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# Lithium and development imaginaries in Chile, Argentina and Bolivia

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## ABSTRACT

The world's largest deposits of lithium lie in brines found underneath salt flats in the desert between Chile, Argentina and Bolivia. Globally, lithium may reduce fossil fuel use by making batteries for cars and renewable energy storage more affordable. This article analyzes ongoing debates about lithium in these three countries to identify what hopes, fears and expectations different stakeholders are bringing to debates about lithium. My approach builds on the idea of resource imaginaries, particularly the concept of sociotechnical imaginaries that highlights the importance of science and technology to projections of desirable futures. I analyze the tensions, visions and metaphors used by different stakeholders, including activists, the media, and state and industry officials, to imagine and thus legitimate lithium extraction. This study finds three co-existing positions in these debates: lithium as a commodity, as a strategic resource or as the subject of a sociotechnical imaginary. Chile, Argentina and Bolivia are converging on the last of these, best described as a reimagining of the relationship between mining and development in which lithium, through innovation and industry, will redefine the relationship between Latin American economies and global markets. This imaginary projects a binary between raw and industrial materials and deterministically assumes that science and technology will transform the former into the latter. Disagreements and challenges notwithstanding, the article argues that this imaginary is evidence of a crisis of confidence in development that is creating space for a more dynamic debate about the social value of mining and the proper role of the state in development. This convergence will have also implications for how sustainable, equitable and reliable lithium production will be.

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## 1. Introduction

In 2014 Tesla CEO Elon Musk announced that his company would build a lithium-ion battery “gigafactory” outside Reno, Nevada. Soon after, Tesla unveiled its Model 3 priced at US \$35,000. Although no prototype or test vehicle existed for consumers to try, in just one week 325,000 people paid US\$1000 a piece to pre-order it. Tesla hailed it the biggest one-week launch of any product ever. This episode speaks to the global excitement around lithium and the low-carbon technologies it enables. Lithium-ion batteries are expected to make electric vehicles and renewable sources of energy, like solar and wind power, feasible and (eventually) affordable (Tran, Banister, Bishop, & McCulloch, 2012). Indeed, Tesla is one of several companies behind a boom in lithium demand that has led investors to South America in search of staking their claim to the region's lithium deposits.

Investors encountered a complex and dynamic political terrain in Chile, Argentina and Bolivia, the three countries where the world's largest deposits of brine-based lithium are found. Various

South American stakeholders have been engaged in heated public debates about how to best manage the region's lithium deposits. Whereas some have argued for deregulating lithium, others demand greater state control, and yet others are concerned about the impacts on frontline communities. The three countries have different histories with lithium and natural resource politics. In Chile and Argentina, most natural resources are privately owned, but not lithium. Whereas Chile and Argentina have been exporting lithium for decades, Bolivia has yet to start large-scale commercialization. Bolivia's government, led by President Evo Morales, has re-asserted state ownership of all natural resources, but particularly of lithium. The unknown future of lithium inspires hope and optimism among stakeholders who hail lithium as the “new oil” or “white gold,” or as the potential catalyst for new forms of development. Yet others are skeptical, seeing lithium as a simple source of income or something far worse—the source of a new resource curse.

These wide-ranging debates resonate with recent scholarship on resource extraction in Latin America that highlights that struggles over natural resources are about more than dollars and cents; rather, debates about resources are also about competing visions of how the nation should grow, what levels of ecological harm and human risks society will tolerate, and what activities and groups

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should benefit from extractive activities (Hinojosa et al., 2015; Perreault & Valdivia, 2010; Watts, 2001). This article introduces to this scholarship the concept of *sociotechnical imaginaries*, which emphasize the role of science and technology in collective projects of nation-making. Using imaginaries as an analytical framework, the article captures the nuances, contradictions and complexities in lithium debates while identifying three salient (though partially overlapping) positions: (1) lithium as a banal, market commodity; (2) lithium as a strategic resource; and (3) lithium as the subject of a sociotechnical imaginary that reimagines how mining can serve development goals. Surprisingly, this article finds that despite the multiplicity of histories and co-existing discourses whirling around lithium, Chile, Argentina and Bolivia have been converging around the third position, with implications for how sustainable, equitable and reliable lithium production will be.

Debates about lithium are particularly dynamic because lithium's future is unknown and contested. Stakeholders can therefore gesture to possible futures without answering for the contradictions inherent in extractivism. For instance, while the *New Yorker* projected a hopeful future for Bolivia, asking “can Bolivia become the Saudi Arabia of the electric-car era?,” a local think tank dismissed lithium as providing a “present without a future” (Calla Ortega, Montenegro Bravo, Montenegro Pinto, & Poveda Ávila, 2014). When Tesla announced its battery gigafactory, NPR's Marketplace criticized that “Tesla bets on the present while the future races on,” suggesting that investments in lithium-ion batteries are nonstarters. Contradictions and practical challenges notwithstanding, lithium has an evocative power grounded in its uses in low-carbon technologies and its apparent novelty (Bruckman, 2015; Revette, 2016). At a time when scrutiny of the negative impacts of resource extraction is high, with some Latin American regions introducing mining bans (Broad & Fischer-Mackey, 2016), lithium provides an apparent “clean slate” in that its extraction history is unknown among a broad, global public. Cultural theorist Karen Pinkus (2017, p. 417) notes that fuels that “have not yet been inserted into a system that will consume them, use them up, [may]=hope”; though not technically a fuel, lithium fits this vision. These factors conspire to enable lithium to inspire among South American stakeholders a multiplicity of hopes and fears, analyzed in this article in the context of broader discussions about mining and development.

The article is organized as follows. Section two introduces readers to South American lithium, including how it is extracted, its known and expected impacts, and the political terrain. Section three reviews the literature on resource imaginaries and argues for the usefulness of sociotechnical imaginaries in development studies. A methods subsection is included at the end of the theory discussion. Section four offers the article's empirical material, organized in the three positions identified above. Section five reflects on the overlaps and distinctions of the three positions, the strengths and weaknesses of the lithium-induced sociotechnical imaginary, and the consequences of lithium politics for development debates. This is followed by a short conclusion.

## 2. Background to South American lithium mining

South American lithium production began in the 1980s in Chile and Argentina, home to several salt flats with mineral-rich brines (Fig. 1). Across the border in Bolivia, the Uyuni salt flat holds the world's single largest known deposit. These salt flats are popular with tourists and home to indigenous communities; for instance, sections of Chile's Atacama and Bolivia's Uyuni are protected sites. From the perspective of mining, these South American deposits stand out because of the abundance of lithium and low cost of extraction. More costly deposits of lithium are found in rocks (spo-

dumene and petalite) in China, Australia and elsewhere, and experiments are underway to extract it from hectorite clay (Pistilli, 2016). Extracting lithium from brines does not produce piles of sterile rock or toxic tailings, nor does it require high fossil fuel use or explosives (Kesler et al., 2012). Neither is lithium itself toxic.

The environmental impacts of brine lithium stem mostly from the use of solar radiation to evaporate large amounts of water from the mineral-rich brine (Anlauf, 2015; Kesler et al., 2012). Brines are pumped from underneath the salt crust into large evaporation pools. Below the crust lies a sponge-like formation that is porous, layered and irregularly shaped. Lithium is not renewable; along with other valuable minerals found in the brines, lithium accumulated in salt flats through leaching that occurred over thousands of years. Once in the pools, which are constructed on the surface of the salt flat, the brines are left for the sun to evaporate the water away over many months (Kesler et al., 2012). Adding sodium carbonate to the resulting sludge produces lithium carbonate, which is then exported to chemical facilities worldwide that produce battery-grade and other lithium products.

Scientific studies of the ecological impacts of lithium extraction from brines are still rare. Life-cycle assessments of electric vehicles do not single lithium out as problematic for the environment; instead, factors like the metal oxide paired with lithium (Padashbarmchi et al., 2015) and the source of electricity matter more (Oliveira et al., 2015). The sustainability of electric vehicles, these studies claim, will depend on other issues like battery lifetimes, manufacturing and recycling. By contrast, communities living near salt flats worry about the impacts on water, as the evaporation process is removing water from the world's driest ecosystem (Anlauf, 2015). Little scientific information about this is available, and that which does exist has been produced by the companies that operate there, raising questions of trust and credibility.

Will lithium mining produce wealth and development in this region? Will it be sustainable? Scholars, activists, journalists and politicians have been offering myriad tentative answers to these forward-looking questions, prompting a broad-ranging and complex debate about how to manage lithium-occurring in a context where both the future of lithium is unknown and the past of mining in the region is contested. Mining in Latin America has long produced a cyclical pattern of growth, in which periods of rapid growth are followed by busts driven by the collapse of commodity prices, overcapacity and environmental exhaustion (Bebbington, Bornschlegl, & Johnson, 2013). As detailed in the empirical section below, some fear lithium will reproduce this pattern. However, proving whether or not resource-rich economies under-perform compared to those without natural resources has proved difficult. Looking at data for minerals with longer extraction histories, some scholars argue there is no proof for the so-called “resource curse” (Brunnschweiler, 2008; Lederman & Maloney, 2008), while others disagree (Atkinson & Hamilton, 2003; Bjorvatn, Farzanegan, & Schneider, 2012; Boschini, Pettersson, & Roine, 2013; Orihuela, 2013).

Moreover, Andean countries recently saw increased investment in mining that produced wealth for some but was met also with resistance from groups concerned about negative environmental and social impacts (Bury & Bebbington, 2013). In countries like Ecuador and Bolivia, for instance, progressive leaders that came to power in the 2000s tried to legitimate mining by increasing the state's control of natural resources and claim to royalties, using these to increase social spending (Bebbington, 2012; Bebbington & Bebbington, 2012). Despite national welfare gains, case-studies find that even in these conditions mining remains a contradictory and harmful activity that entrenches inequalities (Bury & Bebbington, 2013; Gudynas, 2010; McKay, 2017). In this context where mining's contribution to development is contested –possibly



Fig. 1. The lithium producing regions of Chile, Argentina and Bolivia.

contributing to a regional “crisis of confidence in development” (Escobar, 2010) and lithium’s future is unscripted—, South American stakeholders are struggling over how best to organize lithium extraction. In this contested and dynamic terrain, the concept of imaginaries is a useful analytical tool for identifying alternative positions characterized by distinct views of mining, development, the state and society.

### 3. Imaginaries of mining and development

Scholars have used the term “imaginaries” to analyze the ways in which representations of mining draw from and in turn shape notions of community and nation (Hecht, 2012; Hinojosa et al., 2015; Mitchell, 2011; Watts, 2001). Drawing on the work of

Charles Taylor (2002) and Benedict Anderson (1983), imaginaries are collective constructions of how individuals understand their place in a culturally and historically-specific world (Perreault & Valdivia, 2010; Shankland & Gonçalves, 2016). Imaginaries both reflect and constitute new identities and the relationships between different groups, such as citizens, indigenous communities, workers or the state. Successful imaginaries are historically and culturally resonant, that is, they draw on shared values, symbols, stories, legends and the like (Hinojosa et al., 2015). Accordingly, scholars have looked for imaginaries in commonly used metaphors, educational materials, media and newsprint, literature and film, and narratives and representations produced by relevant stakeholders in a controversy (Pretes, 1997; Scoones, Amanor, Favareto, & Qi, 2016).

It is useful to contrast imaginaries to mining “discourses.” Like the notion of “frames” used by sociologists of social movements

(Benford & Snow, 2000), stakeholders craft discourses to mobilize target audiences for or against mining projects within existing opportunity structures (Özen & Özen, 2017; Vela-Almeida, Kolinjivadi, & Kosoy, 2018). Though they have much in common with imaginaries, discourses exist in opposition to each other, such as for or against a specific mine (Özen & Özen, 2017) or competing rationales to justify mining in general (Vela-Almeida et al., 2018). In these ways mining discourses reflect competing views about how to distribute responsibilities and benefits within the existing economic and political order, but do not advance or renew imaginings of the nation or citizenship.

By contrast, as in the concept of *imaginative geographies*, imaginaries capture “the representing and practicing of hydrocarbon nationhood and citizen-communities” (Perreault and Valdivia 2010, p. 689). Geographers have thus highlighted the importance of territory to imaginaries. Likewise, Hinojosa and her co-authors (2015, p. 105–06) discuss imaginaries as “territorial projects” that are about “appropriate strategies for territorial development and the futures to which residents might aspire.” They find that elite imaginaries around natural gas development in Tarija, Bolivia deliberately fragmented historical efforts to build a regional political identity. Their case illustrates a national imaginary constituted by ideas about how to demarcate space, sanctioned political identities and rules for relations across scales of government in ways that legitimated gas extraction as well as a new ordering of the territory and polity.

A complementary though distinct concept is that of *sociotechnical imaginaries*, developed by scholars of science and technology in society (STS) to denote “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (Jasanoff, 2015, p. 4). Science and technology have historically been valuable tools to the powerful, who have used them to promote state-led projects of development and modernity (Hecht, 2009; Jasanoff, 2015; Mitchell, 2002; Scott, 1998). For this reason, sociotechnical imaginaries are useful for examining the relationship between resources, development and nation-making. A seeming “clean slate,” lithium is particularly suited to animate imaginaries of a clean transport and energy future.

This article extends use of this concept to Latin America, where leaders have recently turned to science and technology to revitalize economic policies (Rajao, Duque, & De, 2014). To illustrate, Bolivian President Evo Morales has used science and technology to reinforce the nationalist aspects of his political project (Centellas, 2010). This was on view when his government launched Bolivia’s first telecommunications satellite, named *Tupac Katari* in homage to the leader of an indigenous rebellion in 1781 against Spain. President Morales explained to the Bolivian public,

Two-hundred and thirty-two years ago, before being dismembered by the Spanish empire, Tupac Katari said: “Today I die, but I will return as millions.” Our grandfather, Tupac Katari, transformed into a communications satellite, will now be a light, a star that illuminates the liberation of our people in Bolivia. (Rodríguez-Carmona & Aranda Garoz, 2013, p. 21)

The satellite would expand access to health and education so Bolivians would never again be exploited by “the industrial and imperial North,” Morales added. The episode illustrates an emerging sociotechnical imaginary in which satellite technology is used to retell long-erased histories, advance an indigenous national identity in defiance of Western imperialism and assert a uniquely Bolivian modernity. By featuring the launch in a report about lithium policies, officials linked various demonstrations of the country’s growing scientific and technological prowess to a political project of re-imagining the nation as modern.

Sociotechnical imaginaries thus draw attention to the ways in which science and technology take on political values and meanings, as the privileged means with which to deliver on promises of a better future. For many Third World countries, such promises invariably use the language of development—a contested and multifaceted project in which science and technology participate in at least two ways (Escobar, 1995; Ferguson, 1990; Pretes, 1997). First, in addition to economic growth, development implies social transformations achieved through scientific and technological advancements. As with the example Bolivian satellite technology, for many Third World nations scientific and technological achievements have long-been a coveted means towards global parity (Hecht, 2012; Medina, da Costa Marques, & Holmes, 2014). Indeed, technological determinism, or the belief that technologies develop independently of society and drive social change, has often been at the heart of development projects (Cherlet, 2014).

Second, development itself is a form of knowledge about the Third World produced by experts invested in the promotion of false binaries such as Third/First World, developed/underdeveloped, producers/consumers and modern/backwards. Escobar (1995), Ferguson (1990), Mitchell (2002) and others have demonstrated how, convinced of these binaries, development experts have unleashed interventions on the “Third World” with poor results and reinforcing power asymmetries between so-called modern agents and underdeveloped subjects. Yet these binaries are neither natural nor scientific; instead, they reflect the simplifying assumptions and biased gazes held by those with a claim to expertise and authority (see also Latour, 1993).

Sociotechnical imaginaries reflect a particular kind of knowledge and discourse about development—one that puts science and technology at the center of progress. By analyzing development discourses and policies as sociotechnical imaginaries, the analyst can shed light on the assumptions and contradictions underpinning development promises, such as those that sustain false binaries, technological determinisms or normative appraisals of the ideal citizen (Eaton, Gasteyer, & Busch, 2013; Hsu, 2017; Jasanoff & Kim, 2009; Kim, 2015; Levidow & Papaioannou, 2013; Pfothenauer & Jasanoff, 2017; Smith & Tidwell, 2016; Tidwell & Smith, 2015). Ideally, by examining debates about extraction-led development as sociotechnical imaginaries operating at a national level, social scientists can provide insights into efforts in Latin American societies to dissolve such binaries or challenge technological determinism. At a minimum, the concept complements and extends other approaches to the study of resources and imaginaries by exposing how science and technology are mobilized and come to embody political purposes and values.

### 3.1. Methods

Following studies like those of uranium (Hecht, 2012) and oil (Mitchell, 2011), I treat lithium itself as subject to an imaginary and identify the consequences of such imaginaries for: (1) the state and nation; (2) anticipated stakeholders; and (3) broader development goals that might be facilitated or hindered by lithium extraction. Drawing on the sociotechnical imaginaries literature, I looked for positions on lithium in documents and semi-structured interviews with individuals active in lithium policy and extraction living and working in each country (Table 1).

Data collection proceeded as follows. In 2014 and 2015 I spent two-weeks in each country conducting interviews. Despite the ongoing boom, only a small number of individuals in each country are actively involved in the lithium sector. Individuals can be grouped into state officials, consultants and industry officials, and scientists engaged in research and development. I asked respondents to describe the trajectory of lithium activities in their country, their role in that trajectory, and their hopes and fears for

**Table 1**  
List of sources.

	Interviews	Policy documents (2008–16)	Media (2010–16)
Chile	State officials (3); Consultants & Industry (3); Scientists (1)	Reports by <i>Cochilco</i> , <i>Corfo</i> and those used and prepared by the President's Expert Committee for Lithium	Articles published in <i>El Mercurio</i> , <i>La Tercera</i> y <i>La Segunda</i> ; 2010–16. Also environmentalist blogs
Argentina	State officials (5); Consultants & Industry (3); Scientists (2)	Presentations prepared by Salta and Jujuy's Mining Ministries	Articles published in <i>La Nacion</i> and <i>El Tribuno de Jujuy</i> ; 2010–16
Bolivia	State officials (2); Consultants & Industry (3); Scientists (2)	Press notes and releases from National Evaporated Industries Commission ( <i>Comibol</i> )	Reports published by non-governmental groups, both critical and favorable to the government, e.g., by Zuleta, CEDLA, and others

how lithium policy and results might evolve. The goal was to interview officials in every relevant regulatory agency, in a mix of lithium producing companies (incumbent, new), consultants and scientists. Interviews typically lasted between one and two hours and were conducted in Spanish.

Second, I collected relevant policy documents and media articles. Policy documents were collected at government offices and online. For each case, I consulted the agencies with primary responsibility for regulating lithium. In Chile, this included the Copper Commission (*Cochilco*) that advises the government on minerals policies and markets; the Development Corporation (*Corfo*) that owns lithium deposits; and reports prepared by an Expert Committee set-up in 2014 to propose new national lithium policies. For Bolivia, I analyzed materials by the National Evaporated Industries Corporation (*Comibol*), a state-owned company re-founded in 2007 to produce, among other things, lithium. Materials prepared by each agency varied widely. While Chile and Bolivia's agencies have produced many written documents, in Salta and Jujuy mining ministry officials provided me only with PowerPoint presentations. Whereas in Jujuy this material was complemented with interviews, in Salta I interpret the relative dearth of information as reinforcing the government's market-friendly policies, described in the next section.

Media coverage of lithium was also analyzed for each country for the period 2010–16 (Table 1). Although the lithium market has been receiving unprecedented media attention, there is little scholarship on it. In order to capture as broad a range as possible of information about the lithium trade, I collected media articles through three “Google Alerts,” one for each country. These returned articles from local and international newspapers as well as the specialized business press. Local newspapers listed in Table 1 appeared frequently in the alerts and were therefore searched for additional articles the alerts may have missed. Three bilingual undergraduate students assisted me in reading through this material to identify (1) recurring statements, metaphors, images, symbols and the like that spoke to the values guiding lithium policies, such as references to a cartel, comparisons to other export commodities or assertions of technological prowess; and (2) references to events and speeches in other countries and the timing of key events, to assess whether policy ideas and ideals were being copied across jurisdictions. Finally, we analyzed documents by oppositional environmental NGOs and social movements.

## 4. Lithium debates in Chile, Argentina and Bolivia

### 4.1. Lithium as a “banal” commodity

In 2013, *Cochilco*, the agency that supervises copper and mineral exports for the Chilean government, published a report about the global lithium market. This report, like others that preceded it, treat lithium as a market commodity. *Cochilco* (2013) reports on the global price of lithium, known reserves and projected demand, and predicts lithium export profits. The report reiterates that

lithium is plentiful worldwide and, compared to Chile's other exports, not particularly lucrative. Interviewees and the report echoed a common claim: one-year of lithium sales generates as much revenue as copper in one-month. *Cochilco*'s report highlights that in 2011 copper exports were worth US\$43.614 million while lithium accrued just US\$204 million.

Armed with these figures, many state and industry officials felt strongly that lithium is not particularly valuable nor important for Chile's future growth. They rejected any comparison with oil and felt that a 1979 policy declaring lithium a “strategic mineral” should be repealed in favor of deregulating lithium. Their position is similar to that of state and industry officials involved in procuring uranium for France's nuclear power plants (Hecht, 2012). These officials positioned uranium as a “banal” commodity, as opposed to a strategic element in nuclear power, to advocate for a global market that did not cater to diverse resource nationalisms. Similarly, some Chilean officials appealed to lithium's banality to argue against nationalistic ideals of control and in favor of deregulation, so as to attract foreign investment.

Government officials in the Argentine province of Salta shared this attitude. Between the mid-2000s and 2011, Salta's government issued permits to 15 companies to extract lithium from brines in 13 salt flats. Salta's fast and easy permitting process enabled a brine grab as officials prioritized attracting foreign investment (Davis & Wakabayashi, 2010; Méndez, 2011). These policies were consistent with national mining policy started in the 1990s during the Menem administration and maintained by successive governments (Nacif, 2015). Salta's policies succeeded in attracting a new generation of lithium mining companies that operate as joint ventures, typically formed from a mining company (usually Canadian or Australian), an electronics company (French, Japanese or Korean) and a car company (Toyota and Mitsubishi have been the most active). These are new companies oriented at the car market, and differ from incumbent lithium producers—companies like SQM, FMC and Albemarle (formerly Foote, then Rockwood)—which are international chemical companies selling a diversified portfolio of lithium products.

Although advocates of free markets are usually dominant, in the case of lithium this position is currently the weakest of the three identified. It has guided policy only in Salta, Argentina and is surprisingly weak even in Chile, where policies privileging private activity and the free market normally dominate (Liverman & Vilas, 2006). In Bolivia, its influence collapsed after a failed effort in the 1990s to sign a contract with FMC to extract lithium from Uyuni. Frontline communities forced Bolivia's central government to cancel the contract, arguing that FMC had received excessively favorable conditions and would pay low royalties. FMC left Bolivia for Argentina, while the Bolivian government had to reverse the free-market policies it had implemented at Uyuni. They re-introduced ecosystem protections and extended the state's control over mining around the protected salt flat (Strobele-Gregor, 2012).

What explains the comparatively weak influence of this position? The Bolivian case suggests it is partly due to public frustration with a development model that privileged foreign

investment and export-oriented mining. Two characteristics of lithium also complicate efforts to position it as a banal market commodity. First, as a chemical product, lithium cannot be easily standardized and thus resists commodification. Even lithium carbonate, the most widely traded form of lithium, is not a standardized product from the perspective of consumers like battery anode and cathode manufacturers. Lithium's claim to be a banal commodity is further weakened by the fact that the mineral is traded in private contracts; like uranium in the 1950s (Hecht, 2012), there is no public market nor a listed price for lithium products, rendering reports of a global price speculative as these are based on intimate, privileged information.

Second, Salta's junior companies have run into production problems that highlight the importance of place-based expertise. Because each salt flat and brine are unique, extraction and processing require experimentation, talent and time. Like lithium, the salt flats resist standardization. Although consultants and the media focus on quantifying reserves, supply bottlenecks are more likely to come from hurdles to production stemming from the lack of site-specific experience. As of early 2018, none of Salta's new junior ventures had begun selling lithium on the market. Only one new company, Orocobre, begun sales seven years after getting started; their operations, located in neighboring Jujuy province, took off after Orocobre partnered with incumbent firm SQM. Chilean officials at Cochilco and Corfo estimate that it takes 10 years from start to first sale when operating at a salt flat where brines and climatic conditions are unknown.

#### 4.2. Lithium as a "strategic resource"

In 2008 *Forbes* confidently declared this South American desert region "the Saudi Arabia of Lithium" (Koerner, 2008). The metaphor raises the promise of great wealth alongside the specter of the resource curse. Like oil or uranium, lithium appears to be both a lucrative global commodity and a strategic resource, amenable to being used as a weapon in global politics. Journalists, policy makers, scholars and activists who hold this view assume that global markets and geopolitics produce winners and losers. They assume that nation-states are stable entities engaged in a zero-sum battle over natural resources, power and money. The winners in the battle are typically corporations, wealthy consumers and powerful nations, and the losers are communities near sites of production, weaker countries and disenfranchised workers.

This view of lithium is widespread and particularly strong in the United States. In the 1950s–60s, the US government stockpiled lithium (as it did uranium, see Hecht, 2012) and sent the US Geological Survey to South America in search of new deposits. When in 1979 Chilean law-makers declared lithium of "strategic national interest" they were following the US government's example. Forty years later, to obtain Nevada law-makers' support for Tesla's battery gigafactory, CEO Elon Musk promised the facility would use only US-sourced lithium. Yet the only existing US source, Nevada's Silver Peak mine, produced only a tiny fraction of Tesla's needs (870 of 24,000 tons the gigafactory plans to consume per year). The United States government stepped in to revitalize the moribund Silver Peak mine, while US-based news reporters insistently tout potential US-sources of lithium, and describe lithium as vulnerable to supply bottlenecks and strategic to national security (Tahil, 2007).<sup>1</sup> Though many analysts counter that lithium is plentiful (Lagos, 2012), implicit in these reports is the assumption that US economic, scientific and technical dominance requires control over raw material deposits (Energy, 2011; Kesler et al., 2012; Oliveira et al., 2015).

<sup>1</sup> U.S. sources of news about lithium include *OilPrice.com*, *Bloomberg*, *Scientific American*, and *The Financial Times*.

Outside the US, this view was shared by some Argentine officials and journalists. Reporting from the nation's capital in Buenos Aires during the Kirchner government, these officials and journalists supported creating a cartel to coordinate prices and production (see for instance, NA, 2011, 2014a, 2014b). Called the Organization of Lithium Producers, or OPPROLI in Spanish, the cartel would allow South American nations to maximize their rents and exercise geopolitical influence. Proposed first by Rodolfo Tecchi, director of Argentina's science agency, the idea was supported by the Kirchner government's top mining authority.

OPPROLI was not well received in Chile or Bolivia, and after the 2016 election was discarded in Argentina by incoming President Mauricio Macri. Press releases from Bolivia's lithium mining corporation, Comibol, rarely mention the cartel option (see also Echazú Alvarado, 2015), and in Chile policy-makers raise the idea mostly to critique it (the exception is Lagos Miranda, 2009). Nevertheless, the Argentine press continues to use this language: a recent newspaper article says that new policies introduced by Macri to facilitate foreign investment have unleashed a new "a war for lithium" in the provinces of Salta, Jujuy and Catamarca (Dinatale, 2016).

A final variant of this view is found among environmentalists and scholars who worry that lithium will devastate ecosystems and the livelihoods of communities for the benefit a few large businesses (Calla Ortega et al., 2014; Strobele-Gregor, 2012). Their analysis is based on the idea of the resource curse: because of its strategic importance, as governments rush to develop lithium deposits they will trample on the rights and health of communities, particularly indigenous ones, living near salt flats (Anlauf, 2015; Calla Ortega et al., 2014; Revette, 2016). Though these critiques are not currently grounded in scientific evidence –as noted in section 2, environmental impact research is yet to be done–, they reflect the concerns of many living in frontline communities.<sup>2</sup> Implicit in these critiques is the assumption that natural resources are at the center of a zero-sum game for power and money, with local communities at the losing end of the struggle.

#### 4.3. A lithium-focused sociotechnical imaginary

The third position observed in South American lithium debates projects a sociotechnical imaginary in which lithium will be used to foster scientific and technological advancements, producing a new kind of development that, according to its advocates, will be more sustainable and fair than previous efforts. This view can be traced to Bolivia. In 2007, the Bolivian Congress approved a proposal to create a public corporation (Comibol) to extract lithium from the Uyuni salt flat (NA, 2009; Romero, 2009). President Morales has championed this policy, which grew into a national industrialization strategy to generate employment, value added, wealth and sovereignty (Echazú Alvarado, 2015; see also, Friedman-Rudovsky, 2011; Nacif, 2013). Elites justify this policy arguing that South American economies have been harmed by predatory foreign businesses which export raw materials without investing in innovation or human capital. Past patterns of inequitable and boom-bust development can be overcome by national control over natural resource management and by fostering industrialization.

Between 2007 and early 2018, Bolivia's lithium team developed and patented a method for extracting lithium carbonate from Uyuni brines, begun producing pilot-scale quantities of lithium and commercial-scale quantities of chemical fertilizer for the Brazilian market, and built significant infrastructure. This includes extending power lines and roads as well as building new labs and

<sup>2</sup> See statements by local residents in interviews conducted by Luis Martín-Cabrera, accessed 01/12/2018, [https://www.youtube.com/watch?v=kyuVOANX\\_ps](https://www.youtube.com/watch?v=kyuVOANX_ps).

pilot-scale manufacturing facilities for battery components. Importantly for Morales' lithium program, this was achieved by Bolivian-trained scientists and engineers. Foreign workers and capital have not participated in lithium extraction and processing, though they have been hired to design and build the assembly and pilot-scale manufacturing plants necessary for making battery components and other finished goods.<sup>3</sup>

The intellectual foundations of Bolivia's "industrializing with sovereignty" agenda are laid out in a report called, *From Brines to Batteries: Sovereignty and Global Supply Chains* (Rodríguez-Carmona & Aranda Garoz, 2013). This report explains the region's economic problems as the result of a historical failure to support science and innovation for development. This was true of colonial economies, of 20th-century import substitution policies and of 1980s-era structural reforms. During the era of import-substitution, innovation failed because the region manufactured luxury, not mass consumer, goods. Structural reforms meanwhile returned Latin American economies to their colonial role providing industrialized nations with raw materials. By contrast, *Brines to Batteries* argues that lithium provides an opportunity to foster innovation-led development. Although plans for a "Lithium University" stalled (Revette, 2016), in 2013 construction started on a research center near Potosí with scientific equipment never before available in Bolivia. Also in 2013, Morales' government passed the *Patriotic Agenda 2025* that funds science and technology in heavy industries, including facilities that process zinc, sulfuric acid and copper.

Argentine officials in Jujuy province similarly see lithium as an opportunity to do more than export raw materials. Jujuy's mining ministry declared lithium of "strategic interest," following the Chilean example which they considered successful. To implement this policy, Jujuy's mining ministry created a state-owned company, called JEMSE, to participate as a minority partner in lithium projects. While the majority partner (always a foreign company) provides capital and expertise, JEMSE contributes local experience. Through JEMSE, the provincial government captures rents, has an inside-view of operations and helps companies negotiate with local communities and the federal government. In parallel, and following the Bolivian example, Jujuy's provincial government increased science funding for the National University of Jujuy to hire high-profile scientists, create new research centers and host foreign visitors. At the national level, Argentina's science agency followed suit, for instance, funding a new center for lithium battery research at the National University of La Plata and hosting several conferences (e.g., in April 2011 and June 2013 in Jujuy; in September 2012 in Buenos Aires).

Jujuy provincial officials have also tried to cater to the needs of frontline communities. For instance, in Susques, a town near Orocobre's new lithium development, the government extended transmission lines and built a business park for local businesses. Officials in the mining ministry and JEMSE shared a common narrative: they were forcing lithium companies to consult early with local communities to identify development opportunities, like the business park. Officials thus hoped to usher in what they called "mining 2.0"—a new generation of mining activities that avoids past abuses. Their ultimate goal was to use lithium to re-legitimate mining and thus stimulate the mining economy beyond lithium.

Meanwhile in Chile, forced by scandal and public pressure, state and industry officials also begun to promote a lithium-focused sociotechnical imaginary. For the first time in decades, in 2012 the Chilean government announced it would issue a new lithium production license. However, the plan failed after the Mining Min-

istry was accused of foul play. The ministry granted the new license to SQM, a Chilean company that was then the world's single largest lithium producer. Its rivals complained that SQM won under unfair conditions and Chilean observers questioned the legality of the tender process (Miranda, 2012; NA, 2012). In parallel, engineering students and some environmental NGOs challenged the government's push to privatize lithium through the tender, arguing that lithium was strategic and therefore should be nationalized and transformed, through science and innovation, from a raw material into goods with value-added (for instance, see Candia Cares, 2012; Liberona, 2012; Radio Universidad de Chile, 2012). These views were articulated in the press and blogposts, and at a 2012 workshop organized by engineering students at the University of Chile called "Lithium, Sovereignty and Challenges."<sup>4</sup> Dozens of students heard engineer and economist Manuel Riesco advocate for a national lithium corporation; a founder-member of Chile's National Center for Alternative Development, Riesco has long challenged free-market policies. Opposite him, another engineer, Jaime Alée, argued for increasing lithium research and development. Together, the speakers represented each side of this imaginary: nationalization and innovation.

Chilean policy changed after 2015, when the new administration of President Michele Bachelet appointed a committee of experts to advise on a lithium policy. Two dozen individuals with training in law, environment, economics and science, and who represented industry, workers, indigenous communities and state agencies, met weekly for six months. To everyone's surprise, rather than privatize lithium and deregulate its permitting process, the committee recommended creating a state-owned company to exploit it. Their final report emphasized that the state play an active role in the economy to progress towards sustainable and equitable development. Far from deregulating lithium, the experts concluded that its status as a "strategic" resource should be enshrined in the Constitution (Comisión Nacional del Litio, 2015).

But their report also went further, articulating a vision for Chile to become an exporter of solar energy by taking advantage of the nation's natural advantages. Lithium is found in the Atacama Desert, which receives many hours of high-radiation sunlight. The experts advocate for "...an industry in energy storage based on technology that meets global quality standards and is cost competitive, so as to significantly improve the country's productivity and transition towards a knowledge economy, taking advantage of our privileged conditions as a natural laboratory and with a vision for transforming Chile into a global leader for solar-based energy solutions..." (Comisión Nacional del Litio, 2015, p. 64). Using the language of science (e.g., Chile as a "natural laboratory"), the experts rejected past development plans based on dirty coal-fired power plants, and projected new industries made modern by solar energy and lithium. Raw materials would be transformed to value added exports like solar technologies and energy.

Between 2015 and early 2018, installed solar energy capacity in Chile tripled to 770 megawatts. Bachelet's government also renegotiated Albermarle's contract, forcing the company to pay higher royalties and into a benefit-sharing agreement with local communities (Villagrán, 2016). Among other things, these royalties are funding a new grant competition run by Corfo to support "value-added lithium projects" (Slattery, 2017). In parallel, Corfo tried to rescind its contract with SQM, accusing the company of cheating the government out of US\$17 million in royalty payments. As of early 2018, SQM faces several legal procedures for its operations and two major corruption scandals. In 2012 SQM's chairman, Julio Ponce Lerou, was accused of gaming the stock market in his

<sup>3</sup> Comibol Press Releases give an account of these achievements.

<sup>4</sup> The workshop is available online, accessed 08/4/2018, <http://www.uchile.cl/multimedia/82736/foro-en-fcm-sobre-litio-soberania-y-desafios>.



favor. Soon after, Chileans learned that SQM had issued fake invoices to reduce its tax bill and transfer money to politicians. One beneficiary of this scheme was Pablo Wagner, who led the botched 2012 tender process that benefited SQM, thus confirming the kind of corruption many had always suspected (Molina Sanhueza, 2015).

## 5. Discussion

Faced both with opportunity and push-back, leaders and officials have had to legitimate lithium extraction with new policies and a range of policy-relevant documents and statements. Based on this material, across these South American producers, three distinct positions are discernible (Table 2): (1) lithium as a commodity, best left to the market to manage; (2) lithium as a strategic resource, too important to be left to the market because of its potential for geopolitical influence; and (3) lithium as an opportunity for innovation, science and technology to foster industrialization-based development that does not rely on exporting raw materials.

Surprisingly, in this case free-market views have lost influence in favor of a convergence around a sociotechnical imaginary in which lithium provides the material and financial resources to develop new industries that yield products with “value added.” Particularly in Chile and Argentina, but to a lesser degree in Bolivia, free-market policies have recently dominated policy approaches to mining and natural resource management (Bury & Bebbington, 2013; Liverman & Vilas, 2006; Nacif, 2015). This loss of influence is not for lack of advocates; in each country, individuals who subscribe to each of these three positions exist within state agencies, industry, academia and social sectors. Free-market advocates all rejected ideas of lithium as strategic, for instance, and emphasized instead that total lithium exports would remain a tiny fraction of revenues obtained from other export commodities, such as copper (Chile), soy (Argentina) or natural gas (Bolivia). Nevertheless, these arguments have for now failed to sway lithium policies.

Instead, over the past few years, policy decisions have reflected the third position, best thought of as a lithium-focused sociotechnical imaginary. This view assumes lithium is a commodity to be sold for profit, as in the first position, with strategic value, as in the second. But it takes both of these positions further by projecting an active role for the state in re-imagining the nation. This is a sociotechnical imaginary because leaders are deploying science and technology to articulate a vision of a desired, future society: it is a vision that breaks with past development models, which assumed that the export of raw materials would maximize profits, and that reimagines the nation as technologically modern and sovereign over the sources of national wealth—including natural resources as well as human talent and skill. It draws on and animates the historically resonant narrative of the resource curse,

conjured not as a hypothesis to be tested but as an abusive history to be left behind.

Given the ascendancy of lithium’s sociotechnical imaginary, this discussion reflects on its consequences for the state and nation, different stakeholders and current development debates. First, as summarized in Table 2, each position assumes a different role for the state and nation. Together they represent points on a spectrum of activity state agents can play: on one end, the state facilitates the market and on the other, it invests in universities, labs, scientists and research to foster technologically-sophisticated industries. Each position contains internal tensions; for instance, within the second position, whereas some saw the state as a source of power, such as through a cartel, others saw it as a threat to communities given its unwillingness to enforce protective laws. Similarly, within the sociotechnical imaginary state ownership varies from nearly absolute in Bolivia to less so in Chile and Jujuy, where the state owns deposits but hires private parties to develop them. Yet the third imaginary assumes the state can play an effective role in the nation’s development by strategically investing in science and technology to foster industries that transform raw materials into goods with value added. Lithium’s sociotechnical imaginary reflects that observed in 1960s South Korea, when the country mobilized science and technology to build manufacturing industries in an aggressive bid to become “developed” (Kim, 2015; see also Chang, 2007). In the lithium triangle, as in South Korea, the benefits to citizens from development are assumed and unquestioned. Policy documents and statements do not elaborate on the identities of potential beneficiaries, nor who might be excluded from these benefits.

However, it is likely that this sociotechnical imaginary will have negative impacts for some communities (Table 3). A number of the new industries lithium’s sociotechnical imaginary promotes are ecologically destructive. In Bolivia, the same lithium policy supports developing heavy industries and chemical processing capacities. In December 2017, the country’s first ammonia and urea

**Table 3**  
Summary of challenges and false binaries by position.

Position	Challenges	False Binaries
1 Banal commodity	<ul style="list-style-type: none"> <li>Lithium is not a standard product</li> <li>Extraction requires expertise</li> </ul>	Free market vs. state intervention
2 Strategic commodity	<ul style="list-style-type: none"> <li>Resistance and conflict</li> <li>Managing supply</li> </ul>	Winners vs. losers of extraction
3 Sociotechnical imaginary	<ul style="list-style-type: none"> <li>Delivering on promises</li> <li>Environmental impacts</li> </ul>	Raw materials vs. Value added goods

**Table 2**  
Summary of three positions on lithium management.

Lithium seen as	View of development	Ideal role for the state	Examples
1 Banal commodity	Trade, exports, and foreign investment foster growth	Facilitate the market, foster cheap exports	<ul style="list-style-type: none"> <li>Chile: state officials estimating supply, demand and prices</li> <li>Salta (Arg): fast licensing of new deposits</li> <li>Argentina: advocates of cartel (OPPROLI)</li> <li>Chile, Argentina, Bolivia: detractors concerned about a resource curse</li> </ul>
2 Strategic commodity	Growth and global politics are zero-sum; a few win, but most will lose	Regulate the market to control supply & increase power; ideally also to reduce negative impacts	<ul style="list-style-type: none"> <li>Bolivia: “industrialization with sovereignty” agenda</li> <li>Chile, Bolivia, Jujuy (Arg): increase state control; invest in universities and new industries</li> </ul>
3 Sociotechnical commodity	Growth through producing goods with “value added”	Invest in science and technology to foster new industries	

fertilizer facility opened and in 2015 facilities at Uyuni were producing potassium for export to Brazil's soy farms. Similarly, Jujuy's provincial government planned to use lithium to legitimate and expand mining as a whole. Even in Chile's Atacama, where there are strong arguments for expanding solar power, it is unlikely environmental impact assessments have kept up with the pace of growth of the solar industry. Examining lithium as the subject of a sociotechnical imaginary highlights a range of likely negative environmental impacts that are overlooked by a narrower resource imaginary that focuses on the impacts to communities adjacent to lithium mines.

The consequences for ongoing development debates of this imaginary are contradictory and, at this point, speculative. Alongside global interest in mining, including for lithium, there exists frustration with the damages it causes. In this context, lithium's unknown future encourages optimism that "this time things will be different" (Revette, 2016). The hopes lithium inspires among some are evident when contrasted with gas and oil; these have been booming in Argentina and Bolivia, yet officials have not jumped on these projects with a sociotechnical imaginary that foretells of a desirable future. Argentina's *Vaca Muerta* shale oil deposit has attracted massive investments from Chevron but no new research institutes to capitalize on that. This contrast points to a question that merits further research: whether advocates of each position are basing their views on lithium's properties or on preconceived ideas informed by previous mining experiences. This analysis suggests both are happening simultaneously but to different degrees, with consequences for debates about mining and development in the region.

Advocates of lithium's sociotechnical imaginary see it as special—lithium is a "clean slate" and enables low-carbon technologies and modern industries—but they are also passing judgement on past development strategies and incorporating some lessons learned from the past. These include the need for states to be more proactive and invest mining royalties in science, technology and industry (Bury & Bebbington, 2013; Chang, 2007; Cherlet, 2014; Maloney, 2007). In response, those who see lithium as either banal or strategic have challenged, even ridiculed, this position. The first group doubts that Chile, Bolivia or Argentina can manufacture batteries competitively with China (Alé, 2013; Lagos, 2012), and the second points to studies of mining's ongoing damages and contradictions (Bury & Bebbington, 2013; Gudynas, 2010; McKay, 2017).

Moreover, despite its talk of rupture, lithium's sociotechnical imaginary remains dependent on mining—indeed, in Jujuy its goal is to re-legitimate mining—and focused on exports. Like other development discourses before it, lithium's sociotechnical imaginary projects a false binary, this time between "raw" and "industrial" materials (Table 3), to justify investments in science and technology, which are assumed to deterministically transform the former into the latter. Yet what counts as a good with "value added" remains ambiguous. Chile's Corfo agency is running a "value added" grant competition that may shed some light on what the Chilean government has in mind (results are expected in 2018). In Bolivia, the Morales government seems adamant on pursuing batteries; in August 2017, it inaugurated a pilot-scale cathode manufacturing plant. Although the exporters would now belong to industry rather than traditional mining sectors, this policy nevertheless maintains the age-old binary between "exporting" and "consuming" countries. There is little indication that the cathode plant's products are for Bolivian consumers.

Notwithstanding such contradictions, and to finish on a cautiously optimistic note, in Chile and Bolivia lithium's sociotechnical imaginary has also sought to transcend mining by using lithium to catalyze new "post-extractive" industries. That is, industries whose core business would rely not on mining but on industrial and chemical processes. As noted earlier, some of these are polluting

activities. But they are also part of a suite of activities associated with a higher order of development than mining. They are projects of modernity, assumed to be more profitable than extraction. Would these new industries, if they emerge, move Chile and Bolivia towards what Arturo Escobar (2010) has called a "post-extractive" economy that is less reliant on mining royalties? (see also Bebbington, 2012). Such a transformation is no easy task. Alternatives to mining need to generate significant amounts of fiscal revenue (Bebbington, et al., 2013), which is difficult to do with manufacturing, agriculture or tourism (McKay, 2017; Mesquita Moreira, 2007).

In his call to imagine alternatives to development that transform, "in theory and in practice, existing notions of development, modernity and the economy," Escobar (2010, p. 342) likely did not have manufacturing, chemical industries or large-scale solar power generation in mind, as Chile's and Bolivia's officials do. Nevertheless, the case of lithium, with its heated debates about how to best manage this resource, gives urgency to the question of what counts as progress towards a post-extractive economy. In the balance lies the legitimacy of lithium mining as well as the specific configuration its extraction will take, shaping how sustainable and equitable it will be. Escobar grounds his call on the observation that development as a discourse and practice in Latin America is currently in crisis, thanks largely to the efforts of social movements that champion pluralism, autonomy and anti-development discourses. Although lithium's sociotechnical imaginary may fail to deliver the transformations it envisions, that leaders felt forced to modify free-market models and articulate a more ambitious vision of development lends support Escobar's observation that a crisis of confidence in development exists. As noted earlier, even where national governments are capturing more royalties for use in pro-poor policies, frustration with mining remains high. Sustainable and fair ideas may still be lacking, but this crisis is creating space in the lithium triangle for new stakeholders to participate in envisioning what the desired future society should be. The detailed understanding of the multiplicity of hopes, fears and assumptions different stakeholders are bringing to current debates about lithium that was presented in this article can help in these efforts to reimagine the role of mining and development in the region.

## 6. Conclusion

The recent trajectory of lithium policies in Chile, Argentina and Bolivia is interesting because free-market arguments are waning in influence in favor of a convergence around the idea that lithium can provide opportunities for a form of development that, according to its advocates, breaks with past patterns of cyclical or highly unequal growth. This view, best thought of as a lithium-focused sociotechnical imaginary, projects a future society in which the state plays an active role in the economy by investing in science, technology and new industries. Rather than export lithium as a raw material, industrialization will produce goods with "value added." Advocates hope this will produce more wealth and create a modern nation.

It is too early to tell if these hopeful visions will succeed or not, nor what the environmental and social impacts of expanded lithium mining will be for communities in the region. Analyzing these new policies and politics of lithium as part of a national sociotechnical imaginary sheds light on some of the shortcomings of this view: while citizens are reimagined as the sovereign owners of the nation's riches, how exactly they will benefit remains vague as do the potential risks and burdens different groups will face. Although this sociotechnical imaginary aims to redefine the relationships between Latin American nations and the global market,

it reifies a false binary between raw materials and industrial goods, through a deterministic view of the power of science and technology to transform the economy. It thus remains an export-oriented imaginary.

Nevertheless, this case suggests that, unlike past rounds of mining, leaders are feeling a need to articulate a more ambitious development agenda around lithium. This is evidence of a growing crisis of confidence in development that responds to a historical moment marked by frustration with mining. South American stakeholders are using lithium, because of its importance in low-carbon technologies, as an opportunity to force a dynamic debate about the merits of mining for development. As lithium's future becomes increasingly known, these debates and policies will continue changing, with consequences for this industry's environmental and social impacts.

### Conflict of interest

Javiera Barandiarán does not work for, consult, own shares in or receive funding from any company or organization that would benefit from this article, and has disclosed no relevant affiliations beyond their academic appointment.

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