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Vincent Bos, Marie Forget

► **To cite this version:**

Vincent Bos, Marie Forget. Global Production Networks and the lithium industry: A Bolivian perspective. *Geoforum*, 2021, 125, pp.168-180. 10.1016/j.geoforum.2021.06.001 . halshs-03320155

HAL Id: halshs-03320155

<https://shs.hal.science/halshs-03320155v1>

Submitted on 2 Aug 2023

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Global Production Networks and the lithium industry

A Bolivian perspective

Vincent BOS

bosvincent@yahoo.fr

Post-Doctoral Research Fellow, EDYTEM, UMR 5204, Université de Savoie Mont Blanc, Pôle Montagne, Boulevard de la mer Caspienne, Le Bourget du Lac, 73370

Marie FORGET

Associate Professor, EDYTEM, UMR 5204, Université de Savoie Mont Blanc, Pôle Montagne, Boulevard de la mer Caspienne, Le Bourget du Lac, 73370

marie.forget@univ-smb.fr

'Declarations of interest: none'.

Corresponding author: Vincent Bos

bosvincent@yahoo.fr

Abstract

This article provides the first detailed analysis within economic geography of the GPN of lithium and of the Bolivian strategy of brine industrialization. Considering extractive and manufacturing chains of the lithium industry, it demonstrates how the production networks' organizational structures and practices are shaped by interconnected relations of cooperation and competition. Specifically the article targets two key points in the GPN literature : i) how the multi-scalar competitive and/or cooperative strategies and practices of forward and backward integrations create and sustain the production networks and their evolution; ii) a combined analysis of the GPN approach with a placed-based interpretation of the political economy of the lithium industry focusing on the central role of states as inter-scalar mediators in strategic coupling relations for the insertion of national economic actors and assets to global markets. We then propose a new interpretation of the global reconfiguration of the extractive chain and its spatial forms.

Keywords

Global Production Networks (GPN), energy transition, Lithium-Ion Batteries (LIBs), lithium triangle, Bolivia.

1. Introduction

Natural resources and energy markets are key sectors of the world economy and at the heart of intricate evolving production networks from local to global. Beyond its justification as a vital part of the response to global change (Bridge *et al.*, 2013; Child *et al.*, 2018), energy transition implies the development of new technologies and energy storage devices. This is particularly the case of the Lithium-Ion Batteries (LIBs) which production relies on a higher demand of raw materials (e.g. lithium, cobalt and nickel). Because of the high power density they offer, these devices meet the specific requirements of key sectors of the global economy, mostly of higher power and autonomy. The case of lithium raises the question of how the energy transition, enacted mostly in the Global North and China, affects extractive regions, mostly in the Global South, where natural resource exploitation for export constitutes a major economic activity. These geographical networks create new 'geopolitics of lithium' which belong to a partially renegotiated resource diplomacy understood as the renegotiation of access to new central resources by state actors and transnational firms and increasing Global South-China relations (Blanco, Razzaque, 2011; Langhorne, 2005).

Indeed, the global economy of lithium consists of a concentrated number of lithium extractive zones (nodes) and key stakeholders (firms and states) which supply the global economy. The extractive

developments and the global flows of lithium minerals, chemicals, derivatives and manufactured products (LIBs¹) reveal a pattern of international global resource demand. The organization of production comes under states and firms that either exploit lithium deposits to obtain basic chemicals², lithium derivatives³ and/or lithium-based energy storage devices. This differentiates territories of raw material extraction from territories that consume the goods produced towards the energy transition (Child *et al.*, 2018).

This article aims at contributing to the rich, yet underdeveloped, Global Production Networks (GPN) analyses that have been conducted in the extractive and energy sectors (e.g. Bridge, 2008; Bridge, Bradshaw, 2017). The GPN approach constitutes a heuristic framework that seeks to understand the complex economic geographies of “fragmented-yet-coordinated” globalization processes (Coe, 2012; Coe, Hesse, 2013; Coe, Yeung, 2015, 2019). It mobilizes a multiscale perspective of social, spatial and temporary interconnections of multiple stakeholders’ relations and practices, encompassing inter-firm, firm-state and extra-firm networks, and their consequent relations of power in the processes of value creation, transformation and capture, that shape the configuration of production networks over time and space⁴. Our article extends recent works on the relations between network territoriality and practices of network coordination in the field. It demonstrates the centrality of extra-firm stakeholders (e.g. state, academics, communities) in the configuration of production networks and in local development outcomes (Arboleda, 2019; Bebbington, Bury, 2013; Yeung, 2017).

It particularly addresses the knowledge gap of the GPN literature analyzing states as inter-scalar mediators in **(1) the strategic coupling of local assets to global markets and players and in the organizational practices of integration** that configure the production networks in the extractive sector. The conceptualization of the strategies of production network integration enables to escape a determinist firm and governance-centered gaze allowing a better understanding of the new geopolitics of extractive industries and energy.

We also demonstrate how **(2) a place-based analysis of the GPN** favors a better understanding of the local development outcomes of the production networks. In Latin America, this approach is particularly useful to understand the socio-spatial circuits through which natural resources are

¹ “The LIB is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and record the reverse path when charging” (López *et al.*, 2019 :73).

² Lithium carbonate, lithium chloride, lithium hydroxide are used to produce derivatives.

³ Ex. Lithium carbonate for LIB cathode materials.

⁴ For a discussion on the similarities, differences and (co)-evolution processes of the concepts of GPN, Global Value Chains and Global Commodity Chains see e. g. Bair, 2008; Coe, Yeung, 2015, 2019; Gereffi, 2018; Neilson, Pritchard and Yeung, 2014.

commodified, exploited and governed, due to the importance of extractive industries in the historical schemes of development.

By outlining the reconfiguration of the production networks of lithium over space and time, due to recent energy transition dynamics, we address two critical points of the GPN recent developments:

(3) focusing on a core regional zone of the GPN, the article combines the networked GPN perspective with a place-based interpretation of an economic system (Coe, Hess, 2013: 7). We demonstrate how the organizational structures and geographical forms of the GPN of lithium are shaped by pioneers of the sector, also called central “agents” (Sunley, 2008) or “lead firms” (Baglioni, Campling and Havice, 2017), by multi-scalar strategies, practices and interactions. The GPN encompasses five core stages of material transformation from extraction, refining, processing/manufacturing, consumption, and recycling for greater value capture in the dispersed economy of the lithium industry⁵. We show how the ongoing tendency of vertical integration oscillates between cooperation and competition as a global strategy of market control (idem). Pioneers and newcomers are mostly engaged in a backward integration trend (Bridge, Bradshaw, 2017) of firms’ activities (Baglioni, Campling and Havice, 2017), part of a broader trend in the global minero-energetic sector (Bridge, 2008). We demonstrate that this backward integration trend⁶ is mainly led in key territories of the extractive chain of the GPN, particularly in the Andes, by stakeholders already integrated into the GPN itself. This induces a socio-spatial reorganization of the structures of the production networks, from upstream raw material extraction to downstream LIBs consumption. Stakeholders try to overcome the critical materiality and embeddedness of the GPN, through new strategies of forward and backward integrations in new territories and industrial sectors.

(4) showing how the GPN are being reconfigured by and respond to the influence of energy transition policies and local strategies. We demonstrate the centrality of the state as key ‘inter-scalar mediator’ (Coe, Yeung, 2019: 782) in the political economy of production networks as a direct and indirect stakeholder to insert local economic actors with global networks (Baglioni, Campling and Havice, 2017; Coe, Yeung, 2019; Yeung, 2017). The analysis of the national industrialization of lithium, from brines extraction to the public production of LIBs, takes place in a “resource nationalism” context that aims at repositioning the state in the governance of natural resources (Perreault, 2006, 2013). It shows how the strategic coupling of national economic actors and assets with global economic actors slowly contributes to the reconfiguration of the organizational

⁵ The exploration phase is not considered as it is not part of the process of material transformation of the resource.

⁶ This means that “(...) downstream firms invest in assets upstream (and vice versa) in order to share risk and capture value” (Bridge, Bradshaw, 2017: 231).

structures and the geographical forms of the GPN. Considering the local development outcomes (Coe, Dicken and Hess, 2008; Henderson *et al.*, 2002), by mobilizing the geographical concepts of place, scale and network (Bebbington, 2003; Coe, Hess, 2013), the article ends by demonstrating how the GPN approach can contribute to an analysis of development in a multi-scalar level perspective. The final focus on the incipient delivery of locally produced LIBs to poor households in favor of universal access to energy in disconnected rural areas illustrates the capacity of a state-owned enterprise to address social needs by conciliating political and economic objectives. Nonetheless, it also shows the difficulty in scaling up this policy due to a yet unstabilized technology, no large scale LIBs production and no solid export contracts.

As well, we address **(5) a knowledge gap in the energy transition studies** that often consider the global lithium-ion batteries needs without relationning it to the resource disponibility. Therefore, mobilizing the GPN approach demonstrates how the global context of energy transition connects the extractive and the manufacturing sectors, revealing complex production networks around nodal spaces and core stakeholders, constitutive of an emergent global market.

A combined methodology of data analysis, the GPN heuristic framework and fieldwork investigation with qualitative research was conducted in Argentina, Bolivia⁷ and Chile (the three countries of the Latin American “Lithium Triangle”) between October 2018 and November 2019, based on field observations, semi-structured and open-ended interviews (119) with multiple stakeholders⁸. This methodology allowed to model and understand the social, spatial and temporal interconnections at the different stages of the GPN of lithium considering both the inter-firm and firm-state relations as well as the extra-firm networks, such as public authorities or local populations, that shape the firms’ activities in terms of regulation and spatial development.

2. Lithium-based Energy Transition: from Trade to Global Production Networks

2.1 Lithium, a strategic resource

⁷ Recent political changes in Bolivia have not been incorporated into this paper, but have not fundamentally reshuffled the original cards.

⁸ Including elected authorities, national and local public servants, economic actors both public and private, of different ranks and departments, members of associations, economic actors, both private and public, majors and juniors companies from the extractive and manufacturing chains and local inhabitants, directly and indirectly engaged with or affected by the lithium economy.

Unlike other non-renewable natural resources, such as oil (Bridge, 2008) or Liquefied Natural Gas (Bride, Bradshaw, 2017), lithium is not a mature industrial sector and is not yet marketed as a “commodity” as it lacks a specific or indexed price for the resource on the stock markets. This situation can be explained by a relatively undisclosed use of the resource until the turning point of the 2010s and the consequent reorganization of the global geopolitics, and hence GPN (see below, Azevedo *et al.*, 2018; Gouze, 2010). Furthermore, Lithium Carbonate Equivalent (LCE)⁹ is currently mostly produced for industrial applications including Lithium-Ion Batteries.

As social constructs (Raffestin, 1980), natural resources result from contingent social processes of material transformation: “resources are not; they become” (Zimmermann, 1951: 15; De Gregori, 1987). The strategic dimension of lithium relies on three main factors: i) its importance in the manufacturing chain being essential to the production of key industrial products, ii) the potential tension, in the future, between high demand due to technological competition and market supply¹⁰, and iii) the concentrated geographical location of its production networks around nodal spaces and stages of material transformation.

The supply structure can be qualified as oligopolistic due to the number of main country producers and the control of the main share of production by an even more reduced number of economic players (Cochilco, 2020; USGS, 2020). Nonetheless, lithium arouses the interests of several stakeholders. Transformed to obtain higher levels of concentration (LCE & derivatives), its chemical properties find openings in several key sectors of the global economy. It has an economic centrality in Information and Communication Technologies and in the automotive sector with the expected bifurcation towards electric mobility allowed by LIBs, explaining its global growth perspective (IEA, 2020; McKinsey & Company, 2020). “Lithium [...] is bringing together energy, automotive and technology companies to foster an energy revolution” (Millennial Lithium Corp., 2020: 4). In the medium term, two main growth drivers of LIBs will dominate the global lithium consumption: Electric Vehicles (EVs) and on-board systems for ICTs (cell phones, laptops, etc.) (Cochilco, 2020; Gouze, 2010; Sun *et al.*, 2017).

In 2019 Lithium-Ion Batteries accounted for more than half of global lithium demand (Roskill, 2020; USGS, 2020), a third (32 %) of which for EVs (Cochilco, 2020). According to industrial forecasts, in

⁹ LCE is the unit of measurement of the global production of lithium. It serves to compare the different volumes of production of various derivatives of the resource.

¹⁰ Despite the falling in lithium carbonate and hydroxide prices in the 2019 and the falling in the demand and sales of lithium compounds for the rechargeable battery industry and industrial applications in 2020 due to covid-19, global demand is expected to grow whilst refined lithium supply would remain tight (Roskill, 2020).

2025 both the global demand (+263 %) and production (+220 %) of LCE could triple compared to 2019 to represent about 1 million tons of LCE (idem; The Motley Fool, 2020)¹¹.

Lithium will not become a “*new eldorado*”. Despite the possible bifurcation of the automotive sector towards electric mobility (hence LIBs) and the economic profit anticipated, lithium will remain a “niche market” equaling to a few hours of oil market transactions. However, the global context of energy transition and the growing use of lithium in key economic sectors provoke a reconfiguration of the organizational structures, network practices and geographic forms of the production networks of lithium around key stakeholders and nodal spaces that hold together the Global Production Networks of lithium.

2.2 Modeling the Lithium Production Networks

Data analysis of lithium’s geophysical distribution and economic flows helps to model a spatial understanding of the political economy and geography of lithium, revealing multi-scalar interconnections between several key stakeholders and territories at different stages of the GPN, that directly contribute to the organizational structures, network practices and geographic forms of production networks.

Lithium is a soft alkali metal, but not encountered in its pure metallic form in nature. It is mainly present in six natural deposit forms: brines (58%); pegmatites (26%); clay (7%); hydrocarbon brines (3%); hydrothermal brines (3%); and zeolite (3%) (López *et al.*, 2019). Each form requires specific technologies for its exploitation and transformation. In the three Andean countries analysed, only brine deposits have been considered. The GPN of lithium is organized by a model of production based on five moments of material transformation (Bridge, Bradshaw, 2017; Coe, Hess, 2013): i) resource mining (extraction¹²), ii) chemical production (refining), iii) product manufacture (processing/manufacturing), iv) product use (consumption) and, v) waste management (recycling)¹³. Each stage of material transformation involves specific forms of lithium products: primary sources (brines, ores and clay), chemical basis (carbonates, hydroxide, chloride) and chemical derivatives, among which the cathode materials used for LIB production¹⁴ (Sun *et al.*, 2017; see fig. 1). These products are globally exchanged raw, as semi-processed chemicals (carbonate, oxide and hydroxide), derivatives or processed goods (LIBs).

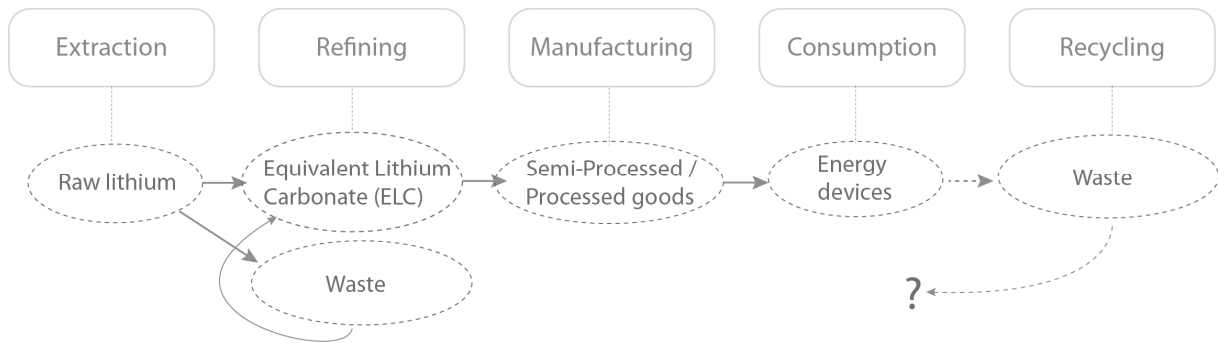
¹¹ The threefold trend in the production was also mentioned by the Technical Director of Eramine Sudamerica S.A, Buenos Aires, Argentina, 11/19/2019.

¹² The five stages are preceded by a pre-stage of exploring.

¹³ Recycling concerns LIBs, manufactured lithium-based devices, scrap production and waste management of raw material after the refining stage, particularly for stationary applications (Pagliaro, Meneguzzo, 2019).

¹⁴ Including lithium cobalt oxide (LCO), lithium manganese oxide (LMO), lithium iron phosphate (LFP), lithium nickel cobalt manganese oxide (NCM) or lithium nickel cobalt aluminium (NCA), etc. (Azevedo *et al.*, 2018; Sun *et al.*, 2017).

Figure. 1 The five stages of material transformation and value capture of the GPN of lithium



Source: elaborated by the authors.

In terms of spatial location, lithium is not a rare ore (USGS, 2020). Resource assessment is debated¹⁵. The resource is said to fluctuate between approximately 31 million and 41 million tons, and its reserves between approximately 8 and 24 million tons¹⁶. In terms of reserves, brines constitute the main reserves: about 60 % to 80 % of the total resources (Gouze, 2010: 85). Continental brines vary between 45 % to 65 % of the reserves (Olivera Andrade, 2016: 92) whereas pegmatites and other rocks oscillate between 20 % and 25 % of the global reserves (idem).

A geohistorical perspective helps to understand the complex configuration and geographic scope or territoriality of the lithium GPN and its evolution. The initial configuration of the production networks began after its scientific discovery at the beginning of the nineteenth century and its first industrialization in Germany in 1923 (Garrett, 2004). Production was soon dominated by the USA and Zimbabwe, from the 1950s until the 1980s, and ranged from about 5000 to 25 000 tons per year between 1980 and 2008 (Mohr *et al.*, 2012). Nonetheless, at the beginning of the twenty-first century, lithium production is marked by a rising trend. In 2019 lithium production was estimated to 95 000 tons (USGS, 2020), corresponding to 325 000 tons of LCE (The Motley Fool, 2020).

Lithium is mainly produced in eight countries: Australia (54.5 %), Chile (23.4 %), Argentina (8.3 %), China (9.7 %), Zimbabwe (2.1 %), Portugal (1.6 %), Brazil (0.4 %) and Canada (0.3 %) (USGS, 2020: 99)¹⁷. The first four occupy a core position in the production networks. This market evolution illustrates a reconfiguration of the extractive chain where nodal spaces of production appear,

¹⁵ Resources and reserves are dynamics. They change according to scientific knowledge, technologies used to measure and extract them due to social needs.

¹⁶ 39 million tons for Gruber *et al.*, (2011 in Olivera Andrade, 2016: 90), 25.5 for Kesler *et al.*, (2012 in idem: 91) and 40.7 for the USGS (2016: 101). Reserves oscillate between 23.6 for Mohr *et al.*, (2012 in idem: 92), 14 million tons (U.S GS, 2016: 101) and 8.3 million tons for Roskill (2016 in López *et al.*, 2019: 42).

¹⁷ Data from Colchico (2020) diverge, with an important gap for the producers: Australia (48 %), Chile (29 %), Argentina (9 %), China (9 %) and others (5 %).

recalling the centrality of space, or “place dependency” (Forget, Bos and Carrizo, 2021) in the configuration of the productive chains.

The reconfiguration of the production networks has led to a spatial enlargement of the extractive territories with a turnaround of the extractive chain as the two previous major countries of production, the USA and Zimbabwe, have been removed from the top of the extractive chain. It reveals a complexification of the networks as the extractive chain evolved from two main producing territories located in North America and Southern Africa to four main producing territories located in different regions, newly central in the extractive chain: Australasia (64.2 %) and South America (31.7 %), these two regions contributing to about the whole (95.9 %) production, the rest scattered among a few other territories.¹⁸ Most of the production is now located in the Global North (56.4 %)¹⁹. These extractive territories constitute new core nodes of the chain whose dynamism could potentially be constitutive of a future global market.

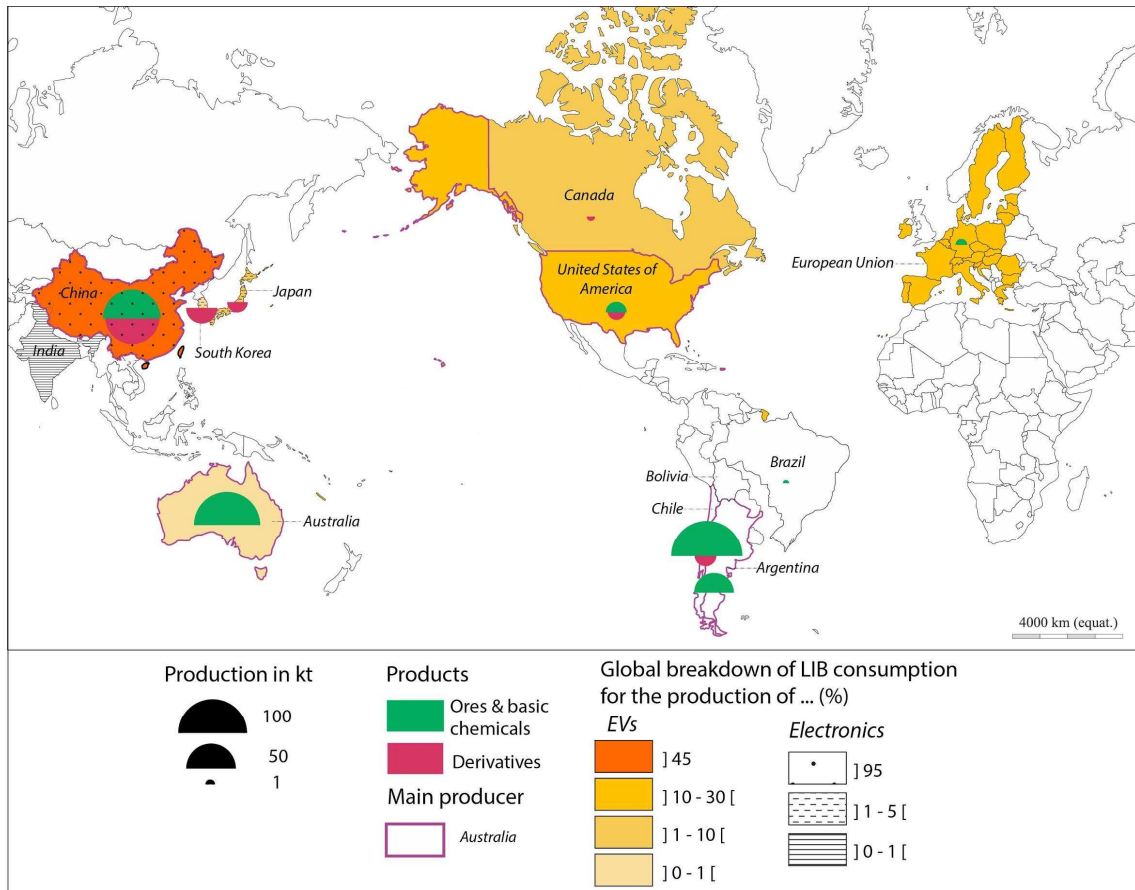
In 2014, the global flows of raw and semi-processed lithium on one hand and derivatives and manufactured products on the other (map 1) demonstrate a considerably unbalanced distribution in the geographic zones of production and consumption (Sun *et al.*, 2017)²⁰. The situation is broadly similar to the structure of the world system, pointing to a specific international division between labor and consumption. However, it illustrates the core position of East Asian countries in the manufacturing stage of LIBs devices, especially in electronics, and in the electric mobility, directly competing in the later with the Global North economies.

Map 1. Global lithium production and consumption poles

¹⁸ Three of the four remaining producing countries point to a specific region: South Africa (Zimbabwe = 2.1 %), Europe (Portugal = 1.6 %) and North America (Canada = 0.3 %).

¹⁹ The expression refers to Australia, Portugal and Canada whereas the Global South refers to Argentina, Brazil, Chile, China and Zimbabwe if we still consider China as a member of this category.

²⁰ The information is not the most recent due to the unavailability of bilateral trade data for all key regions preventing the corrections for re-exports. Nonetheless, it is more accurate than the fallings observed due to covid-19.



Source: Sun *et al.*, 2017 modified by the authors.

The production of raw lithium and basic chemicals takes place in seven territories²¹ but more than nine tenths are concentrated in two regions: Australasia (Australia and China) and South America (Chile and Argentina) (Sun *et al.*, 2017). Australia is the leading country for ore exports while Chile is the leading country for brines. These flows are almost entirely imported by China.

Lithium chemicals are the most traded form of lithium, representing almost three times the outflows of raw lithium. China has the highest production of basic chemicals, including lithium carbonate and lithium hydroxide. Chile produces lithium carbonates such as Argentina which also produces lithium chloride. In terms of lithium chemical exports, Chile, Argentina and Australia are the leading countries with Chile leading the exports of lithium carbonates, Argentina of lithium chloride and Australia of lithium concentrates. These lithium chemical exports are almost entirely consumed by three regions: East Asia (China, Japan and South Korea), North America (USA) and Europe.

Six countries from three regions produce lithium derivatives²². One, East Asia (China, South Korea and Japan), plays a central role by concentrating more than three quarters of the production with

²¹ The European production is presented as a whole.

²² Lithium cathode materials accounted for two thirds (68 %) of the production of lithium chemical derivatives (Sun *et al.*, 2017).

one country, China, representing more than half the production, followed by South America (Chile) and North America (USA and Canada).

Lithium-based manufactured devices are less traded forms of lithium in terms of quantity. The manufacturing stage of lithium is concentrated in one region, East Asia, with South Korea and China for LIBs and products containing LIBs. Three main regions import lithium-based devices: East Asia (China), North America (USA) and Europe.

Therefore, the global lithium economy shows a spatial concentration of production and consumption around three main poles that form the main nodes of the GPN of lithium: i) the extraction of raw material and semi-transformation (basic chemicals) are located in Latin America and Australasia, ii) three regions, East Asia, South America and North America, compete in the production of lithium derivatives but more than three quarters are produced in three Asian countries while, iii) manufacturing is mostly located in East Asia, in the USA and in EU with recent investments.

The socio-spatial reconfiguration of the GPN and its consequent geographic forms in the Latin American “Lithium Triangle” are due to the stakeholders’ strategies and practices of forward and backward integration of the production networks leading to the verticalization of the GPN.

3. Regional integration and GPN reconfigurations over space and time

3.1 Regional Integration strategies in the “Lithium Triangle”

Combining a GPN analysis with a territorial interpretation of the lithium industry allows to better understand how global political, economic and ecological dynamics influence the inter-firm, international and inter-state strategies of forward and backward integration trends that reshape the historic organizational structures and the geographic forms of the GPN.

The location of lithium deposits in a condensed space has given birth to the qualifying expression of “Lithium Triangle” (map 2) which comes under global imaginaries (Barandiarán, 2019) rather than institutionalized strategies of regional integration besides a stated will of shared quantification²³. However, this ongoing cooperation would not hide a fierce state competition to attract foreign investment and transnational firms over each territory by offering distinct conditions to access and exploit lithium, according to the different governmental visions of the role of the state in the GPN (e. g. fig. 2). The regional integration around lithium more likely corresponds to a “bottom-up process” led by extra political stakeholders.

²³ A technical cooperation with the British Geological Survey, the Inter-American Development Bank and the geological service of each country aims to better quantify both the national and regional reserves through a common methodology for brine deposits in altitude (Ms Carolina Sánchez, Mining Secretary of the Nation, Buenos Aires, 02/05/2019).

Each year since 2014, academics of the three Andean countries, and increasingly from the world, share scientific knowledge on lithium through regional workshops: the *International Workshop on Lithium, Industrial Minerals and Energy* (Sérandour, 2018). Academics working in regional universities at the closest of the brines play a key protagonism in structuring these exchanges. These multi-scalar relations could be analyzed as local attempts to reposition the region and hence to reconfigure the local GPN. They try to make alliances and to influence the strategic coupling processes of local assets (resource, knowledge or even agents : academics themselves or local firms) within other stakeholders. These potentially include global firms in search of resources and a local ‘embedding’ strategy. Local academics also aim at concluding alliances with firm-stakeholders. This hypothesis could be sustained by the participation of core firm players in the discussions as the Chilean SQM participation and sponsoring in 2020 demonstrate.

Nevertheless, all the interviews conducted in the region with firm representatives and several academics pointed that firms develop their own strategic and undisclosed knowledge on lithium regardless of local scientific research. Even in Bolivia, discussions on lithium exploitation are marked by peripheral-central dynamics of suspicion between public agents of different arenas (local academics v. central politicians) and territories (e.g. University of Tomás Frías in Potosí v. the public company headquarters in La Paz see below). However, lithium exploitation induces local interactions which are embedded in broader social relationships in this transfrontalier area. The term “Altiplania” could be proposed as an alternative name of the “Lithium Triangle” to overlap the focus on lithium and consider broader resources as much as the social and spatial relations in a shared geographic environmental habitat (Forget, Bos, forthcoming).

3.2 Reconfiguring the GPN

The Andean brines form a trans-border geological area containing more than half (55.1 %) of the global reserves of the resource (brines and ores) and more than three-quarters (84.5 %) of the global brines reserves (Olivera Andrade, 2016). Moreover, brines currently constitute the easiest and cheapest geological form for economic extraction in terms of cost analysis and technologies employed²⁴. The growing economic centrality of lithium for key economic sectors and the perspective of growth of the EV market ²⁵, combined with the local recent public regulations of the resource adopted by the states, particularly in Argentina and Bolivia, have placed the Andean region in a central position of the GPN. It recalls the importance of the embeddedness of natural resources

²⁴ The average cost of production per ton of lithium carbonate from pegmatite oscillates between 8300 and 9000 US\$ v. 4100 and 5750 US\$ from brines and fluctuates, for lithium hydroxide, between 6000 and 9000 US\$ from pegmatite v. 5200 to 6800 from brines (Colchico, 2020).

²⁵ Sales of EV globally rose by 9 % in 2019 compared to 2018 against 65 % from 2017 to 2018 (McKinsey & Company, 2020).

and extractive chains in the GPN as two Andean countries, Chile (23.4 %) and Argentina (8.3 %), produced almost a third of the global production in 2019 (USGS, 2020) while the Bolivian production is not industrialized yet and still in a pilot phase in mid-2019. The economic development of the deposits is driven by complementarities between local assets (lithium deposits) and the needs for market supply of mostly extra-territorial actors (LIBs producers and consumers) situated within global production networks.

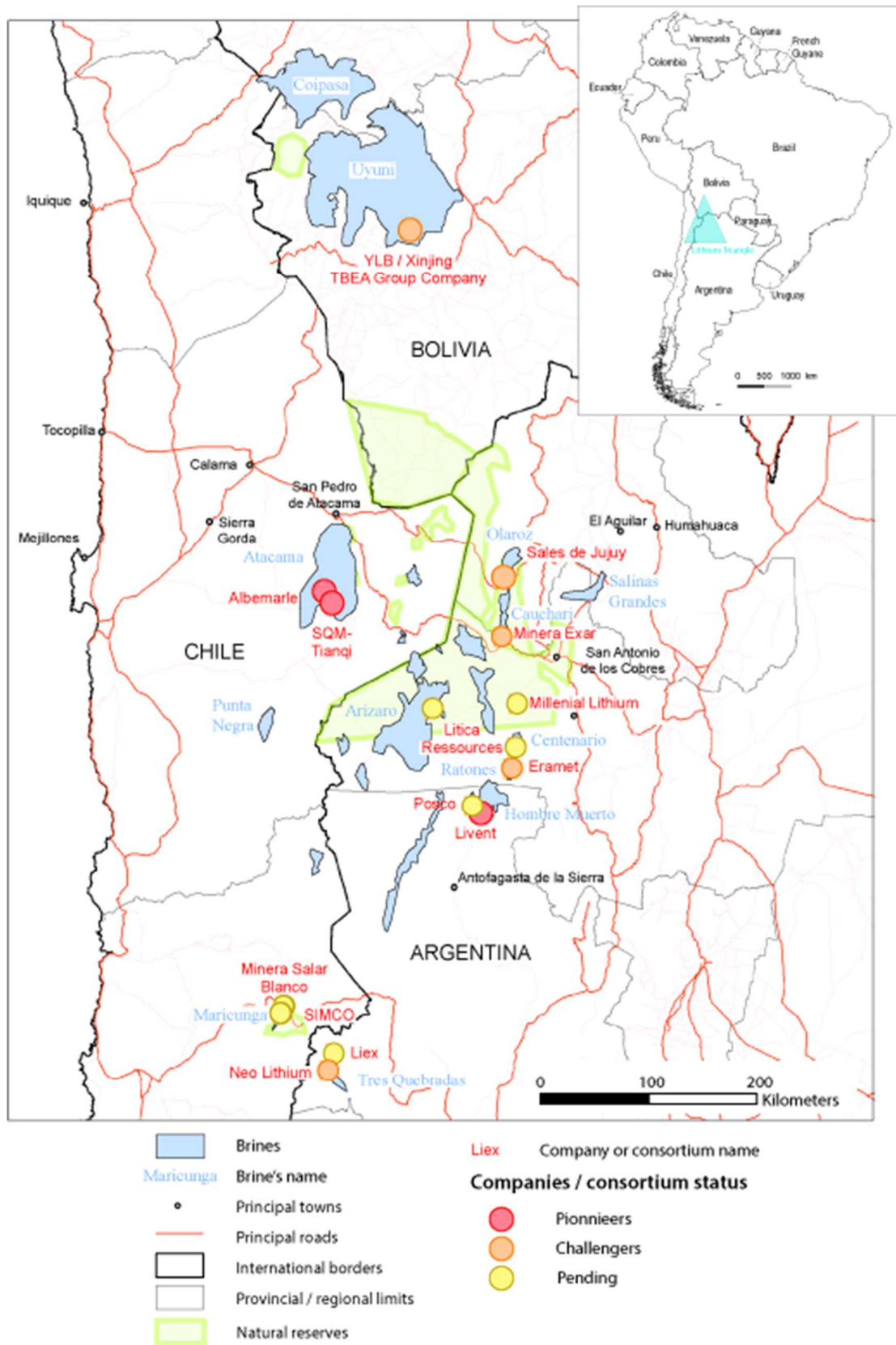
The globalized energy transition has recently complexified the GPN which historically has been dominated by certain stakeholders. Growth in demand and market opportunities have brought out many “challengers” over the last two decades, mostly from the manufacturing chain or engaged in other extractive processes. This change echoes the broader global vertical integration of the extractive sector and the new geopolitics of mining and energy transition.

a. The pioneers of lithium: the early configuration of the GPN

Lithium constitutes a dynamic market in a phase of reorganization, whether we consider the inter-firm or firm-state relations for LIBs production.

As mentioned above, the first industrialization of lithium began in Germany in 1923 with the private firm Metallurgische Gesellschaft (MG), the ancestor of Chemetall, in the chemical industry. Nevertheless, lithium has historically interested states where deposits have been identified due to its strategic use in the defense sector so that Research & Development (R&D) activities have generally been conducted by or in close coordination with the national army. The state, though, plays a central role in the early configuration of the GPN through direct regulation, direct or indirect production, research or providing knowledge and technical support (Horner, Alford, 2019). This is particularly true in the USA and in Chile. In the 1940s, the American government and the private firm Lithium Corporation of America (Lithco, 1947) worked together to develop an industrial application for the resource. During and after WWII, research was conducted to develop the thermonuclear bomb. Then, in the 1970s and 1980s, the interest in lithium decreased in the military sector and rose in the private sector. At that time, lithium was mainly used in the chemical, fertilizer, ceramics, glass and lubricating grease industries. Nonetheless, in Latin America, an early cooperation between public and private actors favored the emergence of pioneer firms which directly contributed to the organizational structure and practices of the production networks and its initial geographic form. These firms now play a strategic role in the GPN. Indeed, early access to the Andean deposits favored a scientific and technological advance for a very small number of stakeholders and hence the capacity to partly structure the GPN (chains and trade).

Map 2. Spatial concentration of lithium in South America and its mains extractive stakeholders²⁶



Source: elaborated by the authors.

²⁶ Data, 11/2019.

In Chile the role of the pioneers results from a direct relation between public and private economic actors. In 1975 the state declared lithium as a material of “nuclear interest” and in 1979 as a material of “national interest”. This ultimate regulation excludes lithium from the legal concessions regime²⁷ and hence provokes a legal restriction of access to the resource with direct spatial consequences. The initially public company SQM (*Sociedad Química y Minera de Chile*), privatized under Pinochet, developed interest in lithium in the early 80’s. SQM accessed lithium deposits in 1995 through a bilateral contract with the public institution CORFO (*Corporación de Fomento de Producción*) which acquired concession rights on lithium deposits in 1977 (OCMAL, OLCA, 2019). This situation demonstrates an early configuration of the GPN based on a horizontal strategy of economic diversification, yet embedded in the national extractive sector. In parallel the private American company Albemarle (then Foote Minerals) accessed the resource in 1980 through a bilateral contract with the same company CORFO.

The situation points out an early configuration of the GPN of lithium at both local (Chile) and global scales based on a vertical backward integration of the production networks from the manufacturing to the extractive chain. In the same way, after its failure to settle in Bolivia, the American firm FMC signed a contract with the Argentinian state to exploit lithium in 1991. This prior historical access to the South American lithium deposits, through cooperative yet contracted strategies of both forward and backward integration for the control of the resource itself and hence its transformation, allowed these pioneer stakeholders to partly dominate the extractive chain in the region. Indeed, with bilateral contracts and concession rights, the three companies secured their access to the deposits and developed key knowledge and technologies to corner the global market of resource extraction and processing. This gave them an advantage over other investors as shown by Gereffi (1994).

Nevertheless, the GPN is dynamic and is characterized by an ongoing reconfiguration due to the arrival of new stakeholders in the region attracted by the global perspective of profit and technological shifts.

b. Diversification and verticalization of the GPN in the “Lithium Triangle”

The GPN is characterized by a competitive environment or “drivenness” i.e., a global strategy of market control (Baglioni, Campling and Havice, 2017). All the stakeholders develop strategies of forward and backward integration of the production networks based on relations of cooperation and

²⁷ Decree 2886.

competitiveness to “vertically integrat[e] direct ownership of activities or by controlling other firms’ activities” (idem; Bridge, Bradshaw, 2017).

In 2019, three firms drove the majority of the global production of lithium. These pioneer firms are all present in the South American lithium triangle, demonstrating its key position as a spatial node of the GPN. This presence can be direct like Albemarle (USA), Livent Corporation (USA) and SQM (Chile), which produce lithium in Argentina and/or in Chile (map 2). Their strategy consists in a direct territorial presence to ensure access to the resource. When associated with the refining stage, it corresponds to the traditional model of integration (fig. 2 A). It also allows the development of early knowledge and techniques that found the GPN’s initial geographic form. In other words, as the firms come from both the extractive sector and/or other manufacturing industries, the early strategy developed covers upstream raw material extraction and refining (fig 2 A.). Therefore, the pioneer firms won a core position in the early constitutive GPN assuming a central role in the extractive chain and more precisely, of the production network as extractive producers and refiners.

This control over the resource, the territories and the production network, may be direct or may rely on cooperative alliances, total or partial, through the conclusion of joint ventures as Tianqi Lithium (China) in Chile, Ganfeng Lithium (China) in Argentina or Sales de Jujuy (Australian-Japanese-Argentinian company)²⁸ in Argentina. Lithium extraction has not always been the core business activity of the pioneers. Indeed, most of these actors developed an interest in lithium because of a previous industrial activity in chemicals for ceramics, glasses, colorants (Chemetall, Albemarle, Lithco), in the military (Livent) or in fertilizers (SQM, Albemarle, Livent as ex FMC). In other words, the core position of the pioneers in the lithium production networks relies on a previous early strategy of economic diversification. This strategy allowed them to develop a leading position in the organization in the actual GPN, by locking key stages of material transformation, particularly connecting the extractive and refining in nodal territories.

Nevertheless, the GPN is dynamic, part of a broader reconfiguration. The region faces the arrival of new economic stakeholders from both the Global North and the Global South. These stakeholders can already be involved in the manufacturing chain of LIBs and lithium-by products, mainly in the automotive sector (fig. 2 D). Joint ventures allow strategic coupling of the extractive, manufacturing and consuming stages by controlling other firms’ activities. This penetration of the lithium production networks is led by those we call the ‘newcomers’, which generally are not total outsiders of the GPN whether because of the strong organizational structures and network practices already developed and the costs of entry in this market. This is for instance the strategy developed by Chinese firms, all driven by the growing market of lithium-based energy storage devices (map 2).

²⁸ Structure analyzed below.

Some distinctions could be made though between these “challengers” according to the current development, or capacity to develop their projects. The acquisition of 23.77 % of the shares of the Chilean pioneer lithium producer SQM²⁹ in Chile by Tianqi Lithium corresponds to an indirect horizontal integration, encompassing the refining stage. It also corresponds to a vertical integration as a whole, through a minority takeover of a pioneer firm. A similar strategy of integration based on majority control is developed by Ganfeng Lithium, “China’s largest lithium compounds producer and the world’s largest lithium metals producer”. This main actor of the lithium manufacturing chain founded a new alliance in 2017 with the constitution of the Minera Exar joint venture with the Canadian Lithium America Corp. Ganfeng controls 51% of the shares to extract and refine lithium in the Argentinian Province of Jujuy from 2018. The ongoing reconfiguration led by the newcomers leads to a backwards integration of the GPN, especially when the newcomers come from the manufacturing stage.

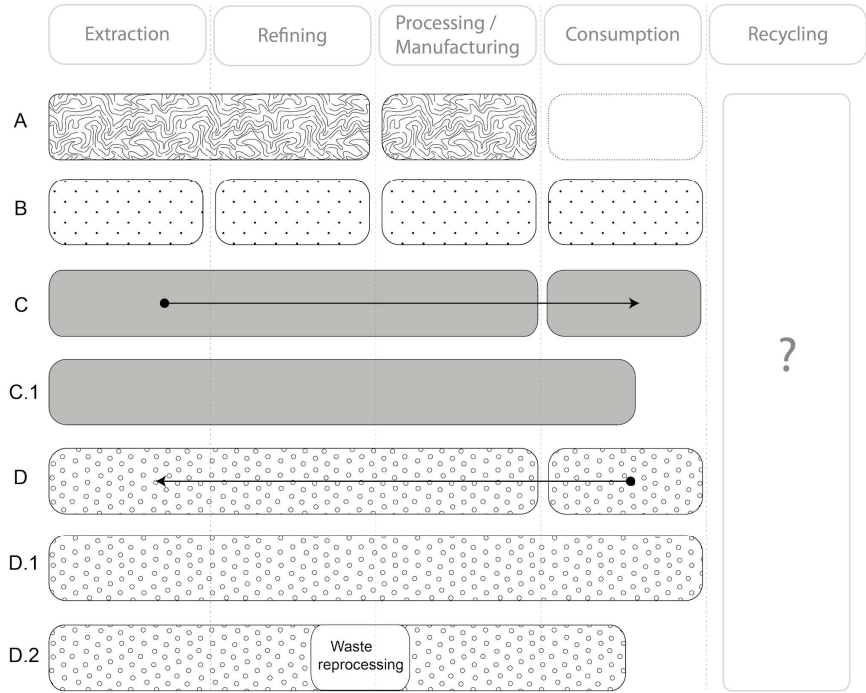
The reconfiguration can also rely on state-firm relations. Indeed, a public participation allows the states to integrate the global market using a forward integration for those controlling the deposits, a backward integration for those controlling the manufacturing industries, or a combined integration for those controlling both (like China or Bolivia, below). The joint venture founded in 2010 between the Japanese Toyota Tsusho Corporation (27.32 %), a global newcomer of the GPN of lithium from the automotive sector and the Australian mining company Orocobre Limited (72.68 %), a newcomer from the extractive chain to form the Sales de Jujuy Pte Ltd., in order to extract lithium (Orocobre Lithium Facility Project), shows another example of the ongoing reconfiguration and verticalization of the GPN in the region. The strategy relies on a multi-stakeholders’ alliance of cooperation towards a concomitant forward and backward integrations depending on the actor considered. Indeed, in 2012, the local government of Jujuy requested to acquire 8.5 % of Sales de Jujuy, through its public company JEMSE, to gain access to the mining concessions in the Province. This strategy conducted by the local authorities in the Province constitutes an example of the integration of public stakeholders to the GPN for a greater value capture in the resource commodification and transformation.

The situation illustrates the potential power of the state as an inter-scalar mediator between local and global, by assuming the role of regulator and of producer. In 2019 the public provincial firm JEMSE formed a joint venture, Jujuy Litio S.A, with an Italian company of electronic components Seri Industrial Spa in order to produce LIBs. However, according to the admissions of several representatives of global economic firms and of public state agents from the extractive and energy sectors, this situation is more a political agreement than a strong strategy of vertical backward integration.

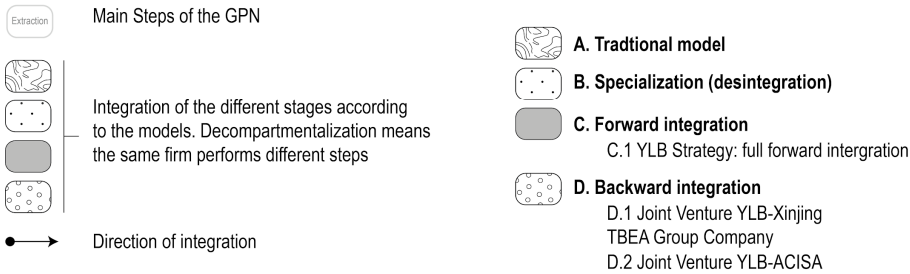
²⁹ It is historically specialized in the chemical transformation of the resource and is also the main producer of lithium in Australia (Ores) through the acquisition of 51 % of the shares of the Greenbushes Mines in 2013.

The Bolivian strategy is different as it aims at vertically integrating the lithium production networks in a direct and dominant forward perspective through a public strategy of industrialization of its brine and local production of LIBs.

Figure 2. Organizational trends in the lithium production network



The four main models of the Lithium GPN



Source: Elaborated by the authors, adapted from Bridge, Bradshaw, 2017, fig. 5. : 230.

4. Bolivia, re-embedding the GPN and social upgrading³⁰

4.1 The Bolivian public industrialization of lithium, an attempt of a direct and dominant total forward integration

³⁰ This section is based on data collected during fieldwork investigation in 04/2019 (see methodology).

Without mentioning the traditional knowledge and local uses of the sodium concentration by local inhabitants, Bolivia's lithium deposits have been known for decades and have attracted several stakeholders from both inside and outside the country. The country possesses more than a third (37 %) of the world brine reserves and around a quarter (26.5 %) of the world reserves of lithium (Olivera Andrade, 2016). However, the pioneer development of the extractive chain has taken place in Argentina and Chile due to the difficulties for private firms to settle in the country. Nevertheless, scientific research has been carried out between 1974 and 1985, beginning with activities conducted by the Bolivian public university UNSA (*Universidad Nacional de San Andrés*, La Paz) with the French public institute ORSTOM (*Office de la Recherche Scientifique et Technique Outre-Mer*; Risacher, Ballivián, 1981).

After the failed installation of the American company Lithco in the country, due to social conflicts and a unilateral modification of the regulations by the state in 1993, the public economic interest for lithium rose at the beginning of the twenty-first century in the global context of higher demand. Since 2008, Bolivia has engaged in a new phase of development based on a direct public industrialization of its lithium deposits located in three main brines, *Uyuni*, *Pastos Grandes* and *Coipasa* (map. 2). The project is part of a broader public strategy of national sovereignty recovery focused on natural resources (Perreault, 2006, 2013) and of consolidation of national identity based on the idea of a public industrialization of lithium to ensure national economic development (Olivera Andrade, 2017; Revette, 2017). Specifically, the public lithium strategy relies on a national-scaled embedded integration of four of the five stages of material transformation, from extraction to LIBs production and partial consumption.

This scheme of development aims to capture greater economic and technological value. The strategy goes beyond a generic trend of forward integration as it targets both the exportation of locally produced LIBs and includes an incipient national consumption. Indeed, the Bolivian strategy constitutes an attempt of 'total forward integration trend' based on a direct control of the production network, yet not 100 % nationally led (fig. 2 C.1). It first relies on a geographical, legal and institutional construction of the resource (Baglioni, Havice and Campling, 2017; Raffestin, 1980). In fact, the regulatory frame corresponds to what Mayes (2015) analyzes as a normative ownership frame of mineral and resource-based commodities and its conditions of access. By law, lithium is declared "strategic, of public interest and of state utility"³¹ and the brines are qualified as state "tax reserves". Therefore, the Bolivian state appears as a core stakeholder of the GPN in its territory. As a

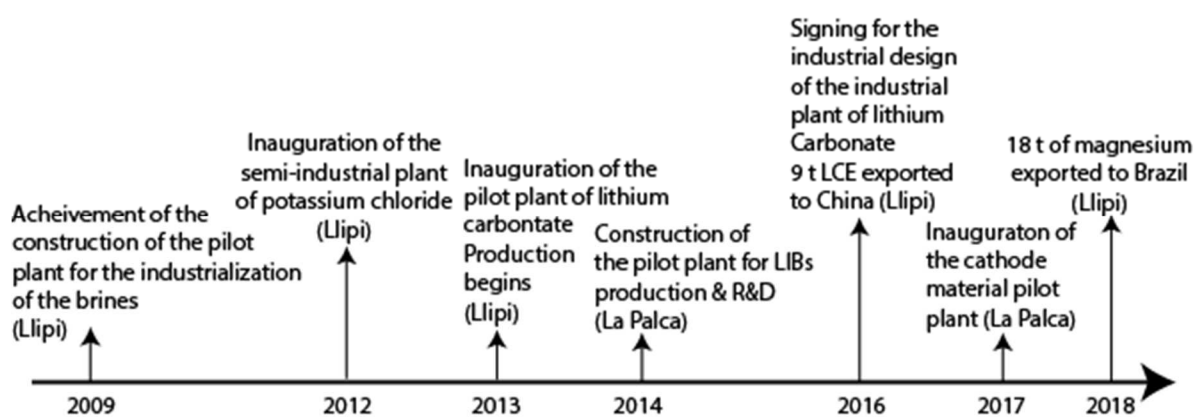
³¹ art. 348 of the Constitution, art. 8 of the mining and metallurgical law.

central regulator, it enjoys a prominent place in the production stage with potential extra-national effects (Horner, Alford, 2019).

Furthermore, it highlights the embeddedness of resource and production networks which only seems to be overcome by strategic alliances and network practices. Indeed, the vertical total forward integration of the production chains starts in two main territories: Llipi nearby the *salar* of Uyuni (extraction and pilot plants) and La Palca (R&D activities, LIBs' production) with an initial extractive process directly controlled and assumed by the "Public National Strategic Company" YLB (*Yacimientos de Litio Bolivianos*)³² in the *salar* of Uyuni in the South East of the country (map 2). The industrialization of brine for LIB production started in 2009, favoring a direct producer role that broadly encompasses the economic exploitation of other materials contained in the area (potassium, magnesium, fig. 3).

Figure 3.

Timeline of the lithium production of the Bolivian Public National Strategic Company YLB



Source: YLB [on line]: https://www.ylb.gob.bo/inicio/acerca_de_YLB Adapted by the authors.

This strategy shows how the state can potentially play a key role in the re/configuration of the organizational structures and network practices of the GPN. The Bolivian extractive process relies on an open pit evaporation which lasts eighteen months (photo 1. A). It involves twenty lines of eight open pit pools of twenty hectares each. In January 2013 a pilot plant for the production of lithium carbonate was inaugurated in Llipi and production began (photo 1. A. B). A year later, a pilot plant of R&D activities for LIB production was inaugurated near the city of Potosí, in the locality of La Palca. In 2016 the public company (then GNRE) exported its first production of industrial grade LCE (about 9 tons, photo 1. C) to China. In 2017 the cathode material pilot plant was inaugurated.

³² The state mining society COMIBOL was first in charge of the development of the lithium deposits before a spin off in 2017 of the GNRE, the ancient structure of YLB.

However, after several years of research, development and investment, the Bolivian state chose to form two “win-win” alliances with interested newcomers from the manufacturing stage, to accelerate its industrialization. On the one hand, these alliances strengthen the Bolivian state allowing to finance its industrialization project and to access the technology. But on the other hand, they undermine it because of the loss of 49% of the shares of the project, also provoking political destabilization. In December 2018 the state-owned company YLB and the German private company ACI Systems Alemania GmbH founded YLB-ACISA a joint venture, 51% owned by the Bolivian state, for the construction of three factories in Bolivia to produce lithium hydroxide for the German LIBs market. From the Bolivian perspective, the alliance corresponds to the “total forward integration trend” previously identified, based on a direct control of the resource and four of the five stages of material transformation, even if the consumption phase is not completed.

From the German perspective, it corresponds to a direct control of the resource and the production networks’ stages through the control of the ownership of the new firm, YLB-ACISA, and its activities. The alliance gave ACI Systems direct access to the refining waste to re-process the lithium that it still contains making the German firm potentially control the five stages of the GPN (fig. 2 D1)³³. This directly influences the GPN by potentially “overshadowing” the Bolivian state and its key control of the raw material in the extractive stage.

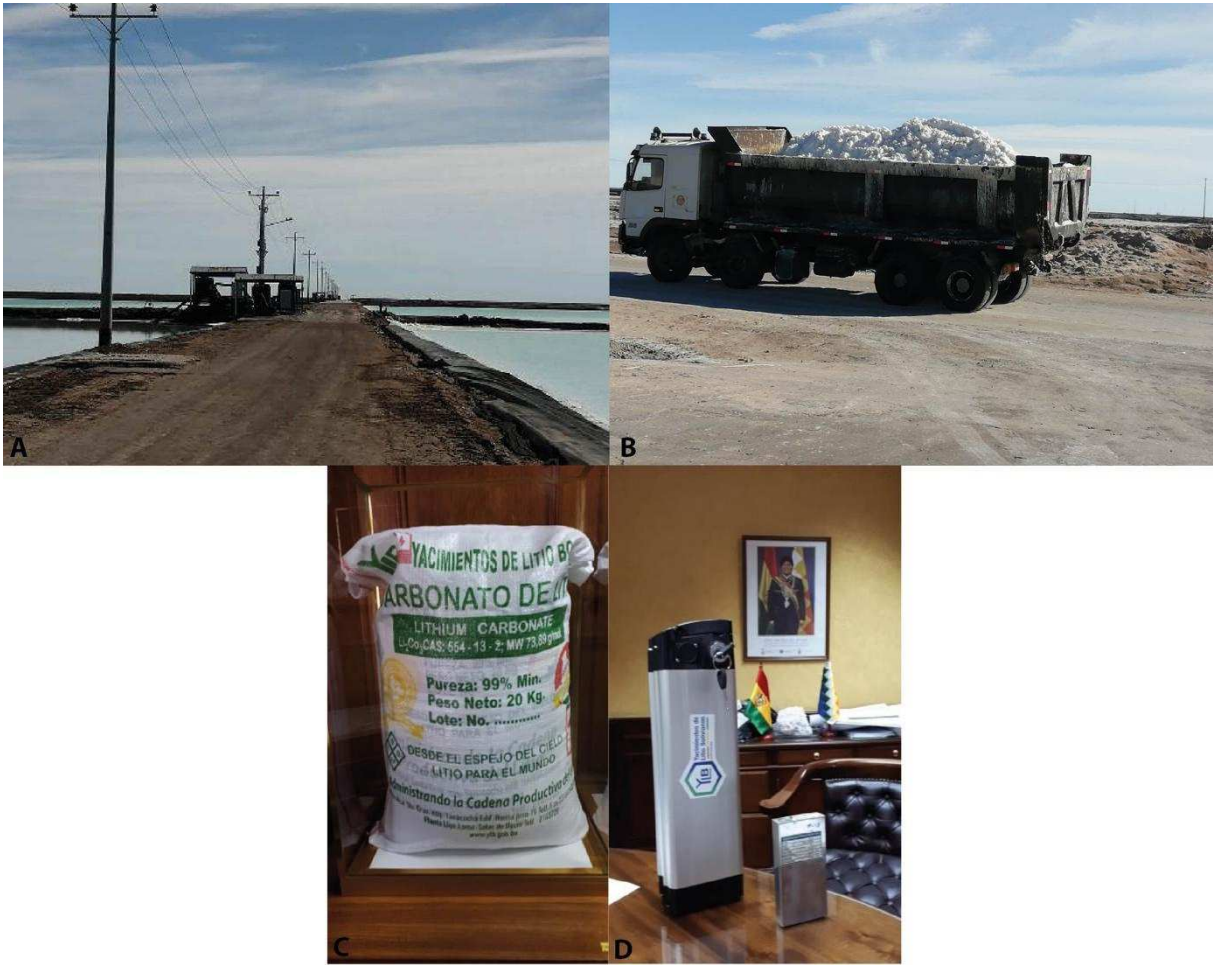
Yet, the contract was canceled due to local grievances a year later in December 2019 by the Bolivian president, before his resignation, demonstrating again the central capacity of extra-firm stakeholders, here the state and local communities, to influence and reconfigure the GPN by their strategies and practices³⁴. In parallel, in February 2019, Bolivia enlarged its lithium industrialization perspectives by concluding new alliances with Chinese newcomers. In August 2019, YLB founded another joint venture with China’s Xinjiang TBEA Group Co Ltd, a manufacturer of electronic components, for the economic exploitation of its two other brines: *Pastos Grandes* and *Coipasa*. The YLB-Xinjiang TBEA Group Company, 51 % owned by the Bolivian state, aims to develop fourteen industrialized plants for the production of twenty products and seven by-products. This Global South alliance shows a total backward integration of the four currently existent stages (Fig. 2D.1) from the Chinese perspective.

³³ The German partner also acquired the rights to retreat the wastes of the brine products after the refining stage. It appeared to be a potential source of higher ELC than the brine and potential way of avoiding the Bolivian deposit and the supervision of the Bolivian partner (Juan Carlos Zuleta, La Paz, 10/04/2019).

³⁴ Apart from this ephemere alliance, the political events do not seem to affect the Bolivian strategy as the continuity of the project and the Bolivian-Chinese agreements demonstrate. However, as mentioned, interviews were conducted in 04/2019, so the political and sanitary effects have not been fully integrated in this analysis through direct interviews.

From the Bolivian perspective, Bolivia gains access to the Chinese market, technologies and investment pointing to a potential total forward integration trend in the organization of the lithium production network including a national and extra-national consumption (fig. 2C.1). The challenge of the Bolivian government remains unchanged. The difficulty of accessing the battery market requires a stabilization of the technology and the establishment of manufacturing in order to achieve sufficient production for both economy of scale and outlets on the markets by signing resale contracts for low-cost and high-performance batteries. The main challenge in the future will probably be to supply battery plants with all other components. Furthermore, the supposed location of the production plants, close to the salt deserts, and the lack of a direct maritime outlet to the Pacific may increase the cost of batteries and make them uncompetitive.

Photo 1. A. Partial view of the lithium open pit pool; B. Truck of brine raw material; C. Bag of bolivian Lithium Carbonate, battery grade; D. Bolivian LIB



Source: Authors, fieldwork, Bolivia, 04/2019.

The “*foundational and strategic role of the state in underpinning the activities of global production networks*” (Coe, Yeung, 2019: 783) reveals its capacity to provoke an incipient spatial and organizational reconfiguration of the structures of the GPN at a local, national, regional and potentially global scale (idem: 783-784). Specifically, the Bolivian national bet on lithium shows three main developments: i) an ongoing process of re-embedding the GPN by local authorities; ii) an ongoing restructuring and verticalization of the GPN by local (YLB) and extra-territorial (ACISA, Xinjiang TBEA Group Co Ltd) challengers from the Global South (Bolivia, China) and North (Germany) mostly involved in the manufacturing chain; iii) an attempt by a non-industrialized Global South country (Bolivia) to provoke a geopolitical revolution in the GPN of lithium and in the LIB industry towards a local production of global class LIBs, lithium chemicals and derivatives: “*From Bolivia to the world*” as the YLB slogan says (photo 1 C., D.). However, this alliance is characterized by political instability that could strongly restrict its spin-off capacity and the functioning of the vertical integration of the lithium production networks.

4.2 A local industrialization to address social needs

Combining the networked GPN approach with territorial analysis in relation to extra-firm stakeholders favors a deeper understanding of the local development outcomes of production networks (Coe, Dicken & Hess, 2008; Henderson *et al.*, 2002) by considering a socio-relational perspective of the notion yet using the geographical concepts of place, scale and network (Bebbington, 2003; Coe, Hess, 2017).

Bolivia’s strategy of brine industrialization provokes the emergence of a new territory of local and global energy transition (Forget, Bos and Carrizo, 2021). The exploitation of the Bolivian brine of Uyuni is connected to the nearby industrial plant of brine industrialization where lithium carbonate is produced. The pilot unit is located 400 km away from the extractive site where R&D activities for LIB production are conducted. First considered for mobile phones when alliances were not sealed and then for electric bikes³⁵, the Bolivian pilot plant found an innovative and unexpected development. In 2019 a few units of Bolivian LIBs were installed in the remote area of Yocalla, near the R&D plant, to provide electricity to unconnected households, contributing to the universalization of electricity access in the country: a LIB generates two hours per night through three electric bulbs (photo 2)³⁶.

Photo 2. Solar installation with LIB from the La Palca plant

³⁵ According to the interviews conducted and the visit of the plant itself, where R&D on LIBs for bikes was conducted.

³⁶ Eight families in 04/2019 of a total target of 190 families (interview with M. Juan Carlos Montenegro Bravo, the director of the Bolivian company YLB, La Paz, 04/12/2019).



Source: Authors, fieldwork, Yocalla, Bolivia, 04/16/2019.

Therefore, not only could the re-embedding process of the GPN in Bolivia allow the country to close the loop of the GPN by forward integrating the organizational structures of lithium production networks by exploiting and transforming its own resource, from raw extraction to LIBs manufacturing. It could also provoke a social upgrade by pushing the integration forward to the consumption stage, providing energy access to vulnerable populations. Considering the recent development, the main challenge for the Bolivian state appears to be its strategic coupling for global insertion in a highly competitive market and an unstable automotive electrics market, and its capacity to produce and install LIBs in the country to alleviate national energy poverty.

This policy positions the state at the heart of the exploitation of nature in order to achieve development, taking up the widely debated scheme of "neo-extractivism" (Gudynas, 2013; Perreault, 2013; Bebbington, Bury, 2013). The will to produce batteries on a national scale highlights the desire to withdraw lithium from the "commodity" category by placing it at the centre of a sociotechnical imaginary (Barandiarán, 2019) as a source of development. The commercialization of industrialized high-technology products implies greater foreign exchange inflows, allowing, in a classical scheme, the activation of economic and social development mechanisms. However, our interpretation³⁷ is that the product is being installed in a test mode due to a national technology not yet stabilized and which does not offer a sufficient production capacity to contractualized outlets on the global markets.

5. Conclusion

³⁷ At the time this text is being written.

This article has demonstrated how the GPN approach can be mobilized to analyze extractive activities from a global energy transition perspective, through the two core points previously identified: the multi-scalar strategies and practices of forward and backward integrations create and sustain the production networks and their evolution; a combined approach of the GPN with a place-based interpretation is necessary to understand the political economy of lithium industry; states play a central role as inter-scalar mediators in strategic coupling relations.

The characterization of the GPN allows a richer understanding of the global economy of lithium by breaking down its different stages and isolating key players and territories in a global context of growing interest for lithium, mostly from extractive and industrialized stakeholders who wish to ensure their access to the resource for their production of LIBs for the electronics and the automotive sectors. The so-called “lithium triangle” constitutes a global node of the GPN. The ongoing restructuring and verticalization of the GPN contributes to the reinforcement of the region in the global geopolitics of lithium. Pioneer stakeholders have increased their presence while the extractive chain is challenged by newcomers from both the Global North and the Global South. This phenomenon takes place in a global context with a tendency towards verticalization of the mining industry which is trying to secure its access to natural resources. Bolivia shows a specific profile as a resource-holder state trying to develop both public extraction and industrialization. It relies on a national-scaled strategy of public regulation, R&D and production based on network forward vertical integration and global backward integration alliances in a highly competitive market. It recalls the centrality of the state in the configuration of the GPN but also the potential role of local communities in these developmental strategies.

The Bolivian LIBs first found an unexpected opening in the electrification of disconnected rural areas, pointing to a possible social upgrading of the re-embedding process of lithium industrialization. Nonetheless, the potential “clustering role” of the lithium triangle in the GPN as a driver for national and regional development must be interrogated. Firstly, the local and global economic gains of the trade flows of raw lithium, basic chemicals, derivatives and lithium-based devices remain quite low compared to general mining exchanges. Secondly, it must be remembered that the Bolivian extraction of lithium has only recently begun despite a long history and that the production of local LIBs remains, after ten years of renewed political interest, in the pilot phase. Thirdly, recent internal political changes could nevertheless negatively impact this horizon by reconfiguring the borders of the role of the state in the economy even if the recent election of president Arce does not break with previous policies. Despite the political uncertainties the bilateral relationship between China and Bolivia remains unchanged and leaves open the perspective of a Bolivian industrialization and hence a vertical integration of the GPN as a potential national driver for its economic development.

Even though social tensions around lithium exploitation were not analyzed here, extra-firm stakeholders such as communities and civil society have the capacity to re-shape the firm-firm, firm-state, extra-firm and state-network relations. They demonstrate how the strategic coupling of endowed states and inward investors is embedded in local relations of power and can be re-oriented³⁸.

As Hesse (2009) encourages, our investigation points out the need to consider the local values of the GPN. The installation of LIBs for universal access to energy in Bolivia, opens a new path of development. It takes lithium out of its “commodity status”, to be used as close as possible to the resource, without going through global markets. This development takes place at a very small scale as only eight families out of a total of 190 benefit of Bolivian LIBs. This situation tends to demonstrate both the difficulties of the government and of the public company to achieve this agenda. Argentina and Chile, ahead of rural electrification, import photovoltaic panels and batteries at low cost from Asia as do Bolivian NGOs working on poverty alleviation. The use of LIBs made of local lithium resources for a national market driven by public funds, in response to the contestation of neo-extractivism, subsidizing these systems, would require strong political will, funds and would most certainly have a significant financial cost.

Finally, mobilizing the GPN approach based on both quantitative and qualitative analysis in order to analyze natural resource commodification constitutes a productive way to reveal the materialities of the energy transition, considering the socio-spatial intricated relations of both the stakeholders and territories that produce and/or consume lithium-based energy storage devices.

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³⁸ Like in Bolivia at the beginning of the 1990' or the end of the 2010'.

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