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New thinking around critical minerals in Latin America

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Executive Summary

This paper examines the window of opportunity for Latin American Countries (LAC) to benefit from the global energy transition. It focuses on geopolitical competition, particularly between China, the European Union, and the United States, and the regional strategies available to maximize the benefits generated from their mineral resources. The paper also discusses the dynamics of supply and demand, the geopolitical concentration of resources, and the importance of strengthening supply chains.

Latin America is a key player in the extraction of copper and lithium, which are fundamental to the global energy transition. The region is home to a significant portion of the world's reserves of these minerals, with Chile and Peru, and to a lesser extent Mexico, standing out in copper reserves, and the countries of the *lithium triangle*, constituted by Argentina, Bolivia, and Chile, standing out in lithium resources. This position gives Latin America a unique opportunity to capitalize on growing global demand driven by the expansion of low-carbon technologies such as electric vehicles and renewable energies.

This analysis suggests that to maximize opportunities, Latin American countries should establish a complementary and coherent mix of policies, including innovative institutional pro-developmental architecture, a new deal in trade policy with developed countries, a strategy for green melting capacity in minerals, a new productivist regionalism and strong multilateral finance for productive change. These measures could enable the region to benefit economically and play a significant role in the global energy transition by promoting socially and environmentally responsible mineral extraction and production.

1. Introduction

Energy transition as a driver for critical minerals demand

Since 2015, 193 countries, plus the European Union, have signed the Paris Agreement under the framework of the United Nations Climate Change Conference (UNFCCC), the main goal of which is to keep the global temperature increase below 1.5ºC with respect to pre-industrial levels. To achieve this goal, each party has established a Nationally Determined Contribution (NDC) setting forth the actions it will take to reduce its greenhouse gas emissions, with a future horizon of zero net emissions (United Nations, 2024).

The consequence of this global statement of intent is that member countries are taking concrete steps to establish a low-carbon economy by shifting away from fossil fuels and towards electrification based on renewable energy sources. As a result, global interest is shifting from hydrocarbons to so-called critical minerals, which are necessary for the development of clean technologies.

This transition involves the extraction and production of minerals that are considered critical for the production, transmission, and storage of non-conventional renewable energy. In this new scenario, minerals are not consumed through combustion; rather, they are used as a constituent part of clean energy production technologies and can be recovered and reused at the end of the useful life of solar panels or batteries.

This transition has been accompanied by global geopolitical changes defined by the control that different nations have exerted over energy production and the minerals or fuels necessary to sustain it. For instance, the UK exercised its dominance in the 19th century thanks to its importance in the global production of coal. The geopolitics of the 20th century were marked, among other things, by the production and control of oil (Pitron, 2020). Now, in the 21st century, the major powers and industrial centers are increasingly focused on securing access to the minerals needed to produce renewable energies, manufacture electric vehicles, and advance the development of digital technologies.

1.1 Critical minerals: their classifications

The classification of a mineral as *critical* is determined, not only by the supply and demand associated with the development of clean technologies, but also by the relative difficulty of finding substitutes for that mineral; the geographic concentration associated with its extraction and processing; the political stability of the producing countries; and the diversity and robustness of supply chains. Since the definition of a mineral's criticality depends on multiple criteria, the evaluation of its criticality varies depending on the country making the classification, and thus, there is no universally accepted list of critical minerals.

For example, the United States distinguishes between critical materials and minerals. According to the Energy Act (2020), a critical material is a non-combustible mineral, element, substance, or material that the Secretary of Energy determines (i) has a high risk of supply chain disruption and (ii) serves an essential function in one or more energy technologies, including the production, transmission, storage, and conservation of energy (US Secretary of Energy, 2024). In the case of the UK, its list of critical minerals is defined not only by high economic vulnerability and high supply risk but also as a watchlist of minerals with increasing criticality, due to rapidly increasing demand or the emergence of risks in supply chains (UK Government, 2022).

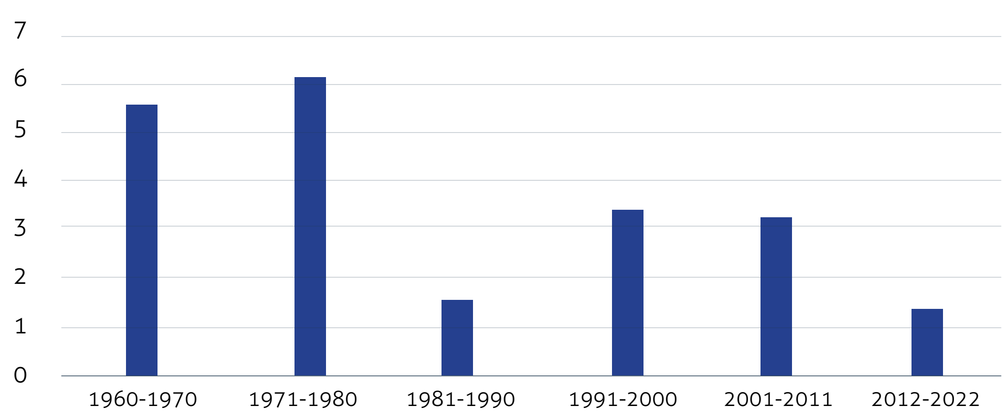
Although the criterion for defining critical minerals depends on the country conducting the analysis, in general terms, a mineral is critical when it is essential for economic and societal development; its production is geographically concentrated; it is not substitutable in the short-medium term; and its supply or associated value chains are subject to risks of disruption. The race to secure the supply of critical minerals is already on. Consuming and producing countries are developing strategies that decisively address this challenge (Lagos et al., 2021).

2. How does Latin America fit into the global energy transition?

Latin America's recent economic history has been marked by volatile growth, characterized by periods of relative boom followed by long periods of decline. After 2003, the region experienced rapid growth driven by the commodity boom, which resulted in an average GDP growth of 3.7%. Behind this commodities boom was China's strong demand for oil, copper, soybeans, cattle, fruits, corn, fish, and other key resources necessary to sustain the rapid structural change in its production matrix. South America is rich in natural resources, so China's demand for, investing in, and financing in these sectors, triggered a dynamic recovery for the region. As in the 19th century, Latin America had won what Díaz-Alejandro (1982) conceived as a *lottery of natural resources.*

After this boom (from 2012 until now), however, the region's GDP growth slowed to only 1.3% on average (including the COVID shock and subsequent recovery). In other words, in terms of aggregate performance, the recent lost decade is slightly worse (in average) than the corresponding decade of the 1980s (Ocampo, 2024), when the region grew by only 1.4%, as shown in Graph 1.

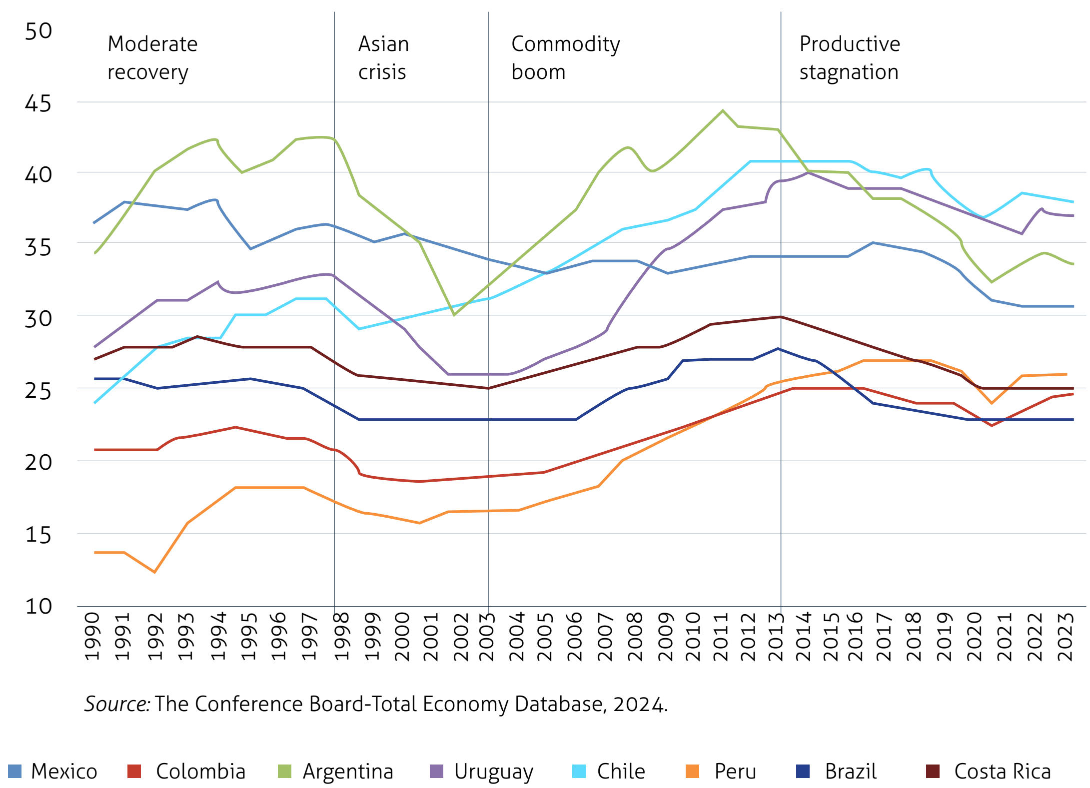
Graph 1. Latin America: GDP growth (1960-2022)



Source: Own elaboration based on World Development Indicators.

This last decade of productive stagnation not only slowed regional growth but also led to a wider income gap with developed regions. As shown in Graph 2, the average per capita income of the countries that explain most part of the region's GDP, has moved away from that of the United States.

Graph 2. Latin America: GDP per capita as a share of the United States (1990-2021)



Source: The Conference Board-Total Economy Database, 2024.

How did the region go from boom to stagnation in this short time span? An economy's response to external shocks is always mediated by its respective policies and institutional arrangements, which determine how these shocks are translated into their internal productive structures (Chang, 2002a). A country's industrial, exchange rate, and tax policies, for example, will determine how much surplus it can accumulate from positive external shocks and how it will use these surpluses.

In the case of the region, however, a relative lack of active industrial policies toward structural change meant that the commodity boom was managed mainly for redistributive goals. Therefore, instead of supporting a process of technological upgrading, the commodity boom pressured economic growth driven by an export basket intensively specialized in natural resources around the region's static comparative advantages (soy, copper, oil, etc.). At the same time, it generated an intense premature deindustrialization of the countries' domestic productive matrices, which was exacerbated by the impact of COVID on their economies (Domínguez, 2024).

One of the lessons of the region's boom experience is that this type of shock, in the absence of industrial policies that redirect surpluses towards strengthening national/regional technological capabilities, can exert pressures that erode internal productive capacities and redirect resources to sectors with low potential for technological growth. According to the Economic Commission for Latin America and the Caribbean (ECLAC), in Latin America, the *premature deindustrialization* (as measured by the manufacturing gap and the manufacturing employment gap) began with the crisis of the 1980s and the radical trade and financial liberalization in the 1990s, but the commodities boom strengthened the trend (ECLAC, 2022). In fact, the gap between the region's real and potential manufacturing capacity (i.e., the manufacturing a region should have in relation to its income per capita level) has widened considerably since the 2000s.

These developments have inhibited the possibility of sustained growth and produced rapidly diminishing returns in the export sectors. Two key reasons explain these outcomes. First, exports of natural resources and low-complexity manufactured goods tend to have low elasticity of demand, which implies a trade dynamism in the short to medium term. Second, these kinds of goods (in contrast with high-quality and complex ones) have low technological spillover and tend to result in enclave-like productive structures (Dosi & Tranchero, 2021; Ffrench-Davis & Díaz, 2019; ECLAC, 2022).

2.1 Energy transition and the new lottery of critical minerals in Latin America

In this context of long-term stagnation, the region enters a new scenario of the climate crisis and a growing global productive transformation towards new sources of sustainable energy. Two main factors impact demand for critical minerals: one geopolitical and the other environmental, the latter being the most important. The first factor involves the US-China competition towards access and control of value chains around key technologies, such as microchips and semiconductors, and the Russian-Ukrainian war, which has led Europe to seek new energy sources to reduce its structural dependence on Russian gas. The second factor is the emerging global climate crisis, which has prompted, on the one hand, new multilateral agreements such as the Paris Agreement and, on the other hand, the need to restructure the energy matrices of countries to overcome their dependence on coal and oil (IPCC, 2023).

This restructuring relies on the emergence of new clean technologies, which, in turn, require massive investments in infrastructure and supply chains, as well as the extraction and processing of a large amount of minerals.

For example, the production of wind turbines, electric cars, or solar panels requires large quantities of a wide range of minerals. An electric car requires more than six times the amount of minerals than a conventional car, and while the latter uses mainly copper and magnesium, the former uses copper, lithium, nickel, magnesium, cobalt, and graphite. An onshore wind turbine needs nine times more minerals than a gas-fired power plant (IEA, 2022).

New clean technologies are expected to rapidly become the main sources of demand for critical minerals. It is estimated that these minerals will see an increase of between four to six times the current production, depending on the ability of governments to take on the challenge of minimizing greenhouse gas emissions and meet the objectives of the Paris Agreement (IEA, 2022).

This growth in global demand for minerals has the potential to produce a new exogenous shock for the region, given that Latin America produces and possesses ample reserves of silver, copper, lithium, and, to a lesser extent, tin, zinc, nickel, and graphite (see Table 1). These minerals are not only key to the technologies mentioned above but are also essential to battery production (lithium and nickel, for example) and electrical grids (copper).

Table 1. Latin America's share in global production and reserves, 2021

	Production	Reserves
Silver	50%	39%
Copper	40%	38%
Lithium	34%	52%
Tin	23%	20%
Zinc	22%	17%
Nickel	10%	22%
Graphire	7%	22%

Source: IEA (2023).

Latin America with its new lottery of minerals could potentially reap substantial benefits from the contemporary energy transition. However, the region must decide which direction to take within the context of the current supply structure and the potential demand for these minerals.

On the supply side, the production structure of critical minerals is highly concentrated, both in economic and geographic terms. For example, four large companies control 56% of lithium mining: Albemarle (21%), SQM (19%), Pilbara Minerals (9%), and Tianqi (7%) (IRENA, 2023, p.45). This concentration, both at a regional and company level, is locked in. Although large reserves are available, the investment level required, together with the conditions that make these reserves economically profitable, mean that the supply structure is taken as given in the medium term.

The demand side is potentially more dynamic. The current demand for nickel, copper, and graphite originates from sectors not linked to the energy transition. However, the demand for these minerals by companies associated with new clean energy technologies is growing exponentially (IRENA, 2023).

This demand and its potential growth have characteristics specific to the deployment of new technologies. First, there is no certainty as to how countries will adapt to the climate crisis, nor whether they will have the sustained political will to implement pro-carbon neutrality measures. Thus, the amount and composition of demand remain uncertain. Second, technological innovation in this area is changing rapidly, opening up the possibility of new combinations of resources, new technologies that substitute certain minerals, and/or new techniques that could more quickly make available reserves that are not profitable today.

Finally, given a supply that is (in the short term) inelastic, geographically, and economically concentrated, and yet strategic for the energy transition (i.e., a growing demand), the market structure is developing around a competition that is less about prices, and more about the control of reserves, production, supply chains, safeguarding supply, and long-term contracts for access to minerals. In other words, the structure of market competition is based on creating and controlling tangible assets (reserves and mineral extraction, for example) and intangible assets (ownership of shares, debt contracts, etc.) that generate rents for the owners (Ahumada, 2023). Thus, the aggregate demand for these minerals has rapidly acquired a character of competition among nations and firms to be the first to access this supply and gain relative control of its provision.

2.2 Race to the minerals: the trade strategies of China, the EU, and the US

The dynamics of geopolitical competition to control the different parts of current value chains can be clearly seen in Latin America, particularly with the race between China, the EU, and the US to control the region's minerals.

a) China, main trade partner and key investor

Of all the major economies, China has adapted most rapidly to the process of energy transition and diversification into the production and processing of critical minerals. Indeed, in aggregate terms, China accounts for about 70% of world cobalt processing, 58% of lithium, 24% of nickel, 42% of copper, 100% of graphite and 93% of magnesium (IEA, 2023, p.1).

In the case of South America, China has become its top trading partner, displacing the EU and the US. Indeed, while in 2002, Latin America's trade with China (exports plus imports) was equivalent to 1.1% of GDP, by 2022, it had increased to 7.8%. However, China's economic penetration has also come through massive financial lending and investments. In the latter, Chinese investments have shifted focus: while during the commodity boom, these went mainly to extractive sectors such as oil, in the post-boom period (2013-2022), they have turned to infrastructure, mainly around renewable energy and electric car value chain (Albright et. al., 2023, p.4).

In fact, in the last decade, China's strategy in LAC has focused in increasing its presence throughout the value chain around energy transition. For example, recent Chinese mergers and acquisitions have gone mainly to the lithium and battery sectors in Argentina, Bolivia, and Chile.

In 2019, Tianqi acquired 24% of the Chilean company SQM. Also, in 2023, the Chilean government announced an agreement with BYD for the installation of a lithium cathode plant which will produce 50 thousand tons per year of cathode material in the Antofagasta region – enough to build 200 to 300 thousand EV batteries each year; and with Tsingshan for the construction of a lithium battery factory in Mejillones (Government of Chile, 2023). In the same year, the Bolivian government announced a $1.4 billion contract with the Chinese conglomerate CBC to create two industrial complexes for the direct extraction of lithium, with the objective not only of extracting the mineral but also of exporting lithium batteries (Government of Bolivia, 2024). Argentina, too, is strengthening alliances with Chinese capital, as exemplified by Minera Exar, a joint venture between Ganfeng Lithium and Lithium Argentina, which owns one of the largest mineral areas in the Olaroz-Cauchari salt flat, the Centenario Ratones Project, developed by a joint venture between Eramet and Tsingshan (Ganfeng Lithium, 2020).

b) United States, re-industrialization and trade agreements

The US has substantially modified its trade and industrial policy, shifting its focus from expanding trade and eliminating barriers, such as tariffs or national requirements, to a fresh emphasis on re-industrializing its productive capacity. In 2022, the US passed the Inflation Reduction Act (IRA), which complements its new Bipartisan Infrastructure Law (BIL) and the CHIPS & Science Act. Taken together, they form the basis of the new US industrial strategy.

The IRA provides $369 billion in tax reductions, subsidies, and public credits to stimulate the creation of domestic low-carbon industries. The IRA tax credits apply to products for which the mineral inputs include a specified level of local content, that is, minerals that have been mined in the US or in countries with which it has a free trade agreement (FTA). For example, in the case of electric vehicle purchases, half of the eligible tax credit requires that at least 50% of the battery components be manufactured or assembled in the US, a value that will gradually increase to 100% in 2029. The other half of the credit (USD $3,750) is contingent on electric vehicle batteries containing at least 40% of critical minerals produced in countries with which an FTA exists. This percentage will increase to 80% by 2027 (S&P Global, 2023, p.11).

This implies a substantial increase in the demand for minerals such as nickel, lithium, cobalt, and copper. S&P Global estimates that the demand for minerals used to produce electric vehicles will grow by around 28% annually until mid-2035 (S&P Global, 2023, p. 43). As the US is dependent on access to critical minerals from abroad, this would imply an increased demand for these resources from resource-intensive countries with which the US has trade agreements, such as Chile and Peru for copper and lithium, and Mexico for lithium.

Criteria such as friendshoring and nearshoring in US trade decisions have brought about shifts among its trading partners. By the end of 2022, Canada and Mexico had once again become the largest trading partners of the US, displacing China. Indeed, the trade growth rate between geopolitically close countries has increased (UNCTAD, 2023). Along this line, in 2022, the US launched the American Partnership for Economic Prosperity (APEP) to strengthen relations with Latin American countries in the areas of critical minerals, employment, finance, and trade. However, this proposal is non-binding and, in 2024, still lacks sufficient resources to stimulate substantive investment in these areas. Nevertheless, the US has a solid network of FTAs with Chile, Colombia, Central America, Mexico, Panama, and Peru, which provides a solid framework for its trade and investment in the region.

In this sense, while China has focused on strong trade and investment flows, the US has focused on establishing multilateral cooperation through the APEP and consolidating previous bilateral institutional ties through its network of Free Trade Agreements.

c) EU and the expansion of FTAs

In recent decades, the EU has experienced an increasing market dependence on energy and raw material suppliers in Russia, Asia, and Latin America. The EU is concerned not only about establishing new energy sources beyond Russian gas but also about its dependence on China for access to critical minerals. Currently, 90% of the EU's supply of rare earths comes from China (Bersi et al., 2023).

To address these concerns, the European Commission launched its Green Deal Industrial Plan 2023. With a projected investment of $1.8 trillion, the Green Deal focuses on industrial reconstruction around renewable energies. In turn, the EU, through the Critical Raw Materials Act, will require that 1) at least 10% of the critical minerals consumed annually in the member countries have been extracted in the EU; 2) at least 40% of internal consumption has been processed in the EU; and 3) at least 25% comes from local recycling (EU, Regulation 2024/1252:11).

The Commission, in addition, seeks to relax the rules for private investment in clean manufacturing, increase financing for local industry, and ensure the international supply of critical minerals for regional production. In relation to their international relations with mineral-rich regions, the EU has proposed to strengthen trade agreements and/or create new agreements with, for example, Latin American countries. These agreements aim to secure formal and permanent access to these minerals and guarantee a set of rules that accelerate the green transition. For example, the EU has increased pressure to sign an FTA with Mercosur and Mexico and to modernize the FTA with Chile. One key innovation in these negotiations is the chapter on critical minerals. The chapter imposes important restrictions on implementing the national industrial stimulus policies through, for example, export controls (as China, Indonesia, Zimbabwe, or Namibia have done) or measures like preferential prices and seek to secure a permanent provision of minerals to the EU.

Thus, to compete with US import substitution policies and China's expansionist strategy, the EU is seeking to enact regulations to protect European access to critical minerals through trade agreements with countries in the region.

3. Making strategic use of the mineral lottery:

Latin America's new challenge

3.1 The discreet charm of inertia

Latin America is in the midst of a mineral lottery: the demand for its minerals is growing while the supply is relatively given, at least for the medium term. This situation opens a green window of opportunity for the region (UNCTAD, 2023 b). At the same time, the region is under pressure to expand mineral extraction by broadening its territorial reach and exploiting reserves that have not yet been developed. Such a path would pose serious ecological and social threats, especially for the communities surrounding these reserves, unleashing a destructive dynamic sometimes referred to as green extractivism (Dominguez, 2024; Mejia-Muñoz & Babidge, 2023). For example, it is estimated that around 54% of critical minerals are located in or near territories inhabited by indigenous communities. Extraction requires high water consumption, which has led to water shortages in the surrounding communities (IRENA, 2023, p.54).

Given the rise in international demand for these resources, not only are private and public sector activities expanding, but investments are also increasing, which could support economic recovery. This recovery tends to be seen by both the political and economic elites as a positive outcome, since it implies a rise in the accumulation of rents for business actors, and a rise in the fiscal capacity for the states and its political elites. Thus, strong political coalitions form around such interests and expectations that promote and protect this type of growth pattern. These coalitions include export unions, foreign investors, political parties, sectors of the public apparatus, and international interests and agendas (Doner & Ross Schneider, 2016).

The political economy around this growth pattern tends to have two characteristics. First, it creates a strong coalition reluctant to implement policies that could somehow challenge their established strategy. In other words, to maintain the status quo, they become unwilling to, for example, use their market power to negotiate better trade agreements and/or impose new rules on foreign direct investment (FDI). Secondly, it suffers from a tendency toward short-termism, that is, a tendency to privilege the immediate gain without considering the long-term ecological, social, and productive consequences of the given strategy.

3.2 How to overcome short-termism?

Latin America must ensure a pro-development institutional order and a package of green industrial policies to build technological capabilities and protect communities and territories from the threat of extractivism.

a) A State with a long-term vision and action

Developing a set of policies focused on overcoming short-termism is not an easy task. The effects of these policies are tested in the long term, while their costs are assumed in the present. This dynamic invites the possibility of institutional failures, strategic errors, and information asymmetries that make it difficult for the state to foresee future scenarios and act efficiently (Rodrik, 2008). For the state to play a reasonably efficient pro-development role, it must ensure: (1) the elimination of information asymmetries between the central apparatus and key actors in civil society, (2) the inclusion of different voices from civil society in the strategy proposal, (3) inter-ministerial coordination for the implementation of the strategy, and (4) financing for its application.

A strategy cannot emerge vertically but must be generated from a shared diagnosis among key actors in the production process. In the East Asian development experiences (Japan, South Korea, China), these roles have traditionally been filled by bureaucrats and large economic conglomerates, creating an institutionalized flow of information and coordination to define the niches of opportunities for industrial upgrade (Evans, 1995).

However, such an institutional structure leaves no room for the flow of information on environmental sustainability or social protection objectives. The experience of the Nordic countries illustrates a different approach. Sweden, Norway, and Finland implemented a process that included spaces for dialogue between government, universities, trade unions, and representatives of productive development agencies; participants provided input and information covering a broad range of dimensions in the productive transformation strategy (Ahumada et al., 2021).

For example, in the 1980s, Finland set up the Council for Science and Technology Policy (CPCT) under the direct command of the Prime Minister and composed of eight ministers, representatives of industry, university rectors, and representatives of the national public finance office, TEKES. The CPCT establishes the objectives of national productive policy, which are then implemented, with varying degrees of autonomy, by public agencies, such as SITRA and TEKES itself. This institutional architecture for prospective and technological innovation has supported the emergence of national leaders in telecommunication technologies, such as NOKIA, and the building of a network of national suppliers of high-tech components and services around the telecommunication sector. Even after this sector stagnated in the 2010s, the public architecture behind its success has supported national firms as they embrace new sectors such as entertainment, biotechnology, and, nowadays, the circular economy (Ahumada et al., 2021).

b) A window of opportunity for a New Deal for trade agreements

Latin America's trade policy is quite heterogeneous, but economies such as Mexico, Central America, Colombia, Peru, and Chile have been characterized by signing a series of FTAs establishing strong regulations on intellectual property and weak norms on FDI , and trade (UNCTAD, 2022). For example, (1) they have strengthened intellectual property protection and limited spaces for patent flexibilities, (2) they restrict pro-development measures for foreign investments, such as technology transfer or local content requirements for investors, and (3) most of these agreements have investor-state dispute settlement (ISDS) mechanisms that embody a pro-business asymmetry (Chang, 2002; Gallagher, 2008; Perrone, 2021).

Currently, many countries throughout the world are implementing selective export promotion policies and local content requirements for foreign investments. Indonesia, for example, has restricted exports of unprocessed nickel (followed by Namibia and Zimbabwe); the US and the EU have raised tariffs on key technological goods and are implementing investment subsidies to industrial FDIs subject to local content; and China has established its international insertion strategy based on intense technology transfer policies and selective support to industries. However, these policies are blocked for Latin American countries that have signed an FTA with the US and/or the UE.

Thus, Latin America should reform its trade agreements to take advantage of the new strategic minerals lottery through active trade and industrial policies. For example, new foreign investments in these minerals should be subject to a structure that promotes technological transformation (Perrone & Selamé, 2023). Measures towards this goal should include:

i. The participation of local suppliers in complex parts of the value chain: the investment would be conditioned on establishing contracts with national suppliers in medium or high-tech areas. For example, Norway, until the 1990s, conditioned FDI in oil extraction on hiring local operators in the infrastructure so that the oil boom would benefit local businesses and residents.

ii. The transfer of technology to the national productive fabric: this can happen through different measures, such as ensuring that FDI establishes contracts with local universities for R&D projects that will generate nationally owned knowledge (e.g., patents to be transferred to the national government).

iii. Ensure that a percentage of exports resulting from the FDI are technologyintensive: this can be done through an export graduated tax according to the level of technological content or an export ban on low-tech exports (a policy established by Indonesia, Namibia, and Zimbabwe in recent years on certain unprocessed mineral ore).

iv. An environmental and social policy that meets international standards: regulations that ensure that the environmental standards established by international organizations are considered mandatory for the FDI. Also, the protection of the local communities and workers can be secured through their inclusion in the discussion of the investment strategy and by implementing new green and labor protection norms. In this sense, the labor provision of the USMCA can be an example to consider.

v. A new dispute resolution system that replaces the ISDS for a more equitable system: this new system can imply returning to the prior system whereby the nation-state serves as the proper organization providing justice to foreign firms (such as Brazil), creating a new permanent court that replaces ad hoc tribunals (such as the current proposal of the EU) or considerably restricting the scope of the ISDS (such as the USMCA).

vi. Indeed, investment projects should include local suppliers in their proposals, reach alliances with national capitals, ensure the willingness to diversify exports in national territory, protect the environment, and have a more equitable dispute resolution system (UNCTAD, 2023).

In the area of patents, Latin America can take a leading role in promoting a more flexible intellectual property regime in the face of the climate crisis and initiate the discussion on:

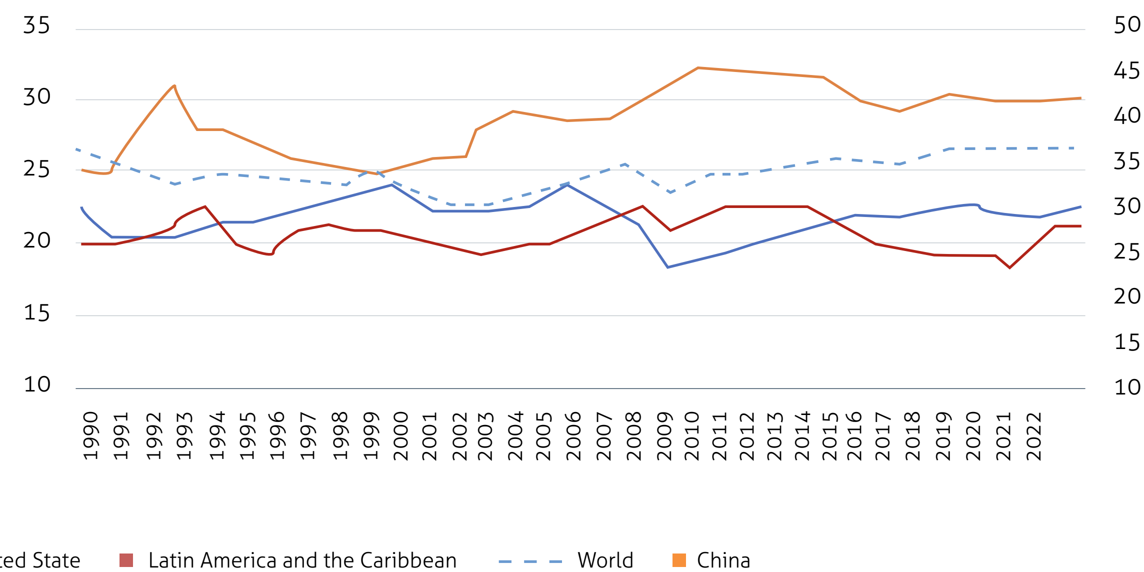
(i) The duration of patents: bilateral and multilateral agreements have established a homogeneous duration of patents of around 20 years (in the TRIPS agreements) or more (in the FTAs). This lengthy duration slows the ability to transfer knowledge essential to the energy needs of today. Discussing a heterogeneous regime, with carve-outs for a shorter duration around energy transition, is a possible route to explore (Jackson & Espinoza, 2019).

(ii) Exception policies: in the face of the climate crisis, increasing the degree of restriction on patent protection to ensure a greater flow of technological know-how for a rapid energy transition is another path that should be considered.

c) A developmental finance

It is necessary to create a financial regime that provides fresh capital and macroeconomic stability for the investments needed for green productive transformation. As shown in Graph 3, since the 1990s, gross capital formation as a percentage of GDP in Latin America has always been below the world average and, except for the commodity boom period, below that of the United States according to the World Bank Indicators.

Graph 3. Capital formation as a share of GDP (1990-2022)



Second axis: China.
Source: World Bank Indicators.

Investments in Latin America are likely to increase with the lottery of critical minerals. But as yet they are not sufficient for the scale needed to establish and sustain productive linkages, diversify exports into green sectors, or for the infrastructure needed to stimulate local suppliers.

Latin American countries can act in concert to strengthen regional financial institutions for development. On the one hand, a regional development bank should be created that not only provides selective soft loans for green investments but also has the capacity to be a space for articulation between governments to establish a regional policy on critical mineral issues (see section 4). On the other hand, governments must guarantee a stable and competitive exchange rate and prevent positive external investment shocks from opening the door to a Dutch disease that negatively impacts non-traditional sectors (Palma, 2019).

In relation to the first point, institutions such as the Development Bank of Latin America and the Caribbean (CAF) or the Inter-American Development Bank (IDB) are already established in the region; however, the scale and objectives required must go further than what these institutions currently provide. A robust development bank should focus on financing investments with technological potential in the areas selected by the institution, either through credits or equity participation, with degrees of control over the company and its profitability (Mazzucato & Penna, 2018). This effort requires coordination in regional frameworks (such as, for example, the Community of Latin American and Caribbean States [CELAC]) and must be of a sufficiently broad scale so that its actions allow for modifying the productive pattern.

Regarding the second point, governments should reconsider the implementation of capital controls (IMF, 2022). These controls can help to limit the inflow of speculative capital or sudden outflows that destabilize macroeconomic balances. Another institutional order that helps exchange controls against Dutch disease has been sovereign wealth funds. For example, Norway's Government Pension Fund Global (GPFG) has acted precisely to safeguard this stability (Ahumada et al., 2021). Brazil, Bolivia, Chile, Peru, and Colombia have sovereign wealth funds that are still relatively small in scale, but which can serve as a basis for, on a larger scale, instruments to safeguard a macroeconomy for productive transformation (Ffrench-Davis, 2010).

4. South America and industrial upgrade in copper and lithium production:

Toward a productive regionalism

4.1 Copper in Latin America and the need to increase refining capacity

Latin America, and specifically the copper-producing countries in the region, should take on the challenge of strengthening their smelting capacity to recover their share of global refined copper production.

According to the National Minerals Information Center of the US Geological Survey, by 2022, Chile had 21.3% of the world's copper reserves (190 million tons), Peru 9.1% (81 million tons), and Mexico 6.0% (53 million tons), making a total of 36.4% of the world's copper reserves in 2022 (USGS, 2023b). In terms of mining copper production, Chile produced 23.6% (5.2 million tons) of the total global mined copper, Peru 10.0% (2.2 million tons), and Mexico 3.4% (0.74 million tons). Together, Chile, Peru, and Mexico produce 37% of the world's copper. Of refined copper, the three countries are responsible for only 11.0% of world production: Chile 8.1%, Peru 1.1%, and Mexico 1.8%. On the other hand, despite producing only 8.6% of mined copper, China is responsible for producing 42.3% of the world's refined copper (USGS, 2023).

The difference is explained by the low smelting capacity in the copper-producing countries in Latin America. Thus, a significant part of their mine copper is processed only to generate a marketable concentrate that is then sent to industrial centers with refining capacity, mainly China. This country has promoted the construction of smelting facilities, which has allowed it to control a major segment of refined copper at a global level.

Each country’s share of refined copper production is the result of a combination of the type of ore mined and the installed smelting capacity. Copper is usually found in oxide or sulfide form. Oxidized copper ores must be refined at the production site using hydrometallurgical processes. In the case of copper in sulfide form, it is possible to generate an intermediate concentrate product that can be refined in smelters far from the production site which can then be shipped for smelting and refining in other countries. This means that in countries such as the Democratic Republic of Congo, which currently mines copper mainly in oxide form, much of this copper leaves the country as refined copper even though it has no smelting capacity, while countries such as Chile, which mainly mines copper sulfide, have limited smelting capacity that limits their share of global refined copper production.

Furthermore, copper deposits usually have both mineralogical forms – oxides and sulfides – but they are not distributed homogeneously. Therefore, usually, in the first years of exploiting a mine, copper is extracted mainly in the form of oxides. Later, once they are depleted, they give way to copper sulfides. This means that the locally installed refining capacity limits the capacity to produce refined copper. The most widely used process to refine sulfide copper is the smelting process. Therefore, in the long term, when the copper coming from the mine is in the form of sulfide, the available local smelting capacity becomes a crucial factor in controlling the production of refined copper, understood as a critical ore. Although, as a business, the mine is much more profitable than the smelter, and from an economic perspective, one could argue that the most critical impact on national income comes from the extraction and production of a copper concentrate, it cannot be overlooked that lacking the capability to process and refine copper locally exposes the mining countries to a series of vulnerabilities, as will be discussed in the following subsection.

4.2 Copper smelting capacity

China, with 25 smelters in operation, produces 40.6% of refined copper by this method, while Chile, with 7 smelters, of which only 5 are in operation, is limited to producing just 6.7% of refined copper by smelting (Cochilco, 2022, p.25). If the Chilean smelters plus the Ilo smelter in Peru and the La Caridad smelter in Mexico are considered together, the combined capacity of the three countries still falls below 2.0 million tons of copper, far from the 7.3 million tons of refined copper that China produces (Cochilco, 2022, p.26).

The sustained increase in copper smelter refining capacity in China, without a counterweight by the region's copper-producing countries, exposes the latter to a series of vulnerabilities:

(i) Latin American copper producers lose negotiating capacity for smelting and refining charges and consequently must pay the treatment charges as defined by the large smelting countries, mainly China. In 2020, for instance, the treatment charge for Chinese smelters was below $ 70 per ton of concentrate, whereas in Chile, it was above $180/ton on average.

(ii) The use of foreign smelters offers limited control and traceability of greenhouse gas emissions and furthermore, transporting the concentrate by ship to be smelted increases the carbon footprint.

(iii) Finally, the low smelting capacity in Latin America represents a difficulty in advancing scientific and technological development at the regional level for copper refining (Lagos et al., 2021).

Chile's recent National Strategy for Strengthening Smelting and Refining Capacity presented in 2023 (Chilean Ministry of Mining, 2023 [hereinafter, Strategy]), offers an important study case for these issues. The Strategy focuses on increasing the country's smelting capacity and strengthening existing smelters to maintain their production levels with higher standards in terms of environmental performance. The Strategy sets forth actions to encourage the development of new projects, such as developing a robust regulatory framework and instruments to promote investment in the sector. It proposes creating a certification of refined copper in Chile which would provide access to markets that require low-emission copper. It also identifies potential locations for the construction of new smelters to reduce the risks associated with the social acceptance of projects of this magnitude. Finally, it promotes a technological, research, development, and innovation program around the smelting and refinery processes, as well as a training program to respond to the needs of this industry.

This Strategy can encourage a regional discussion about addressing certain elements of this challenge collaboratively, such as by developing research and development programs or creating capacities for the efficient operation of modern smelters. This regional discussion would also provide a forum for sharing best practices regarding environmental and social requirements and the performance of the copper smelting industry.

Any new smelting capacity must meet at least two crucial requirements: it must be clean and profitable. Technology currently exists to meet the highest international emissions standards, as demonstrated by several smelters that operate without generating a significant impact on their environment, such as the Aurubis smelter in Hamburg, Germany.

In terms of scale, expert opinion indicates that to be profitable, a smelter should have a treatment capacity in the order of 1 to 1.5 million tons of concentrate per year. By way of reference, in 2020, Chile exported more than 11 million tons of concentrate, suggesting that there is room for the construction of more than one new smelter with the capacity in that country alone (USGS, 2024, p.8).

Strengthening the smelting capacity in Latin America is a strategic challenge both because of its geopolitical consequences and for the impact that such a policy would have on the production of low-emission copper. The development of modern smelting projects can be seen as an opportunity to show that it is possible to develop large-scale industrial capacity without destroying the environment. It offers a possible way out of the permanent tension between industrial development and environmental protection, which has had a strong impact on mining activity.

4.3 The lithium triangle: an opportunity for regional collaboration

In the case of lithium, Latin America's advantages are undeniable. This is particularly true regarding the lithium triangle, formed by Argentina, Bolivia, and Chile, which account for more than half of the lithium resources identified as of 2023. Of the total global resources, which in 2023 stood at 105 million tons of lithium, Bolivia's share was 21.9%, Argentina's was 21.0%, and Chile held 10.5%, amounting to 53.4% of the total resources. In terms of reserves, Chile ranks first with 33.2% of world reserves, followed by Australia with 22.1% and then Argentina, with 12.9% (USGS, 2024, p.11).

Resources and reserves allow us to evaluate the potential of each country to produce lithium over time and thus meet the growing global demand for this element. Argentina and Chile report significant industrial production, with 29.7% of the lithium produced globally in 2022. Australia, in the same year, produced 51.2% of the world's total (USGS, 2024).

Australian lithium is extracted from spodumene mines, a lithium-bearing mineral that requires milling and concentration processes prior to refining. The lithium in Argentina, Bolivia, and Chile is dissolved in brine, so refining it requires much less energy than extracting it from its rocky form. This difference also translates into lower production costs (ECLAC, 2022).

The countries of the lithium triangle have different regulatory frameworks for mining in general and for lithium. In Argentina, the National Constitution establishes that the provinces have the original domain of the natural resources existing in their territory. The Mining Investment Law establishes tax stability for a period of 30 years. Argentina has chosen to facilitate foreign investment through a favorable regulatory framework. In addition, with the recent creation of YPF Lithium, a subsidiary of YPF S.A., the Argentine state can participate in exploitation projects in the provinces (ECLAC, 2023).

In Bolivia, there is the Mining and Metallurgy Law Nº535, of 2014, also known as the Lithium Law. The Lithium Law establishes the state's dominion over lithium resources in Bolivian territory and defines the forms of participation in the exploitation of the mineral, allowing the participation of private parties through joint ventures with state companies. For these purposes, the company Yacimientos de Litio Bolivianos, YLB, was created in 2017, with the responsibility of carrying out activities throughout the lithium production chain. To date, YBL reports activity in extraction processes and also in the development of materials and battery assembly (BCN, 2023).

Chile has a special regulation for lithium, which has been considered a non-concessional strategic mineral since 1979. Unlike concessional minerals, such as copper, which require a judicial concession for exploration and exploitation, lithium has a particular regime in which State authorization is required for its production (BCN, 2023). This particularity explains in part why, to date, the same two companies have been operating in the Salar de Atacama since the 1980s, when lithium did not arouse the interest that we see today, and no new actor has been able to enter.

The National Lithium Strategy defines the conditions for the development of new projects in Chilean territory as well as the construction of public capacities around the exploitation, refining, and value addition of lithium. This implies the involvement of the State through its companies in the extraction and refining and the generation of research, development, and innovation capacities for which a Public Technological Institute of Lithium and Salt Flats will be created.

Despite the diversity of regulations in the countries of the lithium triangle, it is possible to observe common points: among them is the declaration of intent to participate in the value chain beyond the production of refined lithium in the form of carbonate or hydroxide. To that end, they aim to develop capacities that will allow them to capture not only rents from lithium exploitation but also the rents associated with downstream value addition, which opens up an opportunity for the development of industrial policies.

One factor that distinguishes the lithium triangle, as mentioned above, is that its lithium is extracted from brines from salt flats. Salt flats are complex ecosystems, and brines often differ greatly in composition, so the development of new projects requires being able to design robust processes on a case-by-case basis (ECLAC, 2023). It is essential to properly characterize the salt flats where lithium extraction and production processes are to be developed. Such characterization should include not only the establishment of baselines to better understand these complex ecosystems but also the construction of hydrogeological models to understand their dynamics in the event of possible brine extraction and/or reinjection processes. This is a challenge common to all three countries in the lithium triangle.

Another relevant aspect is the technology involved. The most commonly used process considers the sequential precipitation of the different salts contained in the brine in order to separate the lithium. To achieve this objective, the brine is deposited in large evaporation pools, where it loses a significant amount of the contained water, which impacts the water balance of the salt flats.

A number of alternative technologies, categorized as Direct Lithium Extraction, are currently being developed that will allow the brine to be extracted and the lithium to be selectively removed. This process leaves a brine with a low lithium content that could be reinjected into the salt flat. A wide range of direct lithium extraction options are now available so pilot-scale test campaigns are needed to select the most appropriate one(s) based on the requirements of each project. The construction of technology testing capabilities presents an interesting opportunity for collaboration between Argentina, Bolivia, and Chile. They perhaps could agree on the development of infrastructure accessible to all three countries or, alternatively, create a network of lithium technology test sites that could be configured as complementary facilities in each of the countries.

In short, a crucial opportunity exists to establish a close scientific and technological collaboration at a regional level by developing characterization protocols and hydrogeological models of salt flats and coordinating and cooperating to identify the best technologies for the extraction and refining of lithium. This collaboration should also extend to the research and development around lithium value addition and recycling.

Positioning the region to compete successfully in the global race for lithium requires achieving an adequate balance among the origins of the companies interested in developing new projects. This means designing an investment attraction strategy that seeks to diversify the presence of foreign interests throughout the triangle. Attention should be paid to the relative participation of Chinese and Western interests – the United States and the EU – in the development of new projects, with the aim of ultimately achieving a configuration that allows the countries of the triangle to participate in a robust and diversified manner in the value-added chains associated with lithium.

These opportunities for collaboration require a fluid dialogue between the countries of the triangle to develop common policies while building long-term capacities at the local level.

5. Conclusions and policy recommendations

Latin America, and specifically the mining countries of the region, cannot be left out of the discussion on critical minerals. It is urgent to start a conversation around the implementation of industrial strategies in each country, which will then give way to a broader discussion on development policy in which collaborative mechanisms are explored at the regional level.

This discussion is particularly important in the context of a critical mineral lottery, where the decisions the region makes today will determine how it will or will not take advantage of this demand boom. As we have argued, the region is under pressure to opt for a passive strategy and, as in previous lottery periods, fails to build regional and national productive capacities. To avoid such an outcome, it is necessary to develop both general and specific proposals and policy recommendations to take advantage of the demand boom for an endogenous process of economic development.

In terms of general proposals, we have focused on four elements:

1. Creating institutional capacity for the long-term perspective of the State. Preventing the public apparatus from falling prey to the short-termism of political cycles calls for strengthening an institutional matrix that coordinates various governmental apparatuses with sufficient resources to implement long-term policies.
2. Reform trade agreements on trade rules to create shared value between investors and governments, both in terms of the regulatory framework for foreign investment and patents. For example, it is suggested that regulations on technology transfer, local content and export diversification be established for FDI, along with making the patent regime more flexible in the countries of the region.
3. A new financial architecture for development, with the necessary scale to finance a new infrastructure for the green transition and equipped with an internal corporative structure to coordinate regional policies with national policymakers.
4. A new productive regionalism to coordinate common policies and rules on FDI and national investments, in order to guide capital and resources towards green transformation and scaling in the value chains.

In terms of specific policies related to critical minerals such as copper or lithium, we have focused on two areas:

1. Strengthening smelting capacity as a way to scale up in the copper value chain and strengthening productive regionalism around the so-called lithium triangle. The aim is to reduce dependence on China, reduce carbon emissions associated with transporting large quantities of copper concentrate by ship to smelters far from the countries from which the copper is extracted, and improve the traceability of copper produced at the regional level.

2. 2. In the case of lithium, there needs to be adequate instruments and procedures to characterize these ecosystems and follow up on the eventual impacts that the development of the extraction activity may have on the different salt flats. Possible regional cooperation is needed to identify, test, and validate modern, low-impact technologies for lithium separation to overcome the sequential precipitation production that requires the evaporation of large quantities of water contained in the extracted brines. The text also proposes regional scientific and technological collaboration and designing an investment attraction strategy aimed at diversifying the presence of foreign interests in the countries of the lithium triangle.

These policy recommendations, however, involve a set of political complexities, both national and regional. As discussed above, the political economy inherent in boom periods exerts pressure for inertia through the formation of coalitions with short-term calculations regarding the economic exploitation of these boom periods. A task that goes beyond the scope of this paper, is how to create a political coalition that can promote the transformation of this boom into solid national and regional productive capacities to ensure sustainable growth in the long term.

Carrying out these proposals implies, among other things, the political capacity to link industrial, investment, and trade policies at the level of public discourse. The objective is ensuring the material bases so that the social demands existing today in the countries, are sustainable in the long term. Ultimately, without a complex productive matrix, social policies cannot be maintained beyond the contingency of a boom moment.

At the regional level, the different institutional matrices in terms of trade and mineral management policies in the countries make it difficult to articulate common policies. An urgent political challenge is to think about how to establish an agenda that, despite the differences, inspires the political will to overcome these institutional restrictions.

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[i] By weak regulation we understand a lack of rules that provides the State with more influence and directionality on the investment in the national territory.

[ii] The term "Dutch disease" is applied to the case of different countries that discover oil or other natural resources and observe a process of real appreciation of their currency, with the consequent effect on industrial exports, it was originally adapted from the discovery of natural gas reserves in the North Sea in the late 1950s. This discovery led to a sharp contraction in industrial exports as a percentage of GDP in the Dutch economy, caused by an abrupt real appreciation of the national currency.

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