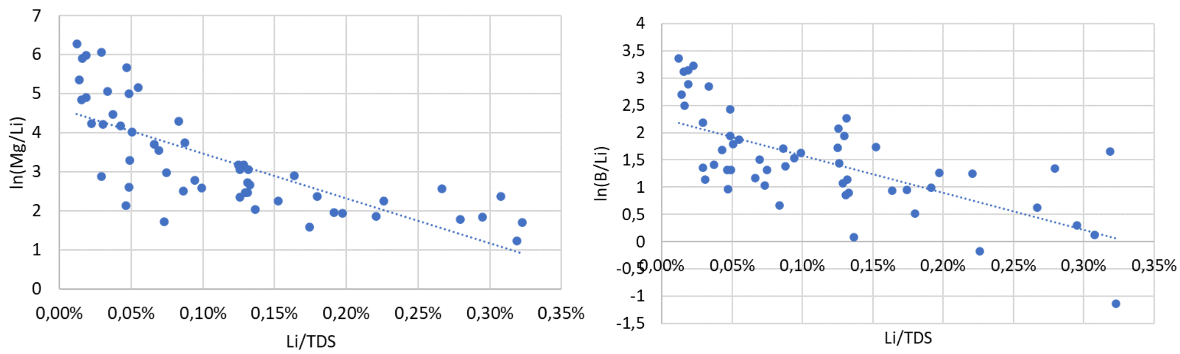
[5] This statement may not be entirely accurate when considering the relevance of opportunity cost when expanding productive capacity at the Salar de Atacama.

selection. It should be noted that not all samples are representative of the chemical composition of brines in saline environments because many come from surface sources. To ensure objectivity, we chose to average the three samples with the highest lithium to total dissolved solids (TDS) ratio in each saline environment. Grammatical accuracy is ensured with precise technical vocabulary. See Appendix B for the proposed average chemical compositions of the saline environments studied by Risacher, Alonso, and Salazar (1999).

In order to determine the production costs based on the saline environments' characteristics, it is imperative to obtain a sample of salt flats where lithium is being currently extracted. This study's primary limitation is that lithium has only been extracted from seven saline environments globally, including the Salar de Atacama, Salar del Hombre Muerto, Salar de Olaroz, and four salt lakes in China, as stated in the Jones, Acuña, and Rodríguez (2021) report. This small sample does not permit the consideration of all salt flat characteristics in the analysis. Thus, research is limited to one characteristic: lithium concentration over TDS (Li/TDS). Figure 2 indicates that Li/TDS highly correlates with magnesium and boron ratios (-0.74 and -0.67, respectively). It is logical because these minerals, like lithium, are part of TDS. In regard to climatic conditions, the Li/TDS ratio exhibits a correlation of -0.31 and 0.15 with precipitation and average temperature, respectively. The correlations show the expected sign, but their magnitude is relatively low. Thus, our study is limited by not considering these characteristics.

Figure 2. Relationships between Li/TDS and other minerals.

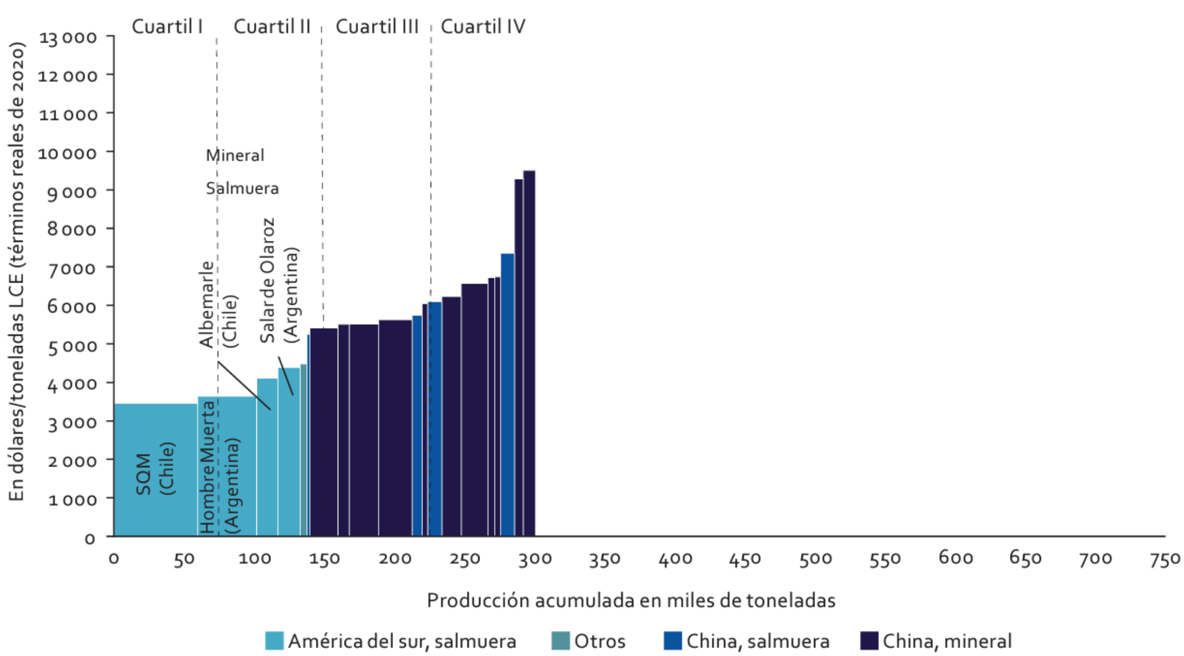
a. Relationships between Li/TDS y Mg/Li b. Relationships between Li/TDS y B/Li



Source: Own elaboration based on data from Risacher, Alonso and Salazar (1999).

Figure 3 displays Jones, Acuña, and Rodriguez's (2021) estimated OPEX per ton of LCE in 2020 for various global projects. It is important to note that these costs consider the ad valorem taxes levied by the companies in their countries of operation, which in the case of Chile is the lease rate of the Salar de Atacama operations.

Figure 3. Lithium carbonate OPEX in 2020.



Source: Jones, Acuña and Rodríguez (2021).

One downside of the Jones, Acuña, and Rodriguez (2021) report is its focus on Latin America, leaving out details about Chinese salt lakes. The primary salt lake in China, Lake Zabuye in Tibet, exhibits high lithium concentration and low magnesium concentration. However, its production has been impeded by geographical limitations (SSM, 2018). Assuming a production process similar to that of salt lakes in Latin America, and with a production of approximately 3,138 tons of lithium carbonate in 2017 (SSM, 2018), it is inferred that this lake corresponds to the first bar (from left to right) of China's brine production shown in Figure 3. Another important region in China with salt lakes is Qinghai, where the Xitai Ji Nai'er and Dongtai lakes are situated. Unlike Zabuye Lake, the lakes mentioned exhibit a lower lithium concentration and a higher magnesium-to-lithium ratio, although they produced more lithium in 2017 compared to Zabuye (SSM, 2018). Because of their high resemblance, it is presumed that they are associated with the subsequent two bars in Figure 3 relating to China's brine production. Considering that distinguishing the expenses between the two Qinghai lakes was unfeasible, the mean cost of the previously mentioned bars is employed.

Table 1 displays the operating expenditures (OPEX) for the five announced operations and their chemical compositions, sourced from Vera et al. (2023). To calculate the OPEX without ad valorem taxes, this study uses a price of $8,350, the progressive lease rate paid by the operations in Chile, the 3% royalty paid to the provincial governments in Argentina for the extracted ore, and the 13% value added tax in China[6]. The Salar de Atacama OPEX is an average of SQM's and Albemarle's costs based on production weight.

[6] In Chile, the value added tax is applicable solely to the sale of lithium within the country. As almost all produced lithium in the country is exported, this tax has been excluded.

Table 1. Chemical compositions and OPEX analyzed.

Proyect name	Country	Li/TDS	Mg/Li	B/Li	OPEX per ton of LCE (US$ 2022)
Salar de Atacama	Chile	0.47%	6.15	0.28	$2,916
Salar de Hombre Muerto	Argentina	0.31%	0.16	0.6	$3,780
Salar de Olaroz	Argentina	0.18%	3.51	No data	$4,628
Zabuye Lake	China	0.15%	0	2.39	$4,650
Xitai Ji Nai'er and Dongtai Lakes	China	0.06%	64.29	1.48	$5,437

Source: Jones, Acuña and Rodríguez (2021) and Vera et al. (2023).

Figure 4 illustrates the exponential relationship between the Li/TDS ratio and OPEX, exclusive of ad valorem tax. This relationship is observed in saline environments and will be utilized to create an OPEX cost curve for Chilean saline environments according to their Li/TDS ratio. Table 2 displays three different statistical estimates for the analyzed relationship, with the exponential model having the highest R^2 value.

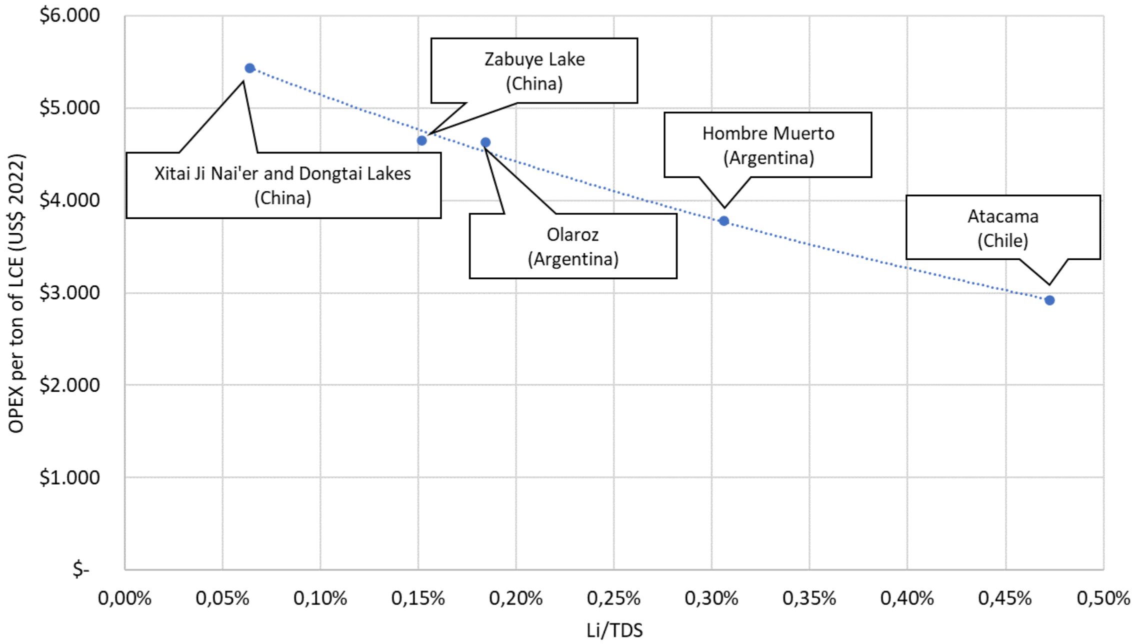
Table 2. Statistical estimation of OPEX cost curve according to Li/TDS.

Model type	Linear	Quadratic	Exponential
Dependent variable	OPEX without tax	OPEX without tax	ln(OPEX without tax)
Li/TDS	-604,686.6	-820,336.7	-151.3795
$(Li/TDS)^2$		39,247,360	
Constant	5,708.036	5,919.653	8.6971
R^2	0.9881	0.9942	0.9956

Source: Own elaboration.

When comparing the Li/TDS ratio between Vera et al.'s (2023) study of the Salar de Atacama and that of Risacher, Alonso and Salazar (1999), it is evident that the former produced a higher estimate. This could be attributed to the surface-level samples collected by Risacher, Alonso and Salazar (1999). Thus, to estimate the OPEX of 39 saline environments in the country, the Li/TDS ratios of Risacher, Alonso and Salazar (1999) were multiplied by 1.5357.

Figure 4. Estimated OPEX per ton of lithium carbonate (US$ 2022) [a]



Note: [a] The line is an exponential trend.

Source: Own elaboration based on Jones, Acuña and Rodríguez (2021) and Vera et al. (2023).

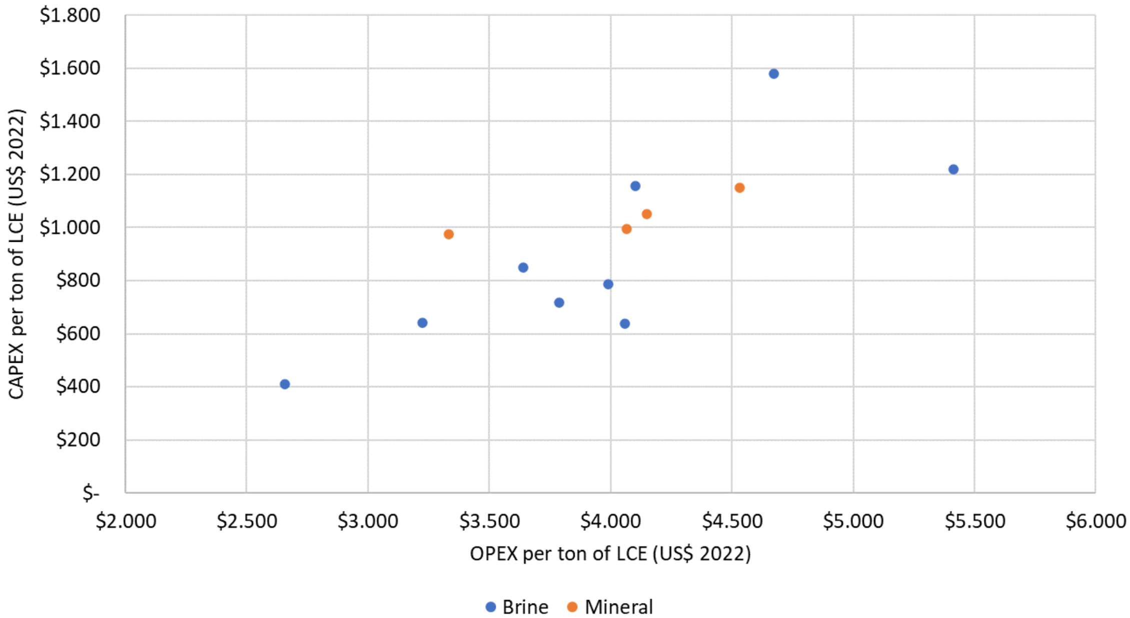
To estimate the capital expenditures (CAPEX) of saline environments, we consider several ongoing projects worldwide involving both brine and mineral mining. Table 3 provides details on the production and costs of these projects. Upon analyzing the relationship between operational expenditures (OPEX) and CAPEX per ton of lithium carbonate equivalent (LCE) for the projects depicted in Figure 5, we observe a positive correlation between these costs. Therefore, we assume that OPEX is a reliable predictor of potential lithium project CAPEX. When analyzing different mining types, there is an observed variation in the slope of the relationship, highlighting the importance of accounting for heterogeneity when estimating CAPEX. Additionally, the model considers the relationship between the expected production and capital expenditure of lithium projects, consistent with the findings of Sterba et al. (2019).

Table 3. Description of costs and production of the projects under study.

Projects under study	Mining type	Production (ton/year)	OPEX (US$/ton)	CAPEX (US$ 000)	CAPEX (US$/ton)
Pastos Grandes (Millennial Lithium, 2021)	Brine	24,000	$3,787	$688,596	$717
Sal de Vida (Rosko, Gunn & Weston, 2022)	Brine	44,700	$2,657	$730,620	$409
Tres Quebradas (King & Dworzanowski, 2021)	Brine	20,000	$3,226	$543,561	$641
Hombre Muerto Norte (Knight Piésold, 2019)	Brine	5,000	$3,638	$125,693	$849
Hombre Muerto Oeste (Galan Lithium Limited, 2020)	Brine	20,000	$3,990	$629,379	$787
Cauchari-Olaroz (Burga et al., 2020)	Brine	40,000	$4,059	$1,004,126	$637
Cauchari (Worley & Flo Solutions, 2019)	Brine	25,000	$4,104	$776,868	$1,156
Candelas (Galan Lithium Limited, 2021)	Brine	14,000	$4,673	$552,791	$1,579
Rincón (Argosy Minerals Limited, 2018)	Brine	10,000	$5,413	$201,026	$1,218
Falchani (DRA Pacific, 2020)	Mineral	63,000	$4,531	$2,392,331	$1,150
Quebec (Ibarra-Gutiérrez et al., 2021)	Mineral	20,000	$4,067	$298,586	$995
Sonora (Ausenco Engineering Canada, 2016)	Mineral	33,400	$3,331	$651,999	$976
Desert Lion Energy (Fowler et al., 2018)	Mineral	20,000	$4,150	$336,605	$1,052

Source: Own elaboration.

Figure 5. Ratio between CAPEX and OPEX of projects in the world (US$ 2022).



Source: Own elaboration.

Table 4 presents various model estimates in order to determine the optimal fit for the data. Table 4, Model 3, notes the heterogeneity aforementioned and reveals that brine mining initiatives possess a lower ratio of CAPEX to OPEX compared to mineral mining endeavors. Conversely, Model 4 in Table 4 enhances the accuracy of the estimation via the incorporation of production; however, it must be noted that economies of scale will not be the subject of this research.

Table 4. Statistical estimation of CAPEX from OPEX and production.

Models	Model 1	Model 2	Model 3	Model 4
Dependent variable	CAPEX	ln(CAPEX)	ln(CAPEX)	ln(CAPEX)
OPEX	0.3387			
ln(OPEX)		1.5855	0.4709	0.5671
Brine			-10.4511	-8.5806
ln(OPEX) x Brine			-1.2384	1.0069
ln(Production)				-0.0953
Constant	-409.0337	-6.3286	-3.0434	3.2291
R^2	0.5833	0.6488	0.7575	0.7810

Source: Own elaboration.

Selecting the latter approach to determining CAPEX increases the importance of having a model that estimates the production of every saline environment. To accomplish this, production is defined as a portion of mineral reserves:

$$production\ (tons\ of\ LCE/year) = \frac{efficiency * reserves}{life\ of\ mine}$$

where $efficiency$ refers to the lithium recovery rate and $life\ of\ mine$ denotes the years of operation of each project. For the purposes of this analysis, it is assumed that $efficiency$ is 65% and $life\ of\ mine$ is 30 years. A Cobb-Douglas function is utilized to calculate the lithium carbonate reserves of every project. Specifically, the formula for reserves:

$$reserves\ (tons\ of\ LCE) = A * K^{\alpha} * L^{\beta}$$

where A represents total factor productivity, K stands for capital, L is indicative of the number of workers, α is the elasticity of capital, and β denotes the elasticity of labor. To adjust for the lithium law, capital is scaled by Li/TDS. This method is consistent with the approach taken by de Solminihac, Gonzales, and Cerda (2018):

$$reserves\ (tons\ of\ LCE) = A * \left(K * \frac{Li}{TDS}\right)^{\alpha} * L^{\beta}$$

For simplicity, we assume that workers make up a portion c of the adjusted capital, and that capital accounts for a portion d of mining concessions (km^2):

$$reserves\ (tons\ of\ LCE) = A * \left(K * \frac{Li}{TDS}\right)^{\alpha} * \left(c * K * \frac{Li}{TDS}\right)^{\beta}$$

$$reserves\ (tons\ of\ LCE) = A * \left(d * concessions * \frac{Li}{TDS}\right)^{\alpha} * \left(c * d * concessions * \frac{Li}{TDS}\right)^{\beta}$$

$$reserves\ (tons\ of\ LCE) = \left(A * c^{\beta} * d^{\alpha+\beta}\right) * \left(concessions * \frac{Li}{TDS}\right)^{\alpha+\beta}$$

$$reserves\ (tons\ of\ LCE) = A^{'} * \left(concessions * \frac{Li}{TDS}\right)^{\gamma}$$

where $A' = A * c^{\beta} * d^{\alpha+\beta}$ y $\gamma = \alpha + \beta$. Thus, the model relies on estimating the parameters A' and γ, which are assumed to be homogeneous across all salt flats. Based on data from Salar Blanco (Atacama Water and Worley, 2022), Sal de Vida (Rosko, Gunn, and Weston, 2022), and Cauchari-Olaroz (Burga et al., 2020), A' is estimated to be 6,121,843.2235 and γ is 1.0142[7]. The final step involves estimating the mining concessions necessary for the potential projects, which will be assumed to be a function dependent on the area, for the sake of simplicity:

[7] To estimate the parameters, we apply the natural logarithm to both sides of the equation followed by a linear estimation using the available data.

$$concessions\ (km^2) = B * area^{\mu}$$

To estimate the model parameters, this study considers the two most significant salt flats in Chile. The Salar de Atacama, with a surface area of 3,000 km^2, is leased for mining concessions by SQM and Albemarle, which cover 1,638 km^2. In contrast, in the smaller Salar de Maricunga, with a saline environment and a surface area of 145 km^2, there are a total of 90 km^2 of mining concessions owned by both public and private companies. These data indicate that B equals 0.7657, and μ is estimated to be 0.9578.

The model's estimation indicates that the 39 saline environments studied, excluding Salar de Atacama, possess a total mineral reserve of 24,186,531 tons of LCE, along with an annual production rate of 524,042 tons of LCE. These estimates are derived by considering the three equations aforementioned, which are pertinent to production and reserves.

In summary, the study uses an exponential model and the Li/TDS ratio of each saline environment to estimate the OPEX per ton of LCE. Next, the mineral reserves and production for each potential project are estimated using the salt flat's surface area and Li/TDS ratio. Finally, a linear model is utilized to derive the CAPEX per ton of LCE from the OPEX[8] and estimated production, resulting in the total production cost:

$$OPEX\ (per\ ton\ of\ LCE) = e^{8{,}6971 - 151{,}3795 * \frac{\mathrm{Li}}{\mathrm{TDS}}}$$

$$concessions\ (km^2) = 0{,}7657 * area^{0{,}9578}$$

$$reserves\ (MM\ tons\ of\ LCE) = 6{,}1218 * \left(concessions * \frac{Li}{TDS}\right)^{1{,}0142}$$

[8] Since potential projects may involve brine mining, the equation can be simplified by incorporating the OPEX model coefficients.

$$production\ (tons\ of\ LCE/year) = \frac{0{,}65 * reserves}{30}$$

$$CAPEX\ (per\ ton\ of\ LCE) = e^{-5{,}3515} * OPEX^{1{,}5740} * production^{-0{,}0953}$$

$$Total\ production\ cost\ (per\ ton\ of\ LCE) = OPEX + CAPEX$$

Appendix C outlines the production cost analysis for 39 salt environments analyzed in Chile.

To determine the average cost of the global lithium industry, a long-term price per ton of LCE must be calculated due to the presence of ad valorem taxes on current operations that are tied to the product's price or value. Table 5 presents various price estimates offered by consulting firms. To maintain simplicity, a conservative estimate of US$20,000 is selected as the long-term price. From Figure 3, it can be concluded that the industry's average production cost per ton of LCE (in 2022 dollars[9]) is US$ 8,702.4[10], including the ad valorem tax imposed on each country's projects. This estimation is based on the CAPEX estimate according to the type of mining and the long-term price.

Table 5. Long-term price estimates for lithium carbonate.

Consulting company	Price per ton of LCE (US$ 2022)
Morningstar (2023)	$20,000
Benchmark Mineral Intelligence (DRA Pacific, 2023)	$20,750
Wood Mackenzie's (Roth et al., 2022)	$24,000
S&P Global (2022)	$40,000

Source: Own elaboration.

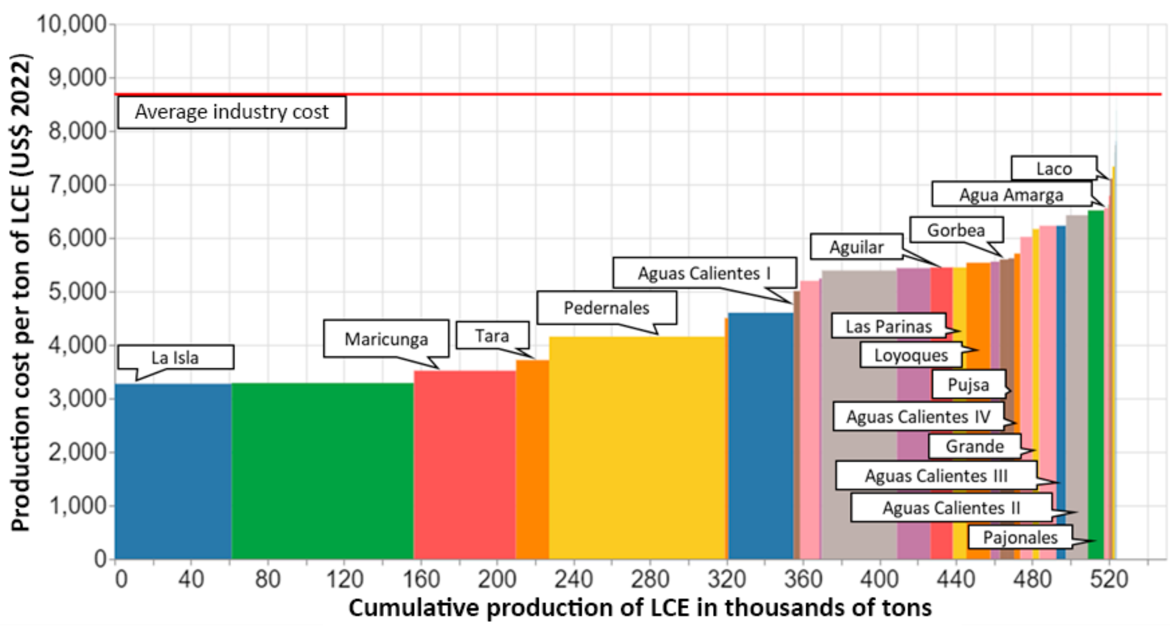
Figure 6 displays the total production costs, including both operational expenses (OPEX) and capital expenditures (CAPEX), for each ton of lithium carbonate equivalent (LCE) across 39

[9] Costs were adjusted based on the consumer price index in the United States.
[10] This cost considers both brine and mineral operations. It is assumed that investors are indifferent to the type of extraction performed.

saline environments. All costs are presented without ad valorem taxes or corporate participation. The red line indicates the industry's average production cost at US$ 8,702.4. Lastly, the 17 salt flats marked with data labels in the figure were considered by the government in the National Lithium Strategy (NLS), except for the Salar de Atacama.

The initial finding from Figure 6 is that all saline environments have production costs lower than the long-term price. However, only 37 projects are appealing to investors compared to the option of foreign operations. It is worth noting that the production costs depicted in Figure 6 do not include any ad valorem tax, as opposed to the industry's average expense, which does. If potential projects in Chile are subject to the same ad valorem tax as those currently paid by operators in the Salar de Atacama, only two projects in Chile would likely be appealing to investors.

Figure 6. Estimated cost of production (OPEX+CAPEX) for saline environments (US$ 2022) [a]



Note: [a] The data labels indicate the salt flats considered by the government in the NLS..

Source: Own elaboration.

The initial findings derived from examining the production costs of saline environments in Figure 6 demonstrate the importance of the design of the tax regime that governs them in the face of competition from investment opportunities in countries such as Argentina, Bolivia and China.

4. Estimates

As discussed in the introduction, the two simplified taxation alternatives are an ad valorem tax or royalty rate on sales, along with the government's shareholding of the projects. This section estimates Laffer curves for both revenue mechanisms and compares them to determine the regime that would maximize the revenue to the government.

4.1. Laffer Curve for Ad Valorem Taxes

The lease rate currently paid by the operations in Salar de Atacama progresses with the price of lithium products. Although the tax progressivity structure is important, mining investment decisions depend on long-term price estimates. Thus, the analysis concentrates on the effective ad valorem tax rate, regardless of the tax progressivity structure, to allow for generalizable conclusions. Assuming equal tax rates among all operations and factoring in a 35% profit tax[11], maximizing taxes can be outlined as collecting the most amount possible, while also taking into account the opportunity cost of investing abroad:

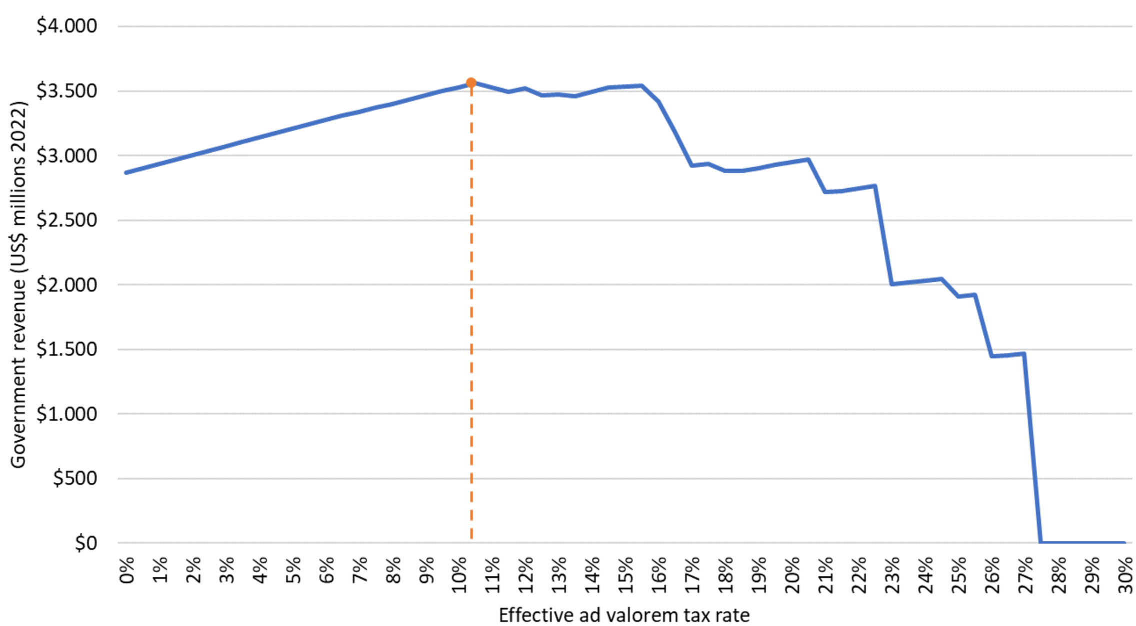
$$\underset{A\%}{Max} \sum_{i=1}^{N} ((P^{LP} - C_i) * 35\% + P^{LP} * A\% * (1 - 35\%)) * Q_i \quad s.a.\ C_i + P^{LP} * A\% \leq \bar{T}$$

[11] In other words, the owners of the operations are supposed to withdraw all profits.

where $i = \{1,2,3,\dots,N\}$ are the salt flats analyzed, P^{LP} is the long-run price, C_i is the production cost per ton of LCE of salt flat i, $A\%$ is the ad valorem tax rate to be set, Q_i is the production in tons of LCE per year of salt flat i, and $\bar{T}$ is the threshold price that defines the opportunity cost. P^{LP} corresponds to a price of US$20,000 per ton of LCE as determined above, and $\bar{T}$ is the industry average cost at US$8,702.4 per ton of LCE.

Figure 7 displays the tax revenue for various levels of the ad valorem tax rate. The Laffer curve's trade-off characteristic is evident, where tax collection increases with the tax rate until it reaches a maximum of US$ 3,578 million with an ad valorem tax rate of 10.94%. When we take into account the 35% income tax, the effective tax rate[12] equals 43.83%. The ideal ad valorem tax rate should be below the current Salar de Atacama lease rate of 26.86% when calculating a price of US$ 20,000.

Figure 7. Laffer curve for ad valorem tax (US$ 2022).



Source: Own elaboration.

[12] The effective tax rate is equal to the taxes collected divided by the proyect's income before taxes.

The aforementioned outcome assumes a uniform ad valorem tax rate for all operations. However, in practice, varying ad valorem tax rates can be imposed based on project attributes and, at the furthest end, individual project rates may be implemented. If this is the case, the problem of maximizing tax revenue is altered to:

$$\underset{A\%_i}{Max} \sum_{i=1}^{N} ((P^{LP} - C_i) * 35\% + P^{LP} * A\%_i * (1 - 35\%)) * Q_i \quad s.a.\ C_i + P^{LP} * A\%_i \leq \bar{T}$$

which is equivalent to maximizing revenue for each project individually. The revenue function increases strictly at $A\%_i$. The constraint $C_i + P^{LP} * A\%_i = \bar{T}$ is active and can be cleared to obtain:

$$A\%_i^* = \frac{\bar{T} - C_i}{P^{LP}}$$

This ad valorem tax scheme generates a tax collection of US$ 4,355 million and a total production of 523,281 tons of LCE[13]. The Salar de La Isla would see the highest ad valorem tax rate at 27.14%, while the Salar del Laco would experience the lowest at 7.97%[14,15]. The effective tax rate is 53.09%. The equation for the optimal ad valorem tax rate highlights the significance of long-term price estimation in defining the tax regime.

4.2. Laffer Curve for Government Shareholding

The government's second mechanism for collecting revenue from lithium projects is to participate in these operations as a shareholder. To maximize profits, the government's

[13] Esta This figure corresponds to the sum of the production of the 37 salt flats that are attractive to investors given the average global industry cost.

[14] There are seven other smaller potential projects with a lower optimal ad valorem tax rate, but Salar del Laco is exposed because it is one of the salt flats considered in the NLS.

[15] Appendix D provides information on the ad valorem tax rate and tax revenue for each analyzed project.

maximization problem can be summarized as follows, assuming that the participation must be equal in all operations and taking into account the profit tax of 35%:

$$\underset{S\%}{Max} \sum_{i=1}^{N} \big((P^{LP} - C_i) * (35\% + (1 - 35\%) * S\%)\big) * Q_i \qquad s.a.\ C_i + (P^{LP} - C_i) * S\% \leq \bar{T}$$

where S% represents the government share. Figure 8 displays the Laffer curve of fiscal revenues excluding production from the Salar de Atacama. The optimal revenue is US$3,698 million and is obtained with a 15.97% shareholding. It is noteworthy that tax revenues under this alternative are somewhat higher than the US$ 3,578 million obtained with the single ad valorem tax rate, which is also mirrored in the effective tax rate, rising to 46.9%.

Unlike the ad valorem tax, the corporate participation by essence can be different in each operation that is carried out, so the maximization problem is:

$$\underset{S\%_i}{Max} \sum_{i=1}^{N} \big((P^{LP} - C_i) * (35\% + (1 - 35\%) * S\%_i)\big) * Q_i \qquad s.a.\ C_i + (P^{LP} - C_i) * S\%_i \leq \bar{T}$$

Since the revenue function is strictly increasing, the opportunity cost constraint is active, i.e., $C + (P^{LP} - C) * S\%_i = \bar{T}$. Therefore, the optimal government share per project is:

$$S\%_i^* = \frac{\bar{T} - C_i}{(P^{LP} - C_i)}$$

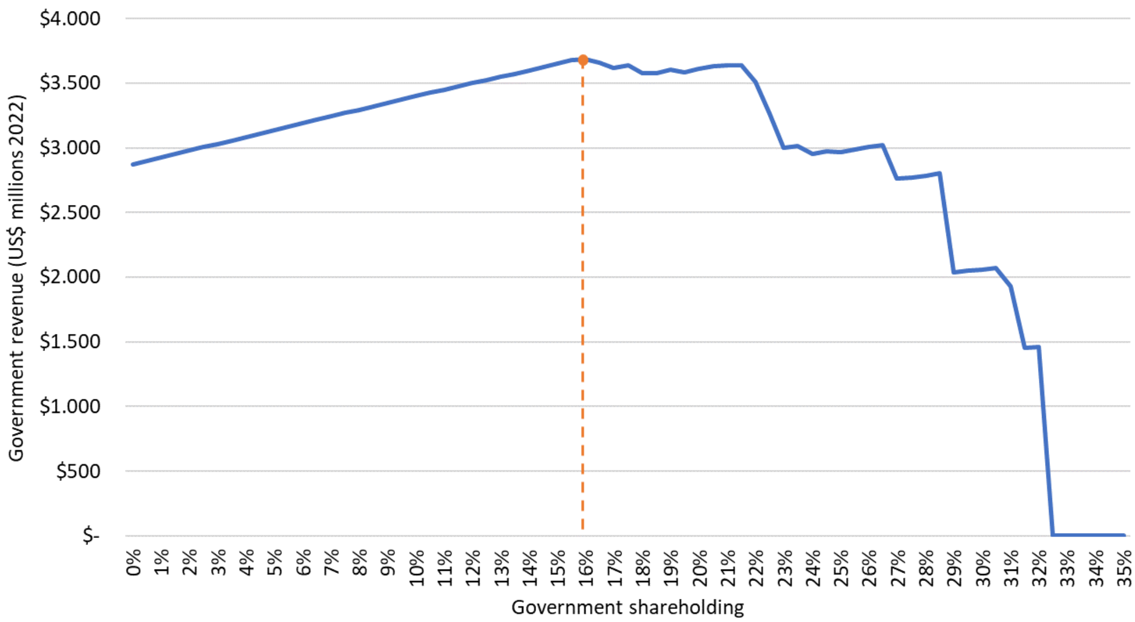
With this participation scheme, the fiscal revenue amounts to US$ 4,355 for all the salt flats considered. Salar de La Isla, with the lowest cost, has the highest participation of 32.45%, while Salar del Laco has the lowest participation of 12.36%[16,17]. The effective tax rate under

[16] As in the analysis of the optimal ad valorem tax, Salar del Laco is exposed because it is the salt flat with the lowest shareholding of those considered in the NLS.

[17] Appendix D details the government participation and fiscal revenue that would be obtained for each of the projects analyzed.

this scheme is 53.09%. It should be noted that at this level of participation, the State would not have majority control in any of the projects. This statement conflicts with the NLS's aim to exercise authority over the salt flats it regards as crucial (Chilean Government, 2023b).

Figure 8. Laffer curve for government shareholding (US$ 2022).



Source: Own elaboration.

In summary, it is observed that the revenue from government participation is equal to the revenue obtained with an ad valorem tax if a particular regime is designed for each potential project. Since the optimal rates depend on deterministic factors such as the opportunity cost threshold price and the long-term price, it is analyzed whether the conclusion depends on these parameters. In order for the government participation revenue to be greater than the ad valorem tax revenue, it must be satisfied that:

$$\left((P^{LP} - C_i) * (35\% + (1 - 35\%) * S\%_i^*)\right) * Q_i > \left((P^{LP} - C_i) * 35\% + P^{LP} * A\%_i^* * (1 - 35\%)\right) * Q_i$$

$$(P^{LP} - C_i) * (1 - 27\%) * \frac{\bar{T} - C_i}{(P^{LP} - C_i)} > P^{LP} * \frac{\bar{T} - C_i}{P^{LP}} (1 - 27\%)$$

$$1 = 1$$

The mathematical derivation just presented shows that the revenue from government share and ad valorem tax will always be equivalent if a specific tax system is designed for each project.

Can an increase in revenue be achieved through a combination of ad valorem taxation and government participation mechanisms? Assuming optimal government share to be implemented, any ad valorem tax rate higher than 0% will make the total cost of the project higher than the opportunity cost, making it unattractive to the investor. In other words, if both mechanisms are to be implemented simultaneously, the ad valorem tax and government participation rates must be lower than their optima, raising at most the same as each mechanism separately.

4.3. Model Sensitivity Analysis

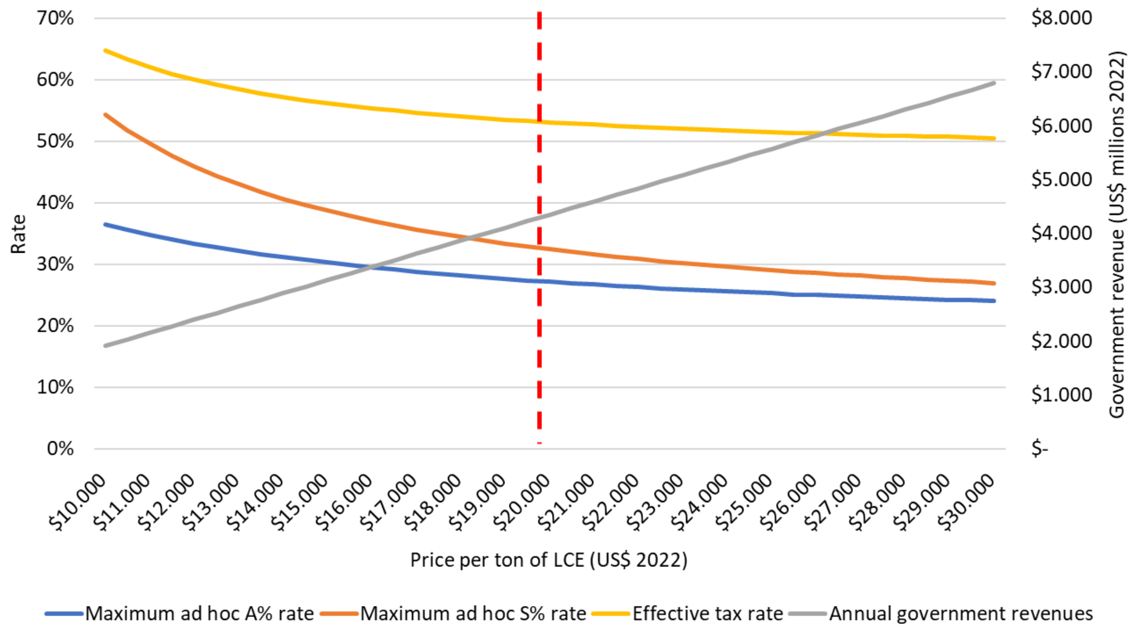
In this section, we analyze how variations in various parameters of the model impact rates and the optimal collection. We specifically sensitize the assumptions related to long price, opportunity cost, and mine life to assess their influence on the maximum ad valorem ad hoc tax rate, maximum ad hoc government share, effective tax rate, and annual revenue[18].

Figure 9 depicts how altering long-term prices impacts the model. Optimal rates are more greatly affected at prices below US$ 20,000 per ton of LCE, whereas changes are less pronounced at higher prices. According to Table 5 in section 3, the long-term price should

[18] The ad valorem tax rate and the maximum government participation are considered as examples. It is specified when the dynamics are different from other rate levels.

exceed US$ 20,000, indicating our model is resilient to varying market and investor estimations.

Figure 9. Variation of rates and revenues in response to long-term price changes.



Source: Own elaboration.

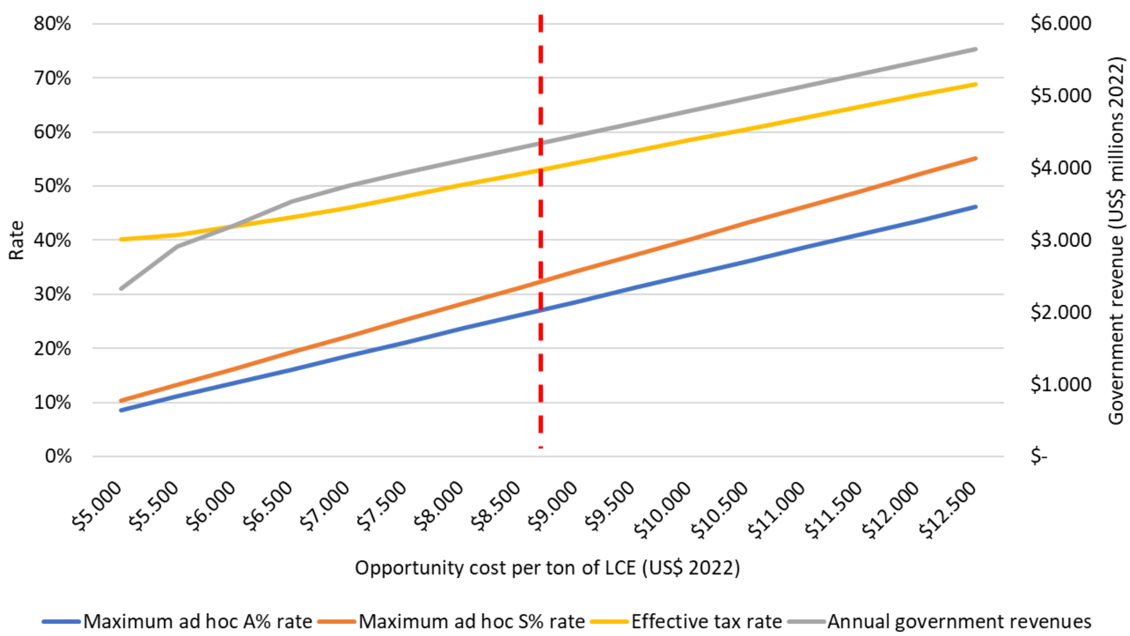
As the long-term price increases, the dynamics of rates decrease, but only if potential project production costs are below a certain threshold[19]. When project costs are high, an increased long-term price causes optimal rates to increase due to the price's impact on project opportunity costs. Despite this relationship, it is observed that changes in optimal rates are only marginal for prices exceeding US$ 20,000, affirming the robustness of our model in this regard.

Figure 10 depicts the impact on the model of altering the investor's opportunity cost. This cost is an essential assumption in the model findings, distinct from the long-term price. A

[19] The threshold production cost where the change in dynamics occurs is US$ 5,150 for the ad valorem tax rate and US$ 6,262 for the government share.

rise of US$1,000 in opportunity cost results in an increase of 5 percentage points in the optimal ad valorem tax rate and 6 percentage points in the optimal share[20]. Examining project cots from Figure 3 of Section 3[21], it is found that 65% of the projects in operation have a cost of US$8,500 to US$10,500. If this range is considered as the probable opportunity costs, the maximum optimal rates deviate by up to 9 and 10.8 percentage points for ad valorem tax and share, respectively, from our model. Even though the percentage changes in rates are high (approximately 33%), the revenue increases by only 14%, reducing the risk associated with selecting an opportunity cost.

Figure 10. Variation of rates and revenues in response to changes in opportunity cost.



Source: Own elaboration.

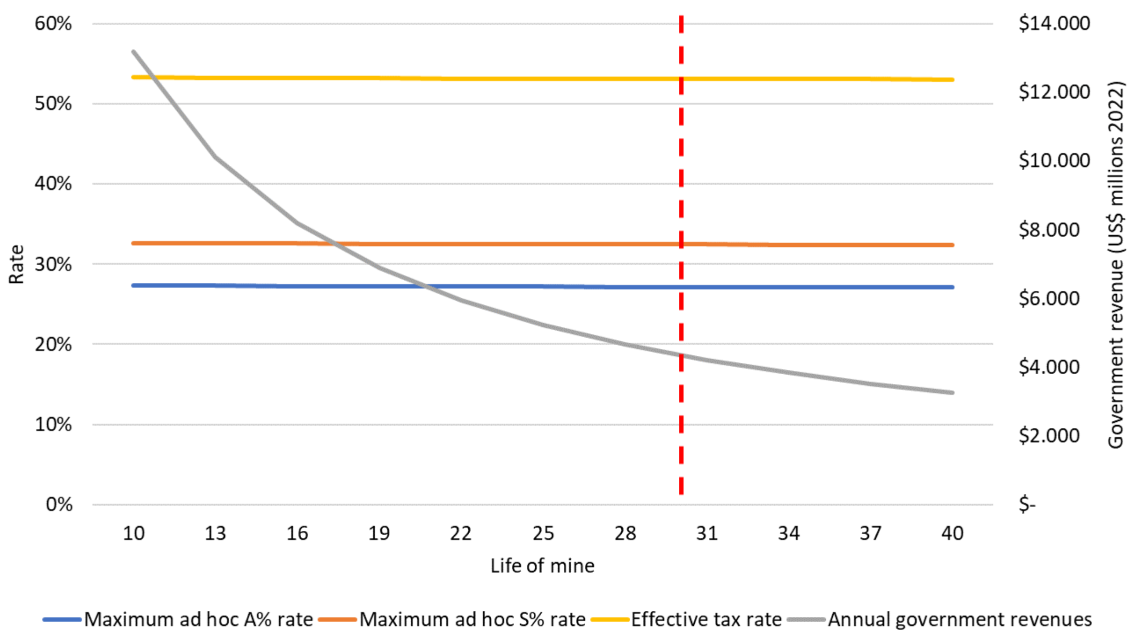
Finally, Figure 11 illustrates how a change in the life of mine or operation considered for the projects impacts the model. The analysis indicates that the change does not result in

[20] The impact on the ideal government share varies with the production cost of the project. The amount presented corresponds to the project with the lowest cost.

[21] To determine the ad valorem tax for these projects, we took a price of US$20,000 into account.

substantial changes in optimal rates, but it does lead to significant alterations in revenue. This happens because, based on the estimated parameters in the model, a change in production has a significant impact on CAPEX and, subsequently, the rates, only if it is a substantial increase (beyond what can be caused by a change in operating life). There is a variation in the present value of the revenue received by the government, but not in the total revenue received from a given project. These findings are applicable to adjustments in other production-related model parameters, like the recovery rate of lithium or the proportion of mining properties concerning the salt flats' surface area.

Figure 11. Variation of rates and revenues in response to a change in the life of mine.



Source: Own elaboration.

5. Conclusions

One objective of the Chilean Government's National Lithium Strategy is to maximize revenue from lithium exploitation to fund social, technological, and productive investments. Two collection mechanisms were considered in this study: the ad valorem tax currently used in Chile and the proposed government shareholding in the NLS. One consideration when designing this tax system is the Laffer curve, which suggests that even though higher taxes bring in more revenue per project, the tax burden results in fewer projects being carried out. We contend that potential lithium exploitation projects will only appeal to investors if they have a production cost lower than the industry's global average cost in our research.

The initial phase of this study involves creating a cost model using the chemical properties of the saline environments found in Chile. To achieve this objective, we calibrated an exponential model to determine the operating cost (OPEX) utilizing the lithium to total dissolved solids ratio of the saline environments. We then computed the capital investment (CAPEX) using the calculated OPEX and an estimation of production based on the reserves of each saline environment.

After calibrating the model, we have estimated the revenue acquired through each collection method. If it were impossible to differentiate between potential projects, the total revenue generated by the ad valorem tax mechanism and the government shareholding mechanism would be $3,578 million and $3,698 million, respectively. If a specific collection system is developed for each project, the government's participation mechanism can be equivalent to the ad valorem tax, leading to a collection of $4,355 million. This can result in an annual production of 523,281 tons of lithium carbonate equivalent (LCE) in all saline environments considered in the study, excluding Salar de Atacama. Finally, it is concluded that no combination of an ad valorem tax and government shareholding would increase the revenue obtained with each mechanism separately.

This study aims to provide a technical analysis of various factors to be considered while determining tax revenue collection systems to be imposed on prospective lithium extraction and production projects. Although the research concentrates on maximizing revenue collection, it is crucial to consider other implications of government participation that have not been addressed, including but not limited to, the consequences of project control, the assumption of risks, the role of the State in the partnership (participating in production, being solely a shareholder, etc.).

A successful National Lithium Strategy would enable several new lithium mining projects in Chile, but most of them are not expected to begin production until after 2030. Nonetheless, Chile could recover its lost dominance in lithium production after 2030 thanks to the increased activity. If the National Lithium Strategy fails to attract new investments, Chile will lose importance in the global market despite having the largest lithium reserves in the world by 2030. This study proposes that if the State continues its requirement to hold a majority stake in partnerships that exploit lithium, only a few deals will be made in the upcoming years.

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Appendix A

Name of the salt flat	Region	Height (m)	Surface area of salt flat (km^2)	Precipitation (mm/year)	Potential evaporation (mm/year)	Average temperature (°C)
Lago Chungará	XVI	4,530	0	338	1,230	1.9
Lagunas Cotacotani	XVI	4,495	0	379	1,070	1.9
Río Lauca	XVI	4,200	0	369.5	1,200	4.2
Salar de Surire	XVI	4,260	144	250	1,280	2.7
Salar de Coposa	I	3,730	85	150	1,300	5
Salar del Huasco	I	3,778	51	150	1,260	5
Laguna Lagunilla	I	3,900	0.2	150	1,490	4.6
Salar de Michincha	I	4,125	2.5	200	1,620	3.5
Salar de Pintados	I	980	51	0.8	2,000	18.5
Salar de Aguas Calientes 1	II	4,280	15	150	1,500	1
Salar de Aguas Calientes 2	II	4,200	134	150	1,500	1
Salar de Aguas Calientes 3	II	3,950	46	150	1,500	1
Salar de Aguas Calientes 4	II	3,665	19.5	180	1,630	2
Salar de Alconcha	II	4,250	3.8	200	1,620	3.5
Salar de Ascotán	II	3,716	243	125	1,630	5.8
Salar de Atacama	II	2,300	3,000	25	2,000	14
Salar de Carcote	II	3,690	108	125	1,630	5.8
Salar de Capur	II	3,950	27	150	1,500	1
Laguna Helada	II	4,300	5.8	180	1,500	0
Salar de Imilac	II	2,949	9.8	40	2,000	10
Salar del Laco	II	4,250	16.2	200	1,500	1
Laguna de la Azufrera	II	4,250	0	180	1,630	1

Laguna Lejia	II	4,325	0	150	1,500	1
Salar de Loyoques	II	4,150	80	150	1,500	1
Laguna Miñiques	II	4,120	0	180	1,500	2
Laguna Miscanti	II	4,120	0	180	1,500	2
Laguna Chivato Muerto	II	4,295	0	200	1,500	0
Salar de Pajonales	II	3,537	104	115	1,350	5
Salar de Pujsa	II	4,500	18	150	1,500	1
Salar de Punta Negra	II	2,945	250	50	2,000	10
Salar de Tara	II	4,400	48	150	1,500	0
Laguna Trinchera	II	4,290	0.4	200	1,500	0
Laguna Tuyajto	II	4,010	0	180	1,500	1
Salar de Aguilar	III	3,320	71	100	1,100	2
Salar de Agua Amarga	III	3,558	23	120	1,100	2
Salar de la Azufrera	III	3,580	3.3	120	1,100	3
Laguna del Bayo	III	4,250	0	140	1,000	-2
Lagunas Bravas	III	4,250	0	140	1,000	-2
Laguna Escondida	III	4,353	3.8	140	1,000	-1
Laguna del Negro Francisco	III	4,110	0	200	1,000	-1
Salar de Gorbea	III	3,950	27	140	1,000	-1
Salar Grande	III	3,950	29	130	1,000	-2
Salar Ignorado	III	4,250	0.7	140	1,000	-2
Salar de los Infieles	III	3,520	6.7	100	1,100	2
Salar de La Isla	III	3,950	152	130	1,000	0
Lagunas del Jilguero	III	4,150	3.4	140	1,000	-2
Laguna Verde	III	4,350	0	170	1,000	1
Salar de la Laguna	III	3,494	0.55	120	1,100	3
Salar de Maricunga	III	3,760	145	120	1,200	4

Salar de las Parinas	III	3,987	40	140	1,000	0
Salar de Pedernales	III	3,370	335	100	1,200	4
Salar de Piedra Parada	III	4,150	28	140	1,000	-2
Salar de Wheelwright	III	4,220	6.3	140	1,000	1

Appendix B

Name of the salt flat	Li/TDS	Mg/Li	B/Li
Lago Chungará	0.0291%	428.8007	3.8993
Lagunas Cotacotani	0.0466%	287.6593	2.6168
Río Lauca	0.0484%	147.9346	11.3922
Salar de Surire	0.1915%	7.0377	2.7008
Salar de Coposa	0.0833%	73.8795	1.9382
Salar del Huasco	0.0989%	13.2659	5.0944
Laguna Lagunilla	0.0140%	210.9830	14.7557
Salar de Michincha	0.0120%	534.8177	28.7336
Salar de Pintados	0.1523%	9.5307	5.6441
Salar de Aguas Calientes 1	0.1743%	4.8454	2.5912
Salar de Aguas Calientes 2	0.0694%	34.6547	4.5270
Salar de Aguas Calientes 3	0.0875%	42.6330	4.0077
Salar de Aguas Calientes 4	0.1247%	23.9747	5.6129
Salar de Alconcha	0.0155%	127.7867	22.6733
Salar de Ascotán	0.3189%	3.4064	5.2338
Salar de Atacama	0.3077%	10.6254	1.1370
Salar de Carcote	0.1309%	15.2570	2.3516
Salar de Capur	0.0372%	87.2595	4.0831
Laguna Helada	0.2205%	6.4444	3.4828
Salar de Imilac	0.0290%	17.8717	8.9241
Salar del Laco	0.0506%	55.6999	5.9686
Laguna de la Azufrera	0.0186%	392.7929	17.8881
Laguna Lejia	0.0548%	172.9629	6.5133
Salar de Loyoques	0.1260%	10.4418	4.2296

Laguna Miñiques	0.0183%	135.6722	23.1170
Laguna Miscanti	0.0225%	69.4882	25.2991
Laguna Chivato Muerto	0.0490%	26.6402	3.7358
Salar de Pajonales	0.0662%	40.4348	3.2206
Salar de Pujsa	0.1310%	11.8320	9.5954
Salar de Punta Negra	0.1287%	23.8607	2.9186
Salar de Tara	0.2796%	5.8718	3.8160
Laguna Trinchera	0.0462%	8.5132	3.7271
Laguna Tuyajto	0.0305%	68.0236	3.1103
Salar de Aguilar	0.1326%	14.2814	2.4391
Salar de Agua Amarga	0.0747%	19.5904	3.7107
Salar de la Azufrera	0.0426%	64.4694	5.3740
Laguna del Bayo	0.0482%	13.3838	6.9832
Lagunas Bravas	0.1971%	6.9017	3.5341
Laguna Escondida	0.0334%	156.0266	17.2077
Laguna del Negro Francisco	0.2668%	12.8731	1.8785
Salar de Gorbea	0.1294%	11.7977	6.9839
Salar Grande	0.0943%	16.0942	4.6559
Salar Ignorado	0.0159%	364.4001	12.1515
Salar de los Infieles	0.1635%	17.9842	2.5390
Salar de La Isla	0.3228%	5.4694	0.3197
Lagunas del Jilguero	0.0862%	12.2525	5.4948
Laguna Verde	0.1798%	10.6115	1.6836
Salar de la Laguna	0.1257%	21.0217	7.9509
Salar de Maricunga	0.2950%	6.2480	1.3566
Salar de las Parinas	0.1364%	7.6364	1.0882
Salar de Pedernales	0.2260%	9.4886	0.8427

Salar de Piedra Parada	0.1319%	21.1508	3.1284
Salar de Wheelwright	0.0730%	5.5464	2.8099

Appendix C

Name of the salt flat	Li/TDS adjusted	Estimated production cost per ton of LCE (US$ 2022)	Estimated annual production of LCE (tons)
Salar de Surire	0.19%	$4,601	34,221
Salar de Coposa	0.08%	$6,228	8,813
Salar del Huasco	0.10%	$6,018	6,387
Laguna Lagunilla	0.01%	$9,269	4
Salar de Michincha	0.01%	$8,633	40
Salar de Pintados	0.15%	$5,196	9,896
Salar de Aguas Calientes 1	0.17%	$5,007	3,456
Salar de Aguas Calientes 2	0.07%	$6,423	11,404
Salar de Aguas Calientes 3	0.09%	$6,228	5,104
Salar de Aguas Calientes 4	0.12%	$5,706	3,176
Salar de Alconcha	0.02%	$8,379	78
Salar de Ascotán	0.32%	$3,288	95,412
Salar de Carcote	0.13%	$5,435	17,588
Salar de Capur	0.04%	$7,334	1,276
Laguna Helada	0.22%	$4,500	1,743
Salar de Imilac	0.03%	$7,733	371
Salar del Laco	0.05%	$7,109	1,062
Salar de Loyoques	0.13%	$5,536	12,647
Salar de Pajonales	0.07%	$6,515	8,499
Salar de Pujsa	0.13%	$5,616	3,089
Salar de Punta Negra	0.13%	$5,390	39,080
Salar de Tara	0.28%	$3,717	17,280

Laguna Trinchera	0.05%	$7,956	27
Salar de Aguilar	0.13%	$5,449	11,862
Salar de Agua Amarga	0.07%	$6,556	2,218
Salar de la Azufrera	0.04%	$7,590	190
Laguna Escondida	0.03%	$7,805	170
Salar de Gorbea	0.13%	$5,597	4,523
Salar Grande	0.09%	$6,166	3,516
Salar Ignorado	0.02%	$8,805	15
Salar de los Infieles	0.16%	$5,239	1,480
Salar de La Isla	0.32%	$3,274	61,247
Lagunas del Jilguero	0.09%	$6,621	400
Salar de la Laguna	0.13%	$6,169	100
Salar de Maricunga	0.29%	$3,518	53,384
Salar de las Parinas	0.14%	$5,449	6,991
Salar de Pedernales	0.23%	$4,155	91,900
Salar de Piedra Parada	0.13%	$5,555	4,777
Salar de Wheelwright	0.07%	$6,785	616

Appendix D

Name of the salt flat	Optimum ad valorem tax rate	Optimum shareholding	Government revenue (US$ millions 2022)
Salar de Surire	20.51%	26.63%	$275.67
Salar de Coposa	12.37%	17.97%	$56.66
Salar del Huasco	13.42%	19.20%	$42.40
Salar de Michincha	0.35%	0.61%	$0.16
Salar de Pintados	17.53%	23.68%	$73.82
Salar de Aguas Calientes 1	18.48%	24.65%	$26.43

Salar de Aguas Calientes 2	11.40%	16.79%	$71.09
Salar de Aguas Calientes 3	12.37%	17.97%	$32.81
Salar de Aguas Calientes 4	14.98%	20.96%	$22.08
Salar de Alconcha	1.62%	2.78%	$0.33
Salar de Ascotán	27.07%	32.40%	$893.87
Salar de Carcote	16.34%	22.43%	$127.02
Salar de Capur	6.84%	10.80%	$6.79
Laguna Helada	21.01%	27.11%	$14.22
Salar de Imilac	4.85%	7.90%	$1.83
Salar del Laco	7.97%	12.36%	$5.89
Salar de Loyoques	15.83%	21.89%	$90.05
Salar de Pajonales	10.94%	16.22%	$52.20
Salar de Pujsa	15.43%	21.46%	$21.75
Salar de Punta Negra	16.56%	22.67%	$283.99
Salar de Tara	24.93%	30.62%	$154.48
Laguna Trinchera	3.73%	6.20%	$0.13
Salar de Aguilar	16.27%	22.36%	$85.49
Salar de Agua Amarga	10.73%	15.97%	$13.53
Salar de la Azufrera	5.56%	8.96%	$0.96
Laguna Escondida	4.49%	7.36%	$0.83
Salar de Gorbea	15.53%	21.56%	$31.93
Salar Grande	12.68%	18.33%	$22.82
Salar de los Infieles	17.32%	23.46%	$10.98
Salar de La Isla	27.14%	32.45%	$574.64
Lagunas del Jilguero	10.41%	15.56%	$2.41
Salar de la Laguna	12.67%	18.32%	$0.65
Salar de Maricunga	25.92%	31.45%	$487.85

Salar de las Parinas	16.27%	22.36%	$50.38
Salar de Pedernales	22.74%	28.70%	$781.34
Salar de Piedra Parada	15.74%	21.79%	$33.92
Salar de Wheelwright	9.59%	14.51%	$3.61