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Artisanal and Small-Scale Mining Developing in Chile: Impact and Structural Barriers to Formalization

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EXECUTIVE SUMMARY

Artisanal and Small-Scale Mining (ASM) plays a meaningful, though often understated, role in Chile's mining sector and regional economies. It is estimated to employ approximately 8%[1] of the mining-related workforce across all minerals, both directly and indirectly. It contributes around 0.072%[2] of national GDP and supports the livelihoods of an average of 21 people per active operation[3]. While its aggregate economic footprint is modest at the national level, ASM's social, territorial, and institutional relevance is significant, particularly in mining-dependent regions.

Chile's ASM sector also holds relevance in a global context. Copper represents the dominant mineral produced by ASM in the country, reflecting both Chile's geological endowment and its central role in global copper markets. In aggregate terms, Chilean ASM copper production by itself would rank approximately 28th worldwide, with an estimated 0.26% share of global output. This creates a structural paradox: ASM appears economically marginal in national aggregates, yet meaningful when considered independently or territorially. Other minerals, including lithium, molybdenum, gold, and silver, play secondary roles within Chile's ASM sector, with the latter three typically recovered as by-products of copper extraction.

This paper aims to contribute to policy-relevant discussions of ASM by offering a unified analytical perspective on the Chilean case, with particular emphasis on institutional design, participation, and economic impact. While a body of literature on ASM exists – particularly for certain commodities and regions – systematic evidence remains uneven, and data scarcity continues to constrain robust empirical assessment. In this context, Chile's ASM sector remains underexamined despite its distinctive governance architecture. This paper differentiates itself by consolidating elements of Chilean ASM, discussing the factors that affect ASM participation with federally-run institutions designed to formalize and support it, and applying a quantitative approach to assess economic contribution.

[1] National Survey of Employment, INE Chile. June-August 2025.
[2] Own Estimation. Source: Central Bank Chile Database and "Anuario de la Mineria de Chile 2024", Sernageomin
[3] NOUS - Regional characterization study of ASM, 2017

Central to the Chilean ASM model is the role of the state-owned Empresa Nacional de Minería (ENAMI), established in 1960, which operates as a market intermediary and support institution for small-scale producers. Chile's approach reflects a developmental state framework in which targeted public intervention addresses structural market failures — such as scale limitations, geographic isolation, and informality — without displacing private actors or market-based pricing. Through ENAMI, ASM producers gain access to guaranteed markets, processing infrastructure, technical assistance, financing mechanisms, and price stabilization linked to international markets. Importantly, this model preserves private ownership and market pricing, prioritizing economic inclusion, formalization, and regional stability over profit maximization, positioning ENAMI as a pragmatic economic instrument rather than an ideological mechanism of nationalization.

This institutional arrangement distinguishes Chile from most ASM-Producing countries, where state involvement is often limited or fragmented. ENAMI purchases ASM output, processes it through concentrating plants and smelting facilities, and reintroduces surplus production into national and international markets. The agency also promotes training, access to equipment, and gradual improvements in reporting and environmental practices, forming a structured–though partial–platform for ASM development.

Despite this structured framework, there is evidence that ENAMI's impact falls short of its ambition in promoting broad-based ASM participation. For example, ENAMI currently reaches only a subset of Chile's ASM activity. Of nearly 2,600 active ASM operations nationwide, roughly 1,500 are formally registered with Chile's National Service of Geology and Mining (Sernageomin), and only about 600 have delivered material to ENAMI since 2016.[4] This partial uptake has important implications both for sector performance and for the interpretation of available data, as a substantial share of ASM production remains outside systematic reporting and commercialization channels.

ASM is traditionally characterized by limitations in data availability, coverage, and reliability. Chile is no exception, despite having such formalizing institutions. The economic analysis in this paper relies on publicly available information from

[4] R. Varas. SONAMI. (2023) "Caracterizacion de la Pequena mineria".

Sernageomin, the National Institute of Statistics (INE), and macroeconomic indicators to derive estimates of production, employment, and GDP contribution.

This paper finds quantitative evidence of only modest aggregate economic impacts associated with ASM copper mining in Chile. However, a central contribution of this paper is to open discussion on how this assessment should be interpreted, as well as prospects for ASM in Chile overall. These statistical relationships should not be taken as evidence of limited economic relevance. Rather, they reflect scale effects, structural invisibility within regional aggregates, and incomplete observability resulting from uneven participation. Four key observations emerge from the analysis:

First, market signals suggest sustained belief in the Chilean ASM model, partly reflecting investor interest in developing alternative supply chains beyond China.

Second, weak aggregate relationships between ASM activity and regional economic indicators reflect measurement and scale constraints rather than institutional ineffectiveness; ASM activity is locally meaningful yet largely diluted within regional aggregates.

Third, while Chile's institutional architecture for ASM — particularly through ENAMI — is comparatively sophisticated, its effective reach remains uneven, creating a persistent gap between institutional design and realized economic integration.

Fourth, there is scope to explore alternative approaches to support the ASM development in Chile through existing and complementary channels, drawing on Global South experiences and leveraging existing resources in more innovative ways. One example is the role of medium-scale mining partnership and other complementary channels, which could expand market access for ASM producers by offering additional formal pathways, greater buyer diversification, more traceable supply chains, and strengthened accountability. Realizing these benefits would require transparent reporting, standardized documentation, and deeper integration into formal monitoring systems. Another avenue involves diversifying the funding mechanisms through targeted microcredit schemes that prioritize sector-specific needs over a longer-term horizon, or by adopting alternative economic evaluation frameworks for financing ASM projects– approaches that

could enhance both project viability and sustained participation in formal channels. Evidence from the literature suggests that such approaches can better align with the cyclical and uncertain nature of ASM activity, supporting more resilient production and investments outcomes.

Thus, structural challenges tied to formalization and empirical limitations in measuring impact fundamentally affect what can be concluded about ASM's economic contribution. Available proxies capture formal presence rather than productive intensity, operational continuity, or informal output.

Overall, this paper positions Chile's ASM framework as a structured and evolving, yet partially constrained model, serving as a concrete example of how an institutional framework can support ASM within a national context. Its economic outcomes cannot be fully assessed without addressing participation and data limitations. By consolidating existing evidence and clarifying institutional dynamics, the analysis seeks to support more informed policy discussions on ASM — without prescribing specific reforms — by emphasizing the importance of context, institutional structure, and data quality in evaluating sector performance. The Chilean case illustrates that while state-backed mechanisms such as ENAMI provide tools for aggregation, market access, and formalization, their effectiveness depends on historical, geological, and sectoral conditions–such as participation density and institutional coordination–highlighting the need to adapt institutional models when applying them to other national contexts.

This context-dependent nature also underscores that institutional experience in one sector may not automatically transfer to others. While outside the scope of this analysis, an illustrative case is ENAMI's recent strategic expansion toward lithium, which may pose challenges to its effectiveness. While its experience working with communities may be valuable, differences in scale, technology, and market structure suggest that lithium may not align naturally with ASM-oriented institutional mechanisms, raising questions about mandate coherence rather than sectoral potential.

EXISTING RESEARCH ON ASM IN CHILE

There is a body of research published to date on ASM and the impact of ENAMI. This has focused primarily on analyzing ENAMI's role and business model such as Meller and Meller, (2021) report, developed for the United Nations Economic

Commission for Latin America and the Caribbean (UNECLAC), or on identifying the differences between legalization and formalization and ENAMI's role in those processes e.g. Atienza, Scholvin, Irarrazabal, and Arias-Loyola, (2023). The most recent study developed by CESCO in 2024 describes the history of ASM promotion and also examines ENAMI's promotional role and model.

All these studies are developed with a sociological perspective and rely on qualitative analysis of the institutional and legal framework for ASM in Chile, as well as the cultural mining tradition and development. Environmental analysis also exists such as Castro and Sanchez, (2002). However, there are not recent studies focused specifically to the impact of the ASM sector in Chile. Economic research within the previously mentioned studies includes analysis of ASM's impact on employment and its seasonal evolution, recognizing that the sector is highly influenced by metal price volatility and alternative employment opportunities in the agricultural sector, among others.

We identified studies that characterize ASM and describe its social impact through quantitative analyses based on surveys conducted with small samples of miners, organizations, and government entities. Another assessment was developed by Rivera, N., & Aroca, P. (2014), who analyze the local impact on income and production across different scales of mining activity. However, we observe a lack of quantitative studies that apply an econometric or statistical approach to assess the economic impact of ASM.

In other words, our literature review identifies a recurring issue that hinders a better assessment of the ASM reality: the lack of quantitative approaches. This is well understood — many documents and strategies highlight the need for deeper characterization and more comprehensive quantitative data to revisit current definitions and support the development of new policies.

BACKGROUND

CHILE'S COPPER MINING INDUSTRY

Copper is a fundamental commodity for the Chilean economy. In 2024, national mine production reached 5.506 million tonnes of contained copper, positioning Chile as the world's leading producer, with a 24.3% share of global output.

During the same year, the value of copper mining exports totaled US$49,534.2 million (FOB), accounting for 49.5% of the value of the country's total exports and 81.8% of total mining exports. The main export destinations were Spain and France in Europe, the United States and Brazil in the Americas, and China and Japan in Asia.

The mining sector contributed 7.2% to Chile's GDP in 2024, while copper mining alone represented 5.8% of GDP. These figures underscore the continued structural importance of copper production to Chile's economic performance and export base.[5]

This economic relevance is also reflected in its contribution to employment. The total direct workforce in the exploitation of mines and quarries currently stands at 302,989 workers, representing 3.24% of the country's total employment.[6] Furthermore, it is estimated that for each direct job in mining, two indirect jobs are created, highlighting the sector's extended impact on national labor markets and regional development.[7]

ASM SECTOR

Production

ASM constitutes a relevant component of Chile's extractive landscape, contributing to production, employment, and local economic activity in several regions. In 2024, ASM accounted for 54,950 tonnes of contained copper, representing approximately 1% of the country's total copper production. In comparison, ASM represented 4.2% of total gold production and 0.7% of silver production.[8] It's worth mentioning that gold and silver are generally obtained as a by-product in large scale mining in Chile and the contribution of ASM comes from both co-production of the copper mined and primary production of registered ASM gold claims.

[5] COCHILCO (2025). 2005-2024 Yearbook: Copper and Other Mineral Statistics from the Chilean Copper Commission (Cochilco)
[6] National Survey of Employment, INE Chile. June-August 2025.
[7] COCHILCO (2024) "Monitoring of variables and relevant indicators of medium and small-scale Chilean mining"
[8] SERNAGEOMIN (2024). Mining Yearbook of Chile 2024 published by SERNAGEOMIN

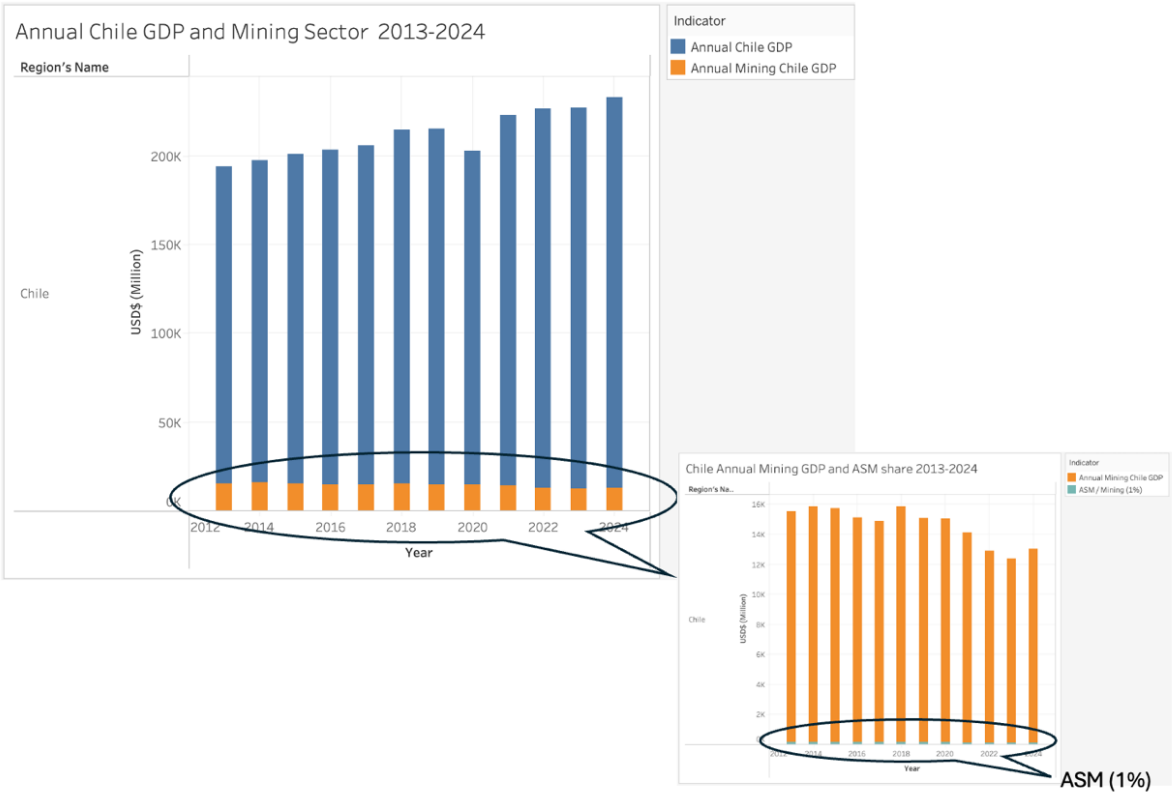

Figure 1: Chile's ASM contribution to GDP. Source: Payne Institute for Public Policy

It is worth noting that, in the aggregate, ASM is an important global provider of copper, given Chile's leading market share. On its own, ASM production could be the 28th largest producer globally, based on a comparison across 54 countries and a total global production of around 21 million tonnes in 2021[9]. Although this may appear modest at first glance, in international terms the Chilean ASM sector–with annual production of 54,950 tonnes of contained copper–could compete with or even surpass the total copper output of countries such as the Philippines, Portugal, South Africa, India, among others. (See complete ranking in Table 1 – Appendix III)

[9] The Global Economy (2021). Copper production – Country rankings

Global rank	Countries	Copper production, 2021 (FMT)
1	Chile	5,624,900
2	Peru	2,299,277
3	China	1,910,000
4	DR Congo	1,740,000
5	USA	1,230,000
6	Russia	941,000
7	Zambia	841,500
8	Australia	813,000
9	Mexico	734,100
10	Indonesia	731,045
…		
22	Turkey	108,000
23	Saudi Arabia	97,527
24	Sweden	88,000
25	Armenia	81,700
26	Bulgaria	70,000
27	Papua N.G.	66,500
28	**ASM CHILE**	**54,950**
29	Philippines	51,586
30	Laos	51,147
31	Portugal	37,900
32	Burma	33,900
33	Vietnam	33,600
34	Finland	32,384
35	South Africa	28,300
36	Morocco	28,000
37	India	26,300
…		

Table 1: Abstract – Copper Production & Country Rankings – The Global Economy. Source: https://www.theglobaleconomy.com/rankings/copper_production/

Employment

In Chile, ASM is subject to varying definitions across institutions and governmental entities, a distinction that will be examined later in the paper. In this section, estimates of ASM workforce distribution are based on Sernageomin's

classification—which defines small-scale mining as operations employing up to 80 workers—and data from the Chilean National Institute of Statistics (INE). For the June–August 2025 period, the employment survey reported 17,011 workers in companies with 11 to 49 employees (which may be considered small-scale mining) and 6,853 workers in companies with up to 10 employees (which could be classified as artisanal mining). It is worth noting that summing the two categories understates small scale mining participation, because the data doesn't include the category for companies with 50 to 80 employees; rather, the next category covers 50 to 199 employees, which exceeds the definition and so no workers from this category are included in the estimate.

Applying the same ratio used previously to estimate indirect employment derived from mining (1:2), ASM generated an estimated total of 71,592 jobs during the same period. The regional breakdown indicates that ASM employment is most significant in the Tarapacá, Antofagasta, Atacama, and Coquimbo regions, each exceeding 2% of total employment, while Arica y Parinacota and O'Higgins show lower but still notable shares, each above 1%. Employment Distribution (see Table 2).

Region	Total Occupied	Direct in Mining*	Direct in ASM	D+I in ASM**	D+I in ASM /Total in region
Arica y Parinacota	117,901	8,226	648	1,944	1.65%
Tarapaca	189,050	17,444	1,374	4,122	2.18%
Antofagasta	362,501	69,843	5,501	16,503	4.55%
Atacama	151,138	27,641	2,177	6,531	4.32%
Coquimbo	399,470	48,452	3,816	11,449	2.87%
Valparaiso	910,525	32,631	2,570	7,710	0.85%
Libertador General Bernardo OHiggins	451,460	23,354	1,839	5,518	1.22%
Maule	509,526	7,661	603	1,810	0.36%
Nuble	217,760	3,023	238	714	0.33%
BioBio	708,882	18,689	1,472	4,416	0.62%
La Araucania	432,279	1,739	137	411	0.10%
Los Rios	182,595	646	51	153	0.08%
Los Lagos	395,498	406	32	96	0.02%
Aysen del General Carlos Ibanez del Campo	58,433	391	31	92	0.16%
Magallanes y Antartica Chilena	98,220	2,334	184	551	0.56%
Metropolitana	4,169,858	40,509	3,191	9,572	0.23%
TOTAL	**9,355,096**	**302,989**	**23,864**	**71,592**	**0.77%**

Table 2: * Exploitation of mines and quarries **D+I = Direct and Indirect Employment. Source: National Employment Survey Jun-Aug 2025, National Institute of Statistics, Chile

While artisanal and small-scale mining accounts for a limited share of direct employment and output within the mining sector, as shown in the preceding charts, it is frequently associated with broader socio-economic relevance at the regional level. This association is typically grounded in the sector's presumed role in sustaining local employment and stimulating demand for regional services, inputs, and ancillary economic activities. However, empirical evidence quantifying these effects remains scarce. Worldwide there is a common concept called "the multiplier effect" which aims to illustrate ASM's role in rural development, but as discussed and acknowledged in the World Bank's "State of the Artisanal and Small-scale Mining sector" report of 2019, the concept hasn't evolved properly and its based mostly in a 1982 study focused on a U.S case, which makes it difficult to apply to the different realities around the world.[10] Moreover, in Chilean regions where ASM and large-scale mining coexist, observed local economic outcomes often reflect the combined influence of both sectors, making it difficult to isolate the specific

[10] DELVE (2019). State of the Artisanal and Small-Scale Mining Sector.

contribution attributable to ASM. As a result, assessments of ASM's regional impact tend to rely on qualitative insights and contextual interpretation rather than on robust, sector-specific measurement.

LEGAL AND INSTITUTIONAL FRAMEWORK FOR ASM

Large-scale and ASM in Chile are governed under a unified legal structure —the Mining Code of 1983. This code, together with the Chilean Constitution and the Organic Constitutional Law on Mining Concessions, forms the core of Chile's mining legal framework, allowing both private individuals and corporate entities to hold mining concessions regardless of scale.

In addition to the Mining Code, several other laws provide more specific governance tools for the mining sector. The Mining Safety Regulation sets out safety protocols and outlines procedures for addressing mining-related incidents. The General Environmental Framework Law mandates environmental compliance for all mining operations, while Law No. 20.551 and its related regulations define the requirements for mine closure and outline the procedural steps operators must follow when terminating mining activities.

From an institutional perspective, the Ministry of Mining serves as the principal authority in regulating and guiding ASM development, including that it is responsible for setting up public policy and ensuring its implementation across the sector. The Empresa Nacional de Minería (ENAMI) is the key institution dedicated to supporting ASM day-to-day operations. It plays a central role in promoting the ASM sector through assistance in production, processing, commercialization, and access to financing—aiming to enhance the competitiveness, formality, and sustainability of small-scale miners.

Although ENAMI has recently assumed additional responsibilities under Chile's lithium national strategy and entered a major partnership for the Salares Altoandinos lithium project, its institutional identity and operational design remain primarily oriented toward the development and support of ASM. It also functions as a primary channel for the distribution and execution of public policies targeted at small-scale mining. Publicly available strategy documents and company statements do not yet specify how ENAMI's ASM focus will be maintained, adapted, or affected

by its lithium activities, leaving open questions about how these dual roles will be balanced as the lithium venture moves toward production.

The National Service of Geology and Mining (Sernageomin) is responsible for technical oversight, safety regulation, geological mapping, and providing technical assistance to mining operators. Together, these institutions create a governance framework for ASM in Chile (see Figure 2).

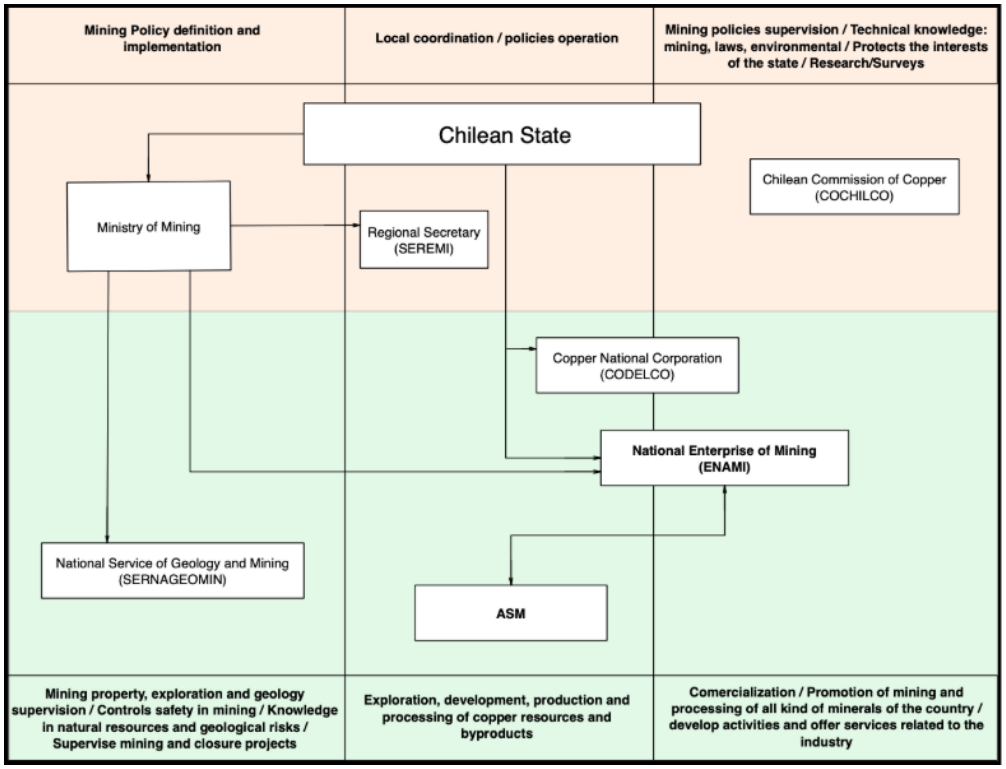

Figure 2.: Chile's Institutional framework for ASM. Source: Payne Institute for Public Policy.

There are eight different technical definitions[11] that categorize mining operations as large, medium, or small scale. These classifications come from both governmental and non-governmental organizations, as well as from various mining-related laws. Within the small-scale category, the artisanal sector is mentioned in only two definitions: one from Sernageomin regarding mining safety regulations, and the other from the Internal Tax Service (SII) (see Table 3).

[11] CESCO (2024). "The importance of Enami for Small and Medium scale mining in Chile" (Table 1), CESCO June 2024

		Regulatory institution or instrument						
Sector	Variable	Sernageomin		Mining code (Law 18,248)	ENAMI	Royalty (Law 20,469)	Taxes (Internal tax services)	SEIA* (Dto.40)
		Mining safety regulations (DS 132)	Mine closure (Law 20,551)					
Small scale	Number of workers	12 to 80 (<12 artisanal)		<12			< 5 (artisanal)	
	Hours worked	27,000 to 200,000 (<27,000 artisanal)						
	Production		<10 kton/month (extraction)		<10 kdmt/month (sales/processing) metal content	< 12 kton/year copper content		< 5 kton/month (extraction)

Table 3: Small Scale and Artisanal Mining definitions. Source: "The importance of Enami for Small and Medium scale mining in Chile", CESCO June 2024 *SEIA = Environmental Impact Assessment System

ENAMI AND ASM PROMOTION IN CHILE

Building on the institutional framework described above, ASM promotion in Chile relies on the complementary roles of ENAMI and Sernageomin. While ENAMI facilitates economic integration through access to processing and commercialization, Sernageomin's regulatory and technical instruments enable miners to operate within formal safety and operational standards. This coordination is reinforced by Law No. 19,719 (see Appendix II), implemented by Sernageomin, which introduces reduced licensing fees and flexible payment conditions for small-scale mining concession, lowering barriers to formalization. Together, these mechanisms support the gradual incorporation of ASM actors into the formal mining system.

BACKGROUND AND MISSION

Formal support for ASM in Chile began in the early 20th century to counter foreign mining dominance. The state created the Mining Credit Bank (CACREMI) in 1926 to finance and support small miners, later merging it with the National Smelters Company in 1960 to form the "Empresa Nacional de Minería" (The National Mining Company), better recognized by its acronym ENAMI.

ENAMI's main role is to provide technical assistance, financial services, and commercial support to miners who often lack the resources to operate independently in the market. Its model supports the entire ASM cycle, beginning with the promotion of formalization—one of the basic requirements for accessing

its benefits, loans, and various programs—and continuing through to the sale or export of different types of mineral products.

ENAMI operates several processing plants and smelters that enable small-scale producers to process their minerals efficiently and under competitive conditions. These processing plants were largely built between 1929 and 1965.[12]

Rather than charging ASM miners an upfront processing fee, ENAMI purchases ore or concentrates under a custom processing scheme, deducting treatment, refining, and related service costs from the value of the contained metal prior to payment. This arrangement is particularly important given the capital-intensive nature of mining activities. While large-scale (LSM) operations can spread these costs over high production volumes, most ASM miners face cost structures heavily concentrated in extraction activities, royalties, transportation, and toll milling services[13], leaving limited or no financial margins for investment in technology or process improvements. One key observation is that, due to limited lifespan of exploitable reserves, most capital expenditures in ASM are expensed rather than capitalized, effectively "inflating" operating costs and constraining financial flexibility even further. ASM is generally less capital-intensive than LSM but remains capital constrained. While ASM operations rely more heavily on labor and low-cost equipment, limited access to finance and thin margins restrict investment in productivity-enhancing technologies and process improvements.

Within this cost-constrained context, ENAMI's processing relationship provides ASM miners with access to standardized, sector-specific processing terms and pricing formulas linked to international market references, under a formal institutional framework. This reduces their reliance on distant private facilities—often associated with higher transport and service costs–or on informal and illegal processing operations that pose significant safety, environmental, and regulatory risks. In this sense, ENAMI's processing role functions not only as an economic support mechanism, but also a key instrument for risk reduction, operational continuity, and gradual formalization within the ASM sector.

When ASM miners do not sell their production to ENAMI, their formal alternatives appear to be limited and often less favorable. Some may access private buyers[14],

[12] CESCO (2024). "The importance of Enami for Small and Medium scale mining in Chile" (Table 1), CESCO June 2024
[13] R. Varas. SONAMI. (2023) "Caracterizacion de la Pequena mineria".
[14] Mineria Chilena (2015). "Pequenos mineros podran vender su mineral de cobre a San Geronimo".

commodity traders, toll processing facilities or medium-scale miners; however, these options typically require consistent volumes, stable grades, and higher compliance costs, criteria that exclude most artisanal producers. At the same time, ENAMI also sets requirements for ore purchase: as noted in (Seccatore, 2025)[15], it applies a cut-off grade, with each plant determining its own threshold. While this ensures certain quality standards, it can leave many ASM actors with no option but sell to third parties. In this context, an example from Chile's II region shows that two private companies accept low-grade ore below Enami's cut-off and assume responsibility for it transport. Although ENAMI does not formally facilitate these transactions, its purchase thresholds create a market gap that a few private buyers step in to fill, effectively encouraging such sales indirectly. This arrangement becomes a potentially valuable but limited alternative for ASM miners. However, there is no system in place to ensure that these transactions are fair in terms of pricing or that the reported grades are accurate. This raises the question of whether public mining governance, or ENAMI itself, should play a more active role in overseeing such transactions. In many cases, the absence of ENAMI as a buyer of last resort leads miners to suspend or intermittently operate their activities. Other miners may turn to informal or unregulated channels, which increase safety, environmental and fiscal risks. This highlights ENAMI's role not only as a processing and commercialization agent, but also as a critical stabilizing mechanism that helps secure fair and accessible transactions, reduces informality and sustain ASM livelihoods. Yet ENAMI currently interacts with less than 25% of the identified ASM sector, prompting a broader discussion about how ENAMI could be more involved in ensuring equitable access to formal markets and supporting miners who fall outside current thresholds. This implications of ENAMI's role and the challenges faced by ASM miners will be developed further in the discussion section.

Another role of ENAMI is to promote environmental sustainability by offering training programs and implementing social initiatives that improve working conditions and foster community development. One of the main drivers of its environmental commitment is the modernization project of the Hernán Videla Lira smelter, which recently received environmental approval to move forward with a USD 1.7 billion investment in the new facility. The project is expected to bring notable improvements in emissions control, mainly through much higher capture of sulfur and other pollutants compared to the current facility, aiming to capture

[15] Seccatore, J. (2025).

more than 99% of atmospheric emissions, that is even higher than the Chilean environmental regulation (supreme decree 28) that requires to capture at least 95% of emissions.

IMPACT

The creation of ENAMI appears to have been very successful over its existence, with production in ASM and medium-scale mining sectors rising from <50,000 tonnes in 1960 to >400,000 tonnes in 2012. The record over the last decade is less clear, as production was cut in half in 2016[16], following a decrease in copper prices that forced a notable number of operations to close.[17] ENAMI responded through its price support mechanisms, including sustained purchases and support funds aimed at keeping these operations solvent during the downturn.

Despite modest price recovery in 2017-2018, the number of small producers remained below 2016 levels, leaving production levels relatively stagnant thereafter. This illustrates that temporary price improvements were not sufficient to fully reactivate all deferred ASM operations. These dynamics suggest that ASM in Chile adjusted to the post-2016 price shock not by rapid expansion, but by relying on institutional price support and enduring a slow, uneven recovery in activity and deliveries, reflecting both vulnerability to international price swings and the limits of formalization in fully mitigating those effects.[18]

Beyond the recent production figures, there is other evidence that ENAMI's impact does not meet its ambition. As a first indication, participation rates in the so-called formal sector and specifically with ENAMI appear to be well below potential. According to an evaluation of public programs in 2025 conducted by the Chilean Ministry of Finance, there are 3,655 mining operations classified in small-scale and artisanal mining. Of these, 2,587 are currently active, while 1,079 of active operations –approximately 42 percent– are operating informally. Informal operations in this case are defined as those lacking approved exploitation methodologies, closure plans, or formal company registration.[19] Of active mining

[16] CESCO (2024). "The importance of Enami for Small and Medium scale mining in Chile" (Table 1), CESCO June 2024
[17] Nueva Mineria y Energia Magazine (2016). "Crisis del cobre lleva a 203 mineros a cerrar y pone en Riesgo a otros 200 productores".
[18] Mineria Chilena (2017) "Cantidad de pequenos mineros prooductores de cobre cae 10% pese a major precio del metal".
[19] DIPRES (2025) Programa en reformulacion 2025: PAMMA

operations, a relatively small proportion has recently engaged with ENAMI or are engaging with the government to formalize their operations. In 2010, the number of active operations selling material to ENAMI was approximately 1,500. This figure declined steadily following the downturn in copper prices, reaching roughly 770 active operations by 2015. Since 2016, it has remained steady at approximately 600 despite copper price recovery.

Separately, between 120 and 160 operations per year have been registered under Law 19,719, which provides discounted fees and payment flexibility for ASM mining licenses. (for more details on the Law, see Appendix II), i.e., only a small portion of all ASM activity.

For the period 2011-2023, miners benefiting from discounted license fees were geographically concentrated in six regions: Atacama, Coquimbo, Valparaíso, the Metropolitan Region, and O'Higgins. Among these, the Coquimbo region recorded the highest average number of beneficiaries in this period (88), followed by Valparaiso (40) and Atacama (31)[20]. This regional concentration highlights both the territorial relevance of ASM activity and the possible uneven penetration of existing formalization instruments.

The law itself does not establish a "quota" or any other constraint from Sernageomin for accessing the benefit; instead, eligibility is defined by characteristics of the concession (size, use, and type) and requires completion of a formal application to Sernageomin. Experts have identified several factors that may influence the uptake of this policy, including the size criteria, the type of legal entity or company (e.g. Cooperatives, LLC), and the degree to which the law, enacted in 2001, aligns with the current realities of ASM operations.[21]

A second indication relates to ENAMI's institutional capacity to execute its mandate, as reflected in its ability to absorb and deploy allocated resources across its programs. This is reflected in the pattern of spending on direct mining-related services in 2024 (see Table 3). Most of the initiatives underutilized their allocated budgets, and some initiatives–such as competitive capabilities development or production support– report no spending or budget at all. This suggests a gap in the

[20] SERNAGEOMIN. Mining Yearbook of Chile.
[21] Reporte Minero y Energetico (2025). "Propuestas de modificaciones legales en beneficio de la Pequena Mineria y Mineria Artesanal (PAMMA)".

implementation of ENAMI's main promotion plan pillars and raises questions about the effectiveness of instruments beyond their formal design. In other words, limited budget execution may signal not only constrained demand from ASM miners, but also administrative, operational, or financial bottlenecks that reduce ENAMI's practical reach. However, this scenario was different for 2025 results[22]. The company in its FY25 spending plan raised its budget for ASM promotion, for the first time since 2003, by 25%, to US$10 million. This increase, accompanied by stronger fiscal backing, may have enhanced ENAMI's ability to execute programs more fully, suggesting that institutional capacity–rather than solely sectoral conditions–plays a meaningful role in shaping outcomes.

Direct Promotion instrument	Policy - Initiative	2024 Results (US$)	2024 Budget (US$)	Budget Performance indicator (%)
Technical assistance	Advisory Service	4,975,983	6,173,053	80.6
Resources and Reserves Identification and Mine planning	Funding	2,589,465	4,523,174	57.2
District Geology	Funding	351,424	715,500	49.1
Competitive capabilities development	Advisory Service + Funding	-	-	-
Safe production support (Safety)	Advisory Service + Funding	115,800	121,56	95.2
Production Support	Funding	-	-	-
Mining operations reactivation	Funding	231,700	245,700	94.3

Table 4: ENAMI's Promotion Instruments 2024. Source: ENAMI. Available at: https://www.enami.cl/Fomento/Pages/Instrumento-de-Fomento.aspx

Finally, a third indication emerges from the government's own performance evaluation of ENAMI's promotion programs, which provide a more direct institutional assessment of impact. A database managed by the National Budget Directorate (Direccion de Presupuestos, DIPRES)[23] of ASM promotion programs and ENAMI dates back to 2022. In the most recent assessment, all evaluated programs were rated as having low or poor performance. The database also includes evidence of a follow-up process in which ENAMI addresses the recommendations made in preceding reports. While the existence of this monitoring framework reflects institutional oversight and accountability, the uniformly low performance ratings reinforce the concern that ENAMI's outcomes have not consistently aligned with its stated objectives.

[22] ENAMI. Cumplimiento ley de Presupuesto.
[23] DIPRES. Informes de Evaluaciones.

The gaps generated by the low performance raise questions about the effectiveness of the instruments, most of which are supported by public funding. In this context, the design and targeting of these funding mechanisms–and the potential for alternative approaches that better align with ASM realities–will be explored in greater detail in the Discussion section.

Separately, studies report that even after recognition by Sernageomin and ENAMI, some miners report gaps in accounting management, which can affect tax compliance, normally considered part of operating as a formal business. Other producers indicate that they are not registered with Sernageomin or Enami (10% to 15% of 297 producers surveyed)[24], suggesting that a portion of ASM miners may require better guidance and support from the governance framework even during earlier stages of formalization. In the same survey, 18% of respondents reported that they did not apply for the benefits program because they did not know how to do so, 10% stated that the application process was difficult, and nearly 5% said that the process lacked clarity.

CAPACITY AND OUTLOOK

Chile's current ASM promotion policy continues ENAMI's legacy of supporting small miners while adapting the narrative to modern challenges such as environmental sustainability, market competitiveness, and technological innovation. The strategy and ASM promotion policy recently launched by the Ministry of Mining for the period 2025-2034[25] addresses economic, environmental, and social challenges within the formalized sector.

The Ministry's strategy links formalization with downstream industrialization and sustainability initiatives. Within this framework, Chile is modernizing its domestic copper processing infrastructure to increase domestic value addition and processing capacity. A specific example is the US$1.7 billion modernization of the smelter Hernan Videla Lira in Paipote, which has received environmental approval. The project is designed to process up to 850,000 metric tons of copper concentrate per year and includes an electrolytic refinery with a production capacity of 240,000 tons of copper cathodes[26].

[24] NOUS - Regional characterization study of ASM, 2017
[25] Ministerio de Mineria. Politica de Fomento a la Pequena Mineria.
[26] Mining.com. (2025). "Chile's ENAMI wins environmental permit for new $1.7B copper smelter".

The ASM strategy also incorporates complementary initiatives addressing environmental management and regional development. One such project is the development of green cement from copper slag tailings[27], which aims to create synergies with the construction industry and generate potential economic impacts at the regional level through environmental improvements and employment creation.

The operationalization of these infrastructure and complementary initiatives is supported by ENAMI's recent financial developments. After nearly a decade of losing money, Enami recorded an operating profit in 2024[28], and a net profit in 2025[29]. In May 2025, the national budget included a direct capital infusion of US$25 million[30] from the government to modernize ENAMI's operations. In July 2025, ENAMI announced a debt restructuring plan, including its first bond issuance without a state guarantee for over US$ 40 million, which attracted investor interest. [31] And in mid-September 2025, ENAMI reported receiving strong interest from major miners and traders to finance its smelter modernization.[32]

The infrastructure development targeted toward ASM, particularly the expansion of smelting capacity, is highly significant. Further, ENAMI's ongoing efforts to modernize and expand its smelting capacity[33] — potentially adding approximately 500 thousand tonnes, or more than double its current copper concentrate processing capacity — are a strategic milestone. This investment may improve market access for ASM producers while also enhancing traceability and data collection for the sector. By increasing processing capabilities, ENAMI not only enables small-scale miners to access higher-value markets but also ensures quality control and supply reliability for domestic and international buyers. The projected production capacity from ENAMI's smelter might push the Chilean ASM sector into the top 20-25 producers globally, demonstrating its potential to influence global copper markets. This further underscore a structural gap in ENAMI's current reporting: many ASM actors, particularly those operating informally or in smaller

[27] S&P Global (2025). ENAMI develops green cements from copper slag tailings in Chile".
[28] BNAMERICAS (2025). "Chile's Enami stabilizes finances, paving the way for US$1.5bn Altoandinos lithium project".
[29] ENAMI (2026) "ENAMI Cierra en forma inedita con utilidades por Segundo ano".
[30] Reporte Minero y Energetico (2025). "ENAMI recibe US$25 millones para modernizer plantas y fortalecer la pequena mineria".
[31] ENAMI (2025). "ENAMI logra reestructurar deuda con historica primera. Colocacion de bonos por 1 millon de UF a 5 anos".
[32] REUTERS (2025). "Chile's ENAMI attracts interest from miners, traders for smelter financing".
[33] ENAMI (2025). "ENAMI recibe aprobacion Ambiental para nueva fundicion de cobre en Paipote".

operations, are not fully captured in production statistics, which underrepresents the sector's true economic and strategic contribution.

ECONOMIC/ECONOMETRIC ANALYSIS

The core challenge in evaluating these programs lies in the absence of fundamental data: the number of mine sites, the number of operating licenses, and production metrics within the ASM sector. This is not a new issue for researchers. In fact, the lack of reliable baseline data is a recurring problem noted across multiple studies on the ASM industry.

Therefore, to assess the economic impact of ASM on the Chilean economy, we propose an econometric approach using the best available data. This methodology could be further improved as better data becomes available in the future.

DATA

Since the most detailed and reliable information obtained in this study relates to the mining licenses that received discounted fee benefits, the analysis focuses on concessions as the primary proxy for ASM activity. Given that ASM's economic footprint is expected to be predominantly local–especially regarding employment, income, and basic consumption–concession activity was aggregated at the regional level. Although this proxy does not perfectly mirror ENAMI's registry of active producers, it offers a consistent and geographically comparable measure of ASM intensity across Chile. This regional-level approach enables the assessment of potential economic relationships in areas where ASM is most likely to generate economic spillovers.

The data were gathered from the SERNAGEOMIN's *Yearbook of Chilean Mining*[34] *("Anuario de la Mineria de Chile")* and cover the period 2011-2023 for the concessions. This information differs slightly from the figures SERNAGEOMIN publishes on its website regarding the total number of miners awarded the benefits of law 19,719, the Special Mining License for Small-Scale and Artisanal Mining[35] (*"Patente Minera Especial para Pequeños Mineros y Mineros Artesanales"*), even though both sources originate from the same institution.

[34] SERNAGEOMIN. Mining Yearbook of Chile.
[35] SERNAGEOMIN. Law 19,719.

The remaining data and sources are summarized in the table below:

Variable	Document/Database	Source	Period	Units
Number of Concessions	Yearbook of Chilean Mining	SERNAGEOMIN	2011-2023	Concessions
Concession area (hectares)	Yearbook of Chilean Mining	SERNAGEOMIN	2011-2023	Hectares
Regional annual GDP[36]	Chained volume series, 2018 reference year	Central Bank of Chile	2013-2023	Billions of CLP
Regional Average Income[37]	Supplementary Income Survey (ESI)	National Institute oof Statistics	2011-2021	Pesos (CLP)
Regional Household (HHD) consumption[38]	Chained volume series, 2018 reference year	Central Bank of Chile	2013-2023	Billions of CLP

METHODOLOGY

This study examines whether ASM is linked to regional economic outcomes in Chile. Rather than comparing regions at a single point in time, the analysis focuses on changes within each region over time, which allows us to see how increases or decreases in ASM activity affect local economies.

ASM activity is captured using two indicators derived from mining concessions: i) The number of concessions, and ii) The total area under concession (hectares). These measures are then compared with key regional economic indicators, including GDP, Average Income, and Household Consumption.

Because Chile's regions differ in their economic structure, mining history, institutional capacity, and infrastructure, the analysis controls for these long-standing, time-variant regional characteristics by incorporating region fixed effects. This approach ensures that identification comes from within-region variation over time, holding constant persistent regional factors such as mineral endowments, historical mining specialization, baseline income levels and institutional capacity that may influence both ASM concession activity and economic outcomes.

[36] Central Bank of Chile. Statistical data base. Regional annual GDP.
[37] National Institute of Statistics. Supplementary Income Survey
[38] Central Bank of Chile. Statistical data base. Regional Household consumption.

In addition, national economic trends–such as commodity price cycles, inflation, or macroeconomic policy changes that affect all regions simultaneously– are accounted for through the inclusion of year fixed effects. Together, the region and the year fixed effects form standard two-way fixed effects panel specification.

Multiple model specifications are estimated for each outcome variable, using both level and logarithmic transformations, to capture proportional changes and make the relationships easier to interpret.

Statistical methods accounted for both persistent regional factors and national-level trends, with standard errors adjusted for correlation within regions over time.

This approach allows us to identify whether increases in ASM activity–through more concessions or larger concession areas–are associated with changes in regional GDP, income, and household consumption.

MODEL SPECIFICATIONS

1. Level-Level model

Both the outcome and ASM activity are expressed in their original units (levels), meaning they are not transformed into percentages or logarithms. Coefficients represent the direct (marginal) effect of one additional concession or hectare on the economic outcome:

$$\boldsymbol{Y_{r,t} = \alpha + \beta(ASM_{r,t}) + \gamma_r + \delta_t + \varepsilon_{r,t}}$$

With:

- $Y_{r,t}$ = Economic outcome in region r at year t (e.g. GDP, income, or consumption)
- $ASM_{r,t}$ = Measure of ASM activity (number of concessions or hectares) in region r at year t
- β = Coefficient – estimated effect of ASM activity on the outcome
- γ_r = Region fixed effect
- δ_t = Year fixed effect
- $\varepsilon_{r,t}$ = Error term

	GDP	Average Income	Consumption
Number of Concessions	3.012	404.243	8.155*
	(7.003)	(212.686)	(3.131)
Concession area (hectares)	-0.056	6.629*	0.072
	(0.155)	(2.686)	(0.102)
FE: region	Yes	Yes	Yes
FE: year	Yes	Yes	Yes

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Standard errors are in parenthesis

2. Log-Level model

The outcome variable is expressed in logarithmic form, while ASM activity remains in its original units (levels). Coefficients show proportional change in the economic outcome for a one-unit increase in ASM activity.

$$\boldsymbol{ln(Y_{r,t}) = \alpha + \beta(ASM_{r,t}) + \gamma_r + \delta_t + \varepsilon_{r,t}}$$

With:

- $ln(Y_{r,t})$ = Natural log of the economic outcome in region r at year t (e.g. GDP, income, or consumption)
- $ASM_{r,t}$ = Measure of ASM activity (number of concessions or hectares) in region r at year t
- β = Coefficient – proportional change of ASM activity on the outcome
- γ_r = Region fixed effect
- δ_t = Year fixed effect
- $\varepsilon_{r,t}$ = Error term

	Log GDP	Log Average Income	Log Consumption
Number of Concessions	0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)
Concession area (hectares)	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
FE: region	Yes	Yes	Yes
FE: year	Yes	Yes	Yes

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Standard errors are in parenthesis

3. Log-Log model (Elasticities)

Both the outcome and ASM activity are expressed in logarithmic form. Coefficients can be interpreted as elasticities, i.e the percentage change in the outcome associated with a 1% increase in ASM activity.

$$\boldsymbol{ln(Y_{r,t}) = \alpha + \beta ln(ASM_{r,t} + 1) + \gamma_r + \delta_t + \varepsilon_{r,t}}$$

With:

- $ln(Y_{r,t})$ = Natural log of the economic outcome in region r at year t (e.g. GDP, income, or consumption)
- $ln(ASM_{r,t} + 1)$ = Natural log of ASM measure (number of concessions or hectares) in region at year t
- β = Elasticity: percentage change in the outcome associated with a 1% increase in ASM activity
- γ_r = Region fixed effect
- δ_t = Year fixed effect
- $\varepsilon_{r,t}$ = Error term

	Log GDP	Log Average Income	Log Consumption
ln_concessions	0.010 (0.014)	0.030+ (0.015)	0.033* (0.013)
ln_hectares	0.003 (0.002)	0.004 (0.005)	0.009* (0.003)
FE: region	Yes	Yes	Yes
FE: year	Yes	Yes	Yes

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Standard errors are in parenthesis

RESULTS

The table below summarizes the estimated relationship between ASM activity and regional economic outcomes across the three model specifications (level-level, log-level, and log-log). All models include region and year fixed effects, and standard errors are clustered at the regional level.

Specification	ASM Measure	GDP	Average Income	Household Consumption
Level-Level	# of Concessions	Not Significant	Not Significant	Positive*
Level-Level	Concession Area (ha)	Not Significant	Positive*	Not Significant
Log-Level	# of Concessions	Not Significant	Not Significant	Not Significant
Log-Level	Concession Area (ha)	Not Significant	Not Significant	Not Significant
Log-Log	ln (# of Concessions)	Not Significant	Positive+	Positive*
Log-Log	ln (Concession Area)	Not Significant	Not Significant	Positive*

+ $p < 0.1$, * $p < 0.05$

Across all specifications, the results do not show a consistent relationship between ASM concession activity and regional GDP. Neither the number of concessions nor the total concession area is statistically significant in any model. Considering this, we fail to find statistical evidence that ASM activity increases GDP. Given the scale of regional GDP relative to artisanal mining operations, this result is not unexpected. Even if ASM generates meaningful income locally, its contribution may be too small relative to the total regional economy to shift GDP in a statistically detectable way.

In contrast, the results provide some evidence of a relationship between ASM activity and household-level economic indicators, particularly income and consumption. In the level-level specification, concession area is positively associated with average income, while the number of concessions is positively associated with household consumption. Although these effects are not large, they are statistically significant, suggesting that increases in ASM activity may translate into measurable gains at the household level.

The log-log models reinforce this interpretation. The elasticity estimates indicate that 1% increase in the number of concessions is associated with approximately a 0.03% increase in average income (marginally significant) and a 0.03% increase in household consumption (statistically significant). Similarly, a 1% increase in concession area is associated with a small but statistically significant increase in household consumption. These elasticities are modest in magnitude, but they point to a consistent pattern: ASM activity appears to be more closely linked to income and spending channels than to aggregate production.

By contrast, the log-level models do not produce statistically significant results. This lack of significance across all outcomes suggests that when modeling proportional changes in outcomes relative to unit increases in concessions or hectares, the effects are small and less precisely estimated. The divergence between log-log and

log-level results underscores that the detected relationships are modest and sensitive to functional form.

Taken together, the findings suggests that ASM's economic effects are likely concentrated at the household level rather than at the broader regional production level. The absence of a measurable GDP effect, combined with positive associations for income and consumption in some specifications, is consistent with economic mechanism in which ASM primarily supplements household earning and supports local spending, without substantially altering aggregate regional output.

At the same time, the magnitude of the estimated effects remains small. Even where statistically significant, the elasticities indicate that relatively large percentage increases in ASM activity would be required to generate noticeable changes in regional income or consumption. This suggests that while ASM may play an important role in livelihoods, its macro-regional economic footprint appears limited.

Finally, it is important to note that concession-based measures may not perfectly capture actual ASM production intensity. Some concessions may be inactive, underutilized, or intermittently operated. As a result, the estimated relationships may understate or blur the true economic contribution of active operations. More detailed data on production volumes, employment, and localized economic activity would allow for a more precise assessment of ASM's economic role.

OBSERVATIONS, DISCUSSION AND KEY FINDINGS

This paper provides an integrated assessment of Chile's artisanal and small-scale mining (ASM) sector by combining institutional analysis, descriptive evidence, and an econometric exercise explicitly designed to operate under severe data and measurement constraints. Four key interrelated observations emerge.

First, there are market signals suggesting belief in the ASM model and its growth potential. Admittedly, this is in part a function of investor interest in developing alternative supply chains to those that run through China. The government and investor support for ENAMI witnessed recently reflect endorsement of the credibility of ENAMI's operating model and the strategic importance to the government of supporting ASM supply chains. The aggregation of ASM production — channeled through ENAMI — has helped underpin the

volume stability, institutional credibility, and policy justification necessary to attract this investment. Although ASM does not generate investment flows directly, the sector has been instrumental in creating the operational context to attract foreign direct investment, building the base of suppliers for this new project.

The upgrade of Hernan Videla Lira smelter located in Paipote–which will more than double its concentrate processing capacity– is a strategic milestone, enhancing ENAMI's ability to absorb ASM output, modernizing technology that has been in place for over 60 years, with only incremental updates until the current major modernization project, and improving environmental performance, thereby strengthening ASM integration into formal supply chains and supporting sector growth. These outcomes illustrate that even small-scale mining can serve as a catalyst for investment, technology transfer, and broader economic development, although these indirect contributions are not easily attributable to the ASM sector alone.

Second, the absence of robust econometric evidence linking ASM activity to regional economic outcomes should be interpreted as a problem of measurement, scale, and participation rather than as a proof of limited economic relevance. Across multiple panel specifications, ASM activity–proxied by the number and area of discounted-fee concessions– does not exhibit a stable or statistically robust relationship with regional GDP, income, or consumption.

This result is consistent with several structural characteristics of the sector: ASM operates at a modest scale relative to regional economies, limiting its visibility in aggregate indicators; concession–based proxies provide an imperfect measure of economic activity, as they do not capture production intensity, operational continuity, or informal output; and many of ASM's economic effects materialize through localized, household-level, or informal channels that remain invisible in regional aggregates.

Moreover, only a subset of ASM operators engages consistently with ENAMI or appears in official datasets. As a result, both production volumes and associated economic contributions are likely understated in available data. Under these conditions, it is not possible to distinguish conclusively whether weak aggregate results reflect limited economic impact per se, inadequate institutional uptake, or simply the absence of sufficient granular and comprehensive information.

In this context, weak aggregate signals are more appropriately interpreted as a consequence of partial observability rather than as evidence of institutional ineffectiveness or lack of welfare effects associated with ASM activity.

Third, Chile's ASM framework is institutionally advanced yet structurally demanding for small operators, producing a disconnect between institutional sophistication and ability to participate fully. ENAMI is widely regarded as an international benchmark for ASM support, providing guaranteed market access, processing infrastructure, pricing linkage to international markets, and formalization pathways without displacing private ownership or market-based pricing mechanisms.

At the same time, evidence points to persistent participation gaps, uneven formalization uptake, and structural frictions in program execution that limit the translation of ENAMI's institutional model into sustained operational outcomes. While historical production gains and recent investments confirms the strategic relevance of the ASM model, operational realities–including inconsistent budget execution, limited regional uptake, and uneven access to technical and financial support– reveal that the main challenges lie not in the conceptual validity of the ASM framework but in the mechanisms through which it is implemented, monitored, and accessed. Strengthening these operational channels is therefore central to align institutional ambition with measurable sectoral impact.

In parallel, Chile's mining legal framework grants artisanal and small-scale miners the same concessionary rights as large operators, an uncommon feature globally. However, this formal equality masks a practical asymmetry. Regulatory and permitting requirements — designed to ensure environmental protection, worker safety, and technical rigor — impose disproportionately high relative costs on ASM producers, which typically lack the financial, technical, and organizational capacity of larger firms. This doesn't necessarily reflect institutional failure, but this tension does highlight how a scale-neutral regulatory design can translate into elevated legal, operational, and financial risks for ASM operators, reinforcing structural disadvantage within an otherwise inclusive system. These pressures also point to distinct financial and technical support needs for smaller miners to effectively meet regulatory obligations. Said differently, elements of the mining concession system can significantly increase costs, discourage production, and deter investment if designed for the mining sector as a whole rather than tailored to ASM conditions.[39]

[39] BNAMERICAS. "How small-scale mining can move forward amid a large-scale ecosystem in Chile".

The costs of formalization are made particularly challenging by the rising costs and declining profitability of ASM copper mining. While ENAMI's support mechanisms help mitigate price volatility and improve market access for ASM producers, the sector remains highly vulnerable to increases in operating costs, which include for inputs, transport, and regulatory compliance and are impacted by structural factors, such as aging mine sites, declining ore grades, rising exploration and exploitation mining concessions costs[40], and administrative permitting processes.[41] These structural pressures help explain why formalization in Chile often occurs unevenly rather than as a steady transition from informality to full compliance.

Adding to the challenge of ASM formalization is the complexity of what this means in the country. What is observed is a "spectrum of formalization", in which miners may meet some, but not all, of the requirements to be recognized as official ASM producers or formal consolidated small-scale enterprises. The problem begins with the plurality of definitions described in the Legal and Institutional Framework section; this reflects a lack of conceptual alignment across policy instruments rather than institutional weakness. Divergent classifications across institutions can generate uncertainty in the identification and targeting of artisanal and small producers, complicating regulatory oversight, the design and sequencing of formalization pathways, and the allocation of technical and financial support. As a result, this diversity of definitions may limit the effectiveness of otherwise robust institutional instruments, particularly in addressing the specific economic, safety, and productivity constraints faced by artisanal mining activities, including those associated with the development of critical mineral value chains, such as ESG-related initiatives.

Beyond administrative and informational barriers, one of the most binding structural constraints shaping this spectrum of formalization is the capital required to gain access to mining concessions. In many ASM-producing countries, operators commonly work under flexible rental or shared-access arrangements that lower upfront capital requirements, reduce administrative complexity, and allow production to begin with limited legal and financial barriers. In Chile, while mining concessions may legally be rented or sub-leased and such arrangements are

[40] CAREY (2023). Insights. "Congress approved bill that modifies Law No. 21,420 and other mining regulations".
[41] R. Varas. SONAMI. (2023) Caracterizacion de la Pequena mineria.

compatible with selling production to ENAMI, formal participation nonetheless remains tightly anchored to the concession-based property rights system. Whether through ownership or rental, ASM operators must secure and maintain legally valid concession arrangements, comply with associated administrative procedures, and bear the fixed costs linked to formal tenure. As a result, access to mineral rights continues to represent a substantial barrier to entry, particularly for smaller or capital-constrained producers.

These tenure-related barriers help explain why ENAMI-supported formalization mechanisms expanding legal recognition has not necessarily translated into improved operational conditions. In this context, "improved operational conditions" refers to enhanced access to mineral rights, greater exploration capacity, more efficient production practices, and consistent technical and institutional support. Persistent constraints in these areas continue to limit productivity, competitiveness, and long-term viability of many ASM operations.[42] These challenges are further compounded by administrative delays, procedural inefficiencies, and restricted access to technical information and guidance, all of which can function as binding constraints on deeper formal engagement and sectoral expansion.[43]

Under the current institutional framework, formal participation in Chile's mining sector entails a level of regulatory, technical, and administrative capacity that many ASM operators do not possess. Prior to registering a mining concession under ENAMI's framework, ASM operators must obtain multiple sectoral permits, including safety plans, authorizations for the purchase and management of explosives, health service approvals, water use rights, and municipal permits. Sernageomin further requires the submission of a technically defined mining plan endorsed by a qualified professional, together with electricity system specifications, mine access and safety designs, and a closure plan. For many ASM operations — particularly those located in remote areas — meeting these requirements represents a substantial fixed-cost threshold in terms of financial resources, technical expertise, and access to specialized professional services.

Where such capacities are absent or only partially available, formalization tends to remain incomplete or episodic. In these cases, ASM activity often continues outside

[42] Atienza, M. (2023). "Formalization beyond legalization: ENAMI and the promotion of small-scale mining in Chile ".
[43] Molina, D. UNAB (2020). "Estudio de mineros artesanales y pequena mineria Sernagoemin-Chile".

fully regulated frameworks, not as a result of strategic non-compliance, but because the operational and administrative demands of formal participation exceed the sectors prevailing capabilities. High transportation costs to get to ENAMI's processing facilities due to remote locations, limited operational infrastructure or rudimentary equipment that do not meet minimum technical standards, combined with the need for qualified professionals to design and operate projects eligible for formal recognition, further constrain sustained engagement with formal institutions.

As a result, a non-trivial share of ASM production is likely to remain unobserved or only partially captured in official statistics, contributing to persistent uncertainty around the sector's true scale, productivity, and economic contribution. This outcome reflects a broader structural condition in which institutional sophistication coexists with uneven absorptive capacity among ASM operators, constraining the extent to which formalization mechanisms translate into sustained operational integration. This capacity gap–between the requirements embedded in Chile's ASM framework and the sector's ability to internalize them in practice– is central to explaining the divergence between advanced institutional design and persistent economic and productivity constraints within the ASM sector.

Fourth, improving ASM integration likely requires a dual focus: expanding market access channels through medium-scale mining actors while simultaneously aligning financial support and project evaluation frameworks with the sector's structural realities and production cycles.
Medium-scale mining operations could be playing a role in ASM market access — and perhaps an even larger role should be encouraged. As has been discussed, engagement with ENAMI, largely framed herein as the limited participation in formal ASM, may be associated with factors not documented in public sources, such as onerous requirements, long travel distances to sell product or constraints established by ENAMI related to its smelting capacity. This raises broader questions about the optimal production and commercialization pathways for ASM output that does not naturally flow to ENAMI, whether through alternative market channels or through measures aimed at strengthening ENAMI's uptake capacity and the effectiveness of related government policies. Yet it is plausible that to some extent, ASM miners are indeed utilizing ENAMI indirectly, via sales of product to medium-

sized mining operators that aggregate this product in with their own production and sell the volume to ENAMI.

There is little evidence regarding this market channel. Publicly available information does not provide evidence that such arrangements are systematically in place. While some medium-scale companies are occasionally referenced as purchasing material from third parties outside ENAMI, disclosures do not specify the origin or volumes of this material, limiting the ability to assess whether ASM production is being absorbed through these channels.

Nonetheless, this additional channel could also offer potential benefits such as flexibility in payment terms that help ASM miners manage cash flow, access to alternative processing options that accommodate different types of ore, buyer diversification, and regulated, traceable frameworks. To fully realize these benefits and strengthen accountability, medium-sized miners would have to be required to provide transparent transaction reporting, clear documentation of materiel origin, and to integrate formal monitoring systems, enhancing market stability, oversight, and ASM formalization. There would also need to be some stipulation that value was being shared fairly between the ASM miner and the medium sized reseller.

Beyond commercialization channels, the evidence presented in this paper suggests that participation constraints in the ASM sector are not solely logistical or institutional, but also financial and informational. Low uptake of ENAMI programs, limited use of promotion instruments, and reported difficulties in accessing benefits point to structural gaps in how support mechanisms are designed and delivered. In this context, the question arises as to whether alternative approaches— both in financing and project evaluation– could be better aligned with the operational realities of the sector and generate a more meaningful impact on miners' needs and production cycles.

In particular, financing models implemented in other Global South contexts, such as microcredit schemes tailored to ASM communities (Hilson and Ackah-Baidoo, 2010) [44], offer a useful point of reference. Rather than focusing exclusively on short-term production expansion, these approaches have in some cases prioritized longer-

[44] Hilson and Ackah-Baidoo (2010) "Can microcredit Services Alleviate Hardship in African Small-Scale Mining Communities?"

term livelihood stabilization. This includes structuring financial support around income diversification, incremental equipment improvements, and risk mitigation, which may enable miners to gradually strengthen productive capacity and resilience to price volatility. Such models have also been associated with improved repayment performance and more sustained engagement with formal economic channels over time, suggesting that their effectiveness may stem from their closer alignment with the cyclical and uncertain nature of ASM activity.

At the same time, the literature highlights that the performance of these financial mechanisms depends not only on their design, but also on the broader organizational context in which they are implemented. Group-based lending structures, collective accountability, and forms of social collateral have proven effective in environments where community organization is relatively strong and can substitute for formal financial histories. However, in more fragmented or weakly coordinated settings, these mechanisms may face implementation constraints. This suggests that, in the Chilean context, the potential effectiveness of similar instruments would likely depend on complementary factors such as access to information, technical assistance, and the degree of organizational capacity among ASM producers.

Parallel to financing considerations, the way in which ASM projects are evaluated and structured also appears to play a critical role. Evidence from economic feasibility studies of ASM operations (e.g., Marin et al., 2016) [45] indicates that adapting evaluation frameworks to better reflect the scale, risk profile, and operational intermittency of small mining projects could improve both resource allocation and project viability. This may involve more flexible appraisal criteria, staged investment approaches, or simplified cost structures that better align with ASM production dynamics. Incorporating early-stage activities—particularly exploration—into initial project financing and evaluation frameworks may further enhance outcomes by accounting for geological uncertainty from the outset. In turn, this can contribute to reducing information asymmetries and supporting a more realistic assessment of project potential.

By making project characteristics more observable and systematically assessed across both exploration and production phases, such approaches could strengthen

[45] Marin, T. (2016) “Economic feasibility of responsible small-scale gold mining”.

the basis for both public and private investment decisions. Improved transparency and clear risk assessment may also increase the visibility of ASM projects to a broader range of potential investors. This may include not only large mining firms, but also medium-scale investors, specialized funds, and, in some cases, downstream actors seeking access to traceable or differentiated supply streams. While the extent to which such participation may materialize remains uncertain, these considerations suggests that financial and evaluative instruments can influence not only in project viability, but also the composition of actors engaged in ASM-related value chains.

Taken together, these insights point to the possibility that improving ASM integration requires more than expanding market access channels. It may also depend on rethinking how financial support and project evaluation frameworks are designed, ensuring they are more closely aligned with the structural conditions, risk profiles, and production cycles that characterize the sector. Strengthening these dimensions could contribute to improving the alignment between institutional mechanisms and the realities observed across the sector.

CONCLUSION

Chile's ASM sector occupies a paradoxical position: while it represents a small share of national mining output, ASM copper production — considered independently — would rank among the world's leading copper-producing countries. This structural paradox highlighted in this paper means: ASM appears to be marginal in national aggregates yet remains meaningful territorially and institutionally. Thus, ASM volumes are obscured by Chile's dominance as a large-scale mining producer. Moreover, reported production figures capture only miners formally registered, while a much larger universe of roughly 3,600 artisanal and small-scale operators remains partially or entirely outside systematic reporting. By clarifying the distinction between observed outcomes and underlying constraints, this paper reframes Chilean ASM not as a marginal actor, but as a structured yet partially obscured component of the national mining system–one whose full contribution remains contingent on participation, data quality, and strategic alignment rather than on institutional design alone.

This gap between the total ASM universe and formal participation is critical: expanding engagement across all stages — from registration and permitting to production reporting and commercialization through ENAMI and/or

complementary channels — would materially improve both sector performance and the reliability of economic assessments. Such expansion would also enable a clearer empirical connection between ASM activity and regional economic outcomes, addressing the challenge of structural invisibility highlighted in the analysis. If participation and data coverage were expanded, the sector's economic relevance–both nationally and globally– could increase significantly, strengthening the case for continued institutional focus on ASM-specific promotion, aggregation, and oversight.

Four key observations from this study underscore the nuanced understanding of ASM in Chile:

First, there are clear market signals indicating confidence in the ASM model, driven in part by investor interest in developing alternative supply chains beyond China. This suggests potential for growth even if formal participation is incomplete.

Second, the weak correlations between ASM activity and regional economic indicators primarily reflect scale limitations and structural invisibility; these relationships should not be interpreted as evidence of limited local significance.

Third, while Chile's institutional architecture for ASM–particularly through ENAMI– is comparatively advanced, its reach is uneven, highlighting a persistent gap between institutional design and realized economic integration.

Fourth, complementary channels, such as medium-scale mining partnerships and enhanced traceability mechanisms, could expand formal market access for ASM producers, strengthen accountability, and improve the visibility of economic contributions, provided participation and reporting are effectively coordinated. In parallel, the analysis suggests that financial and evaluative mechanisms may also play a role in shaping participation outcomes. Evidence from the literature indicates that microcredit schemes oriented toward longer-term livelihood stabilization—rather than short-term output expansion—can support more sustained engagement in ASM communities, particularly when combined with stronger community organization and access to information. Similarly, adapting project evaluation frameworks to better reflect ASM conditions, including the incorporation of early-stage exploration into financing structures, may improve the transparency and perceived viability of small-scale mining projects over time. While the extent of these effects remains context-dependent, such approaches could contribute to broadening the range of actors able to engage with ASM, including medium-scale

investors and downstream participants seeking more traceable or specialized supply streams.

Beyond issues of measurement, the analysis reveals missed opportunities for strategic alignment. Chile's emerging Critical Minerals Strategy offers a potential platform for integrating ASM into national development objectives, particularly given the sector's role in copper, gold, and silver — minerals already recognized as strategically relevant. However, ASM remains marginal within this framework, with attention largely confined to health and safety considerations. This narrow framing limit recognition of ASM as a contributor to regional development, supply chain resilience, and territorial stability. At the same time, ENAMI's recent expansion toward lithium introduces an additional layer of institutional ambiguity. While ENAMI's experience in aggregation, technical support, and community-based production offers valuable capabilities, lithium extraction differs fundamentally from copper in scale, technology, and market structure, raising questions about mandate coherence and the limits of institutional transferability. The absence of explicit guidance on this transition calls into question the institutional compatibility of these dual functions.

The paper reinforces that data gaps in Chilean ASM are institutional rather than incidental. Production volumes, costs, employment, and productivity metrics are not systematically reported by most ASM operators, and data systems across public entities remain fragmented and weakly integrated. Improving formal participation across the full ASM universe — rather than only deepening compliance among already formalized producers — would enhance data availability, reduce uncertainty in impact evaluation, and allow institutional effectiveness to be assessed more accurately. These constraints limit both econometric analysis and policy evaluation. Improving data collection, through stronger inter-agency coordination, simplified reporting mechanisms, and institutional support during transitional stages of formalization, would significantly enhance the capacity to assess ASM's true economic and social contribution. Under these conditions, uncertainty surrounding ASM's economic and social contribution persist not because the sector lacks relevance, but because participation and observability remain incomplete.

In pointing out a number of challenges in operationalizing formalization of ASM, the paper suggests pathways for ENAMI and the Chilean government to provide greater support for ASM operators to nurture greater adoption rates. There is a presumption that greater participation will allow for more empirical connection

demonstrating the economic impact of ASM. Yet participation alone does not automatically translate into clearer attribution of economic value, particularly in a sector whose contributions are mediated through institutional aggregation mechanisms. Said differently, Chile's ASM sector cannot likely be assessed solely through the lens of aggregate economic impact. Its significance lies in its institutional embeddedness, regional role, and a capacity to aggregate dispersed production into stable, formalized supply chains. Determining whether current conclusions stem from limited uptake, limited information, or both remains a central analytical challenge– one directly linked to the potential of institutional mechanisms such as ENAMI to expand participation across the sector.

Overall, ENAMI's experience demonstrates that ASM can serve as a strategic pillar within national mineral development policy, contributing to supply chain resilience and attracting investment beyond its immediate production scale. However, realizing this potential consistently requires sustained institutional capacity, effective program execution, and broader participation. This analysis also suggests that complementary adjustments in financial design, project evaluation, and early-stage support mechanisms may influence how effectively ASM operators can engage with existing institutional frameworks, and how the sector is perceived by a wider set of potential stakeholders. The Chilean case therefore illustrates both the promise of state-backed ASM integration and the importance of sustained institutional adaptation to translate strategic ambition into lasting impact.

Finally, in considering ENAMI, and Chile more broadly, as a reference point for ASM formalization, the analysis suggests that ENAMI should be understood as a context-dependent developmental-state model rather than a universally replicable template. Its effectiveness rests on Chile's long mining history, accumulated technical expertise, concentrated copper geology, and relatively small ASM sector embedded within a large-scale mining economy. Replication in other countries — particularly those with larger ASM populations or different mineral endowments — would therefore require substantial adaptation. Nevertheless, the Chilean experience offers analytically relevant insights into the role of aggregation mechanisms, state-based market access, and price transparency as tools to reduce informality and stabilize small-scale supply, highlighting lessons that extend beyond ENAMI itself to the broader structural and institutional barriers facing ASM formalization.

APPENDIX I

Historical context about ASM promotion

Artisanal and Small-Scale Mining (ASM) in Chile has been developing since the early 20th century. Its promotion became a necessity for the sector following the arrival of foreign large-scale mining companies around 1906, which weakened the industry of national producers. A joint effort between the public and private sectors led to the creation of the Mining Credit Bank (Caja de Crédito Minero, CACREMI) in 1926.

The purpose of this institution was to promote the processing of all types of minerals found in the country through national companies, supported by loans issued by the Mining Credit Bank. CACREMI's capitalization was planned through the issuance of bonds backed by state guarantees. Over time, the institution was authorized not only to issue loans, but also to buy and sell minerals, support mineral exploitation, and provide financing for investments in machinery—particularly benefiting ASM miners. It eventually evolved to manage its own processing plants as well.

The challenging economic and social environment of the 1950s, combined with a sector growth rate of less than 5%, pushed the Chilean state to establish a more robust institution—not only to promote but also to develop ASM and medium-scale mining. As a result, a merger between CACREMI and the National Smelters Company (Empresa Nacional de Fundiciones) led to the creation, in 1960, of the National Mining Company (Empresa Nacional de Minería, ENAMI) (CESCO, 2024).

Timeline:

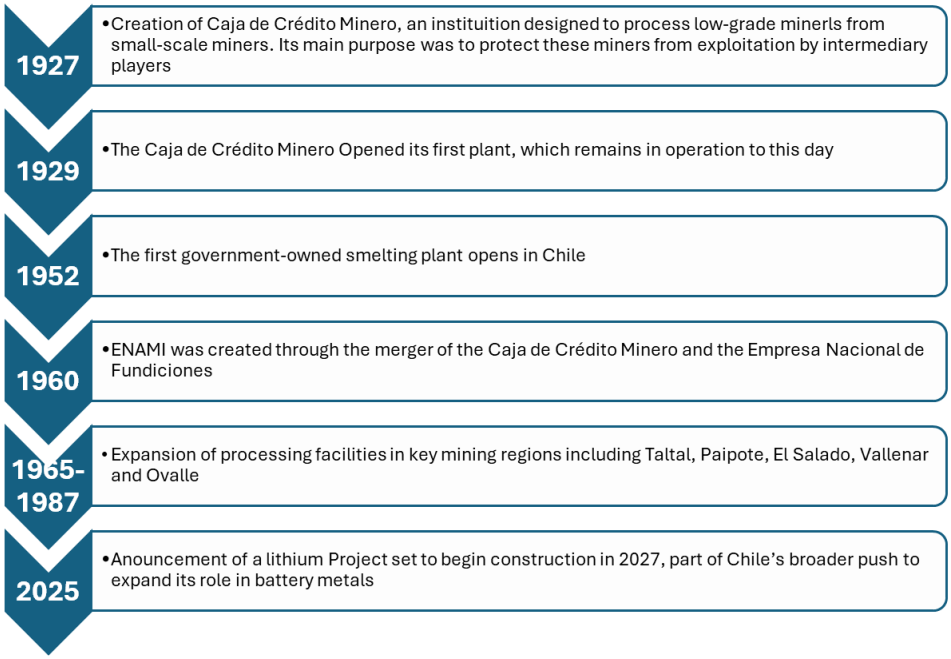

Figure 1. Created by the Payne Institute for Public Policy.

APPENDIX II

Law 19,719 Special Mining License fee for Artisanal and Small-scale Miners

This law establishes a special mining license designed to support small-scale and artisanal miners, recognizing their importance to the mining sector and the challenges they face in meeting regulatory and financial requirements. The reform introduces a simplified and more affordable licensing system while providing debt forgiveness and payment flexibility to promote the formalization of mining operations.

Under this system, eligible miners pay a reduced annual license fee for mining concessions under active exploitation. The amount is equivalent to one ten-thousandth (1/10,000) of the Unidad Tributaria Mensual (UTM) per hectare, paid annually and in advance. The UTM (Unidad Tributaria Mensual) is a monthly tax unit used in Chile to adjust fees, taxes, and fines according to inflation. Its value changes monthly and is published by the Chilean Internal Revenue Service (Servicio de Impuestos Internos, SII). To provide a reference, the UTM typically fluctuates between USD 70 and 90, depending on the exchange rate, meaning that the annual special mining license cost is very modest — around USD 0.007 to 0.009 per hectare.

The special license applies to concessions covering up to 100 hectares for small miners and 50 hectares for artisanal miners, as recorded in their official mensura (survey record). To qualify, miners must operate personally or through legal mining partnerships or cooperatives, employing no more than twelve workers for small-scale mining or six for artisanal mining. They must also hold the necessary operating permits and access rights (servidumbres). Once approved, eligibility for the special license remains valid for two annual payment periods, after which it can be renewed under the same conditions.

The law also simplifies administrative procedures. If at least one claim from a miner's mensura record is under exploitation, all related claims are presumed to be active. For cooperatives or legal partnerships, this presumption applies only to the properties they directly own. Additionally, to avoid excessive concentration of benefits, miners and their close relatives cannot jointly receive the benefit for areas exceeding the maximum limits unless their concessions are located in different municipalities.

Beyond simplifying the licensing process, the law provides significant financial relief. It forgives accumulated surcharges, interest, and penalties, and cancels 90% of outstanding mining license debts owed by small and artisanal miners, as well as their cooperatives and legal partnerships.

Overall, this law represents a major step toward strengthening Chile's small-scale and artisanal mining sector. By reducing costs, improving access to formalization, and providing financial stability, it helps miners continue operating legally and sustainably, contributing to local economic development while maintaining compliance with national mining regulations.

APPENDIX III

Table 2

Global rank	Countries	Copper production, 2021 (FMT)
1	Chile	5,624,900
2	Peru	2,299,277
3	China	1,910,000
4	DR Congo	1,740,000
5	USA	1,230,000

6	Russia	941,000
7	Zambia	841,500
8	Australia	813,000
9	Mexico	734,100
10	Indonesia	731,045
11	Canada	550,418
12	Kazakhstan	510,200
13	Poland	391,300
14	Iran	339,600
15	Brazil	335,761
16	Panama	331,000
17	Mongolia	315,000
18	Uzbekistan	150,000
19	Spain	146,952
20	Serbia	121,150
21	Ecuador	120,000
22	Turkey	108,000
23	Saudi Arabia	97,527
24	Sweden	88,000
25	Armenia	81,700
26	Bulgaria	70,000
27	Papua N.G.	66,500
28	**ASM CHILE**	**54,950**
29	Philippines	51,586
30	Laos	51,147
31	Portugal	37,900
32	Burma	33,900
33	Vietnam	33,600
34	Finland	32,384
35	South Africa	28,300
36	Morocco	28,000
37	India	26,300
38	Eritrea	20,224
39	Mauritania	18,845
40	Pakistan	18,806
41	Botswana	10,670

42	North Korea	10,000
43	R. of Congo	10,000
44	Romania	8,900
45	Zimbabwe	8,650
46	Colombia	8,194
47	Georgia	8,147
48	Kyrgyzstan	6,900
49	North Macedonia	6,600
50	Domin. Rep.	5,600
51	Albania	4,430
52	Bolivia	3,310
53	Azerbaijan	2,657
54	Tanzania	1,700
55	Namibia	1,040

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