# Master Thesis

MSc in EBA - International Business

# The Automotive Electrification and its impact on the Lithium Business

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# 1. Abstract

High expectation over the future developments of the electric vehicle (EV) industry had a considerable impact over another less obvious business in the past ten years: lithium. The white mineral is one of the key ingredients for the production of lithium-ion batteries. The lithium-ion battery is currently the preferred choice for electric vehicles manufacturers thanks to its high energy density, self-discharge rate, and the high number of battery variation available in the market. For this reason, lithium prices have been continuously rising in the past years, together with industrial output and mineral exploration. Conversely, the average price of batteries has been decreasing, reducing the cost of electric vehicles and leading market observers to forecast an EVs boom within the next ten years. The purpose of this thesis project is to study the effect of such growth on the first part of its value chain, lithium compound producers: if on one hand EVs demand is forecasted to increase, the lithium market has been bouncing between industry consolidation, rising prices, and more recently oversupply and shrinking margins. Major firms in the sector have been struggling trading higher production with lower prices for the past two years. This study will first explore the main drivers affecting both the lithium mining sector and the EV sector. Then it will rely on scenario analysis to draw the main links between the two and explore possible future market developments until 2030. Finally, the authors will propose to describe possible business strategies that would help producers to maintain their leadership position and secure a stable long-term growth for the sector.

# 2. Introduction

It is the third element on the periodic table and the lightest solid metal existing. It is present in large quantities on our planet, however low concentration of this metal restricts its extraction to only a few countries around the world. Chile, Argentina, and Bolivia hold more than half of global lithium reserves, followed by Australia and China.

Following the perspective demand of the electric vehicle sector, the price of lithium has experienced a terrific growth between 2010 and 2017, surging from $5180 per ton to $15 000. At the same time, countries such as China and the US have incentivized the development of the EV industry heavily, pushing both consumers and producers to adopt such technology. During 2018 the price of lithium experienced a sudden drop, mostly due to market oversupply, squeezing profitability in the sector.

To date, the electrification process of the automotive industry is widely recognized, but there is disagreement about when and how EVs will finally hit the market. The supply chain is ready to deliver the global market with lithium destined to the battery market - one of the critical suppliers for EVs. However, the automotive market is not demanding significant amounts of EV for now: it is widely accepted that ultimately demand will grow by 2030, affecting the lithium sector once again.

The purpose of this study is to explore both the EV sector, the lithium mining one, and the main relationships between the two. Moreover, it will also attempt to design practical strategic solutions that lithium producers may use to plan their future international business strategies and to design their investments while preparing for the boom of the EVs.

## 2.1. Problem formulation

To ass the main trends shaping the development of the EVs sector and to assess their effect on the lithium supply sector, the authors of this paper subdivided the research question into further sub-questions.

To make forecasts about the future, we need first to provide a complete picture of the past and the present of the lithium sector. Data obtained from this section will be crucial to study the impact of the growth of the EV automotive sector on the lithium business.

*Q1) "What is the lithium sector outlook to date?"*

The EV business has enjoyed rapid growth, and it's forecasted to grow more in the future. However, given the multitude of factors that affect the demand of EVs itself, it will be necessary to provide an extensive overlook on its present state

Q2) "*What is the  EVs sector outlook to date?*"

Despite the best data set, it is difficult to predict what the world will look like in the future. The market for EV vehicles has been growing at a fast pace, and it has not accelerated yet. BloombergNEF (2019) reports the results of different studies on the future size of the EV market, and they all seem to agree up to 2030. After this year, predictions become more conflicting. Thus, the authors decided to explore possible scenarios determining the demand of EVs up to 2030 and its implications on the lithium business

*Q3) "How could the EV sector look like in 2030? What would that mean on the lithium sector?"*

The answer to Q3 will necessarily raise other questions. The lithium business will certainly benefit from growth in the EV sector; however, the strategy of lithium producers will necessarily need to adjust according to future demand. Therefore…

***"How would a lithium producer respond to future changes in the automotive market?"***

The following thesis project will try to answer this research question.

# 3. Methodology

This chapter will outline the methodology applied in the thesis, describing: the research approach and philosophy, the data collection methods, the type of data collected, and the reliability of the findings.

## 3.1. The nature of the research

"Research" is often a misused word. Indeed, as highlighted by Walliman (2011), many of the everyday uses of the term "research" are just referred to the process of collecting data, which is only part of a more systematic and purpose-driven activity.

In this regard, Saunders et al. (2016, p. 5) define business and management research as a systematic way to increase knowledge in the business and management field.

To achieve the above-mentioned goal, the researchers will structure the work following the principles of the Pragmatic Science, as intended by Hodgkinson et al. (2001), overcoming the so-called "relevance gap" (Starkey & Madan, 2001) through a "*research that is simultaneously academically rigorous and engaged with the concerns of wider stakeholder groups*" (Hodgkinson et al., 2001, p. S42). The idea of this research, indeed, is to describe the industry of lithium, and one of the upcoming electric vehicles, outlining the micro-economic and geopolitical dynamics behind them to provide useful academic and business insights.

## 3.2. Research Philosophy

Research Philosophy relates to the source, nature, and development of knowledge, containing the assumptions about the way the world is viewed by the researchers (Saunders et al., 2016). Indeed, this paragraph aims to explain the assumptions and ideas that drive this research to understand the implication of the latter.

The first philosophical aspect described is the one related to the research's ontology, or the set of assumptions about the nature of existence (Saunders et al., 2016). In this regard, the researchers' view of the world is that we live in a dynamic system made up of social agents who continuously influence and change the social structure where they live (Moses & Knutsen, 2007). Going into detail, all the social entities studied in the following thesis project, from the researchers' point of view, exist independently of human thoughts and beliefs, objectively, as also interpreted by Ayn Rand (1982), founder of the philosophical system called "Objectivism".

In contrast with the latter, however, regarding the epistemology, which concerns the nature of knowledge, the researchers embrace the idea supported by the critical realist in the business and management field, which is that a complete understanding of the current social world is only achievable through the study and knowledge of *"the social structures that have given rise to the phenomena that we are trying to understand"*(Saunders et al., 2016, p. 115). The motivation behind this way to interpret reality and knowledge relies on the professional and academical experience of the researchers, and in regard of this particular project thesis, on the idea that a static and firm-centered analysis could not fully explain the dynamics in the lithium and automotive industry, as well as the roles and expectations of the stakeholders involved.

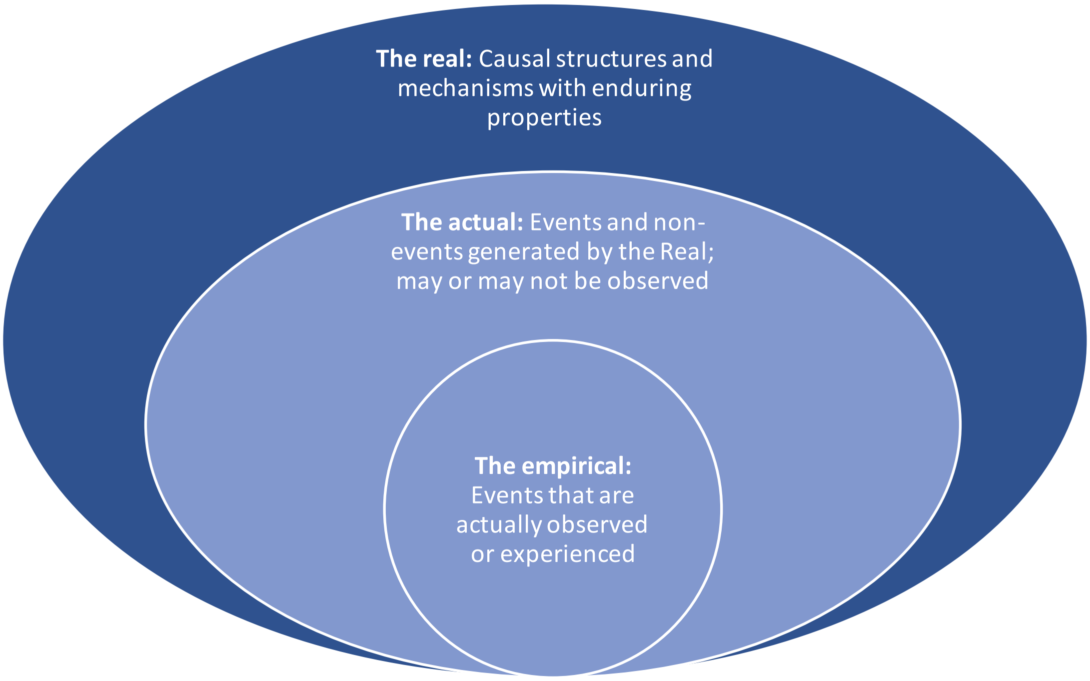


*Figure 1 - Critical realist ontology*

Source: representation developed by Saunders et al. (2016) from Bhaskar ideas (1978)

Finally, in line with the critical realists' perspective, the researchers are aware that their project is value landed. In this respect, the thesis' project aims to enhance business and management knowledge about an industry which, through the electrification of the automotive sector, will gain increasing importance over time. In doing that, the principal driving values will be academic rigor as well as intellectual curiosity to understand the various aspects of the object of study.

### 3.3. Research Approach

Concerning the approach to theory development, the researchers have evaluated the combination of deductive and inductive inferences, also known as "abduction", the most appropriate for the following study. As explained by Saunders et al. (2016), the abductive approach starts with the observation of a "surprising facts" or "incomplete observations" and aims to find the best explanation of the phenomenon object of study, moving back and forth from theory to data. From this perspective, the present research will explore the lithium and automotive industry through the application of principles and approaches for the MNEs in emerging markets and empirical observations, modifying the former when the latter brings out new knowledge about the research's topic.

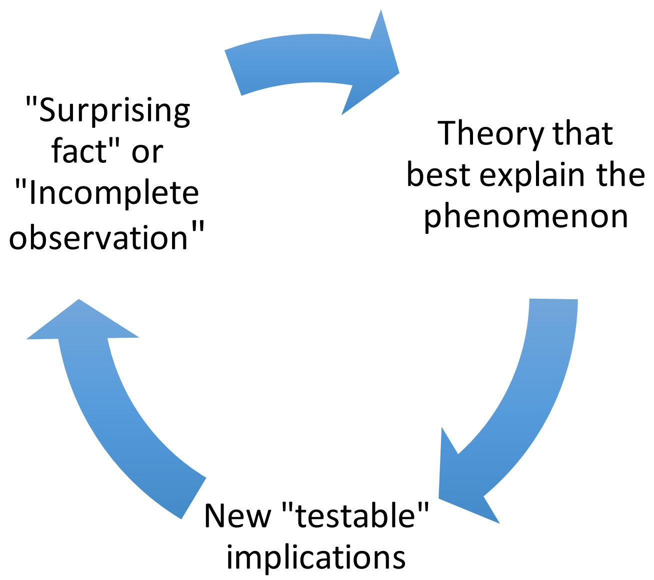


*Figure 2 - Abductive reasoning*

Source: Authors' development of Saunders et al. explanation of Abductive approach

## 3.4. Research Design

### 3.4.1. Research Purposes and Methods

The research design defines the framework of techniques and methods applied to answer the research question. Considering the numerous ways to conduct business and management research, the research design should reflect the purpose of the study (Saunders et al., 2016).

In this respect, the present thesis project aims, at first, to outline and investigate the dynamics that drive the lithium industry and the automotive one, showing the complex network of stakeholders and their role in the vast and intricate business environments. Subsequently, the focus of the thesis will shift towards developing potential scenarios for the development of the electric vehicle and how these could affect the lithium business in the next ten years.

In other words, the purpose of the present project will be to carry on a combined study, partly descriptive and partly exploratory, useful to create and develop a discussion on strategic implications subsequently.

To realize the study's purposes, a *concurrent triangulation design* will be applied, as intended by Saunders et al. (2016). This methodological approach belongs to the so-called "mixed-methods research", where qualitative and quantitative data are collected in the same phase of research. The motivation behind the application of this approach banks on the idea that to develop a more comprehensive analysis of the object of study, a continuous process of comparison between qualitative and quantitative data is necessary. Furthermore, a concurrent triangulation design allows the researchers to overcome the time and resource restrictions of the present project, partly due to the limited research behind the object of study, as well as the weakness of each kind of data – a mono-method quantitative study could be useful to describe a particular phenomenon in an objective manner, but could not correctly highlight and define the social actors and structures as a qualitative study. As also underlined by Johnson and Onwuegbuzie (2004), while qualitative research seeks to explain multiple-constructed realities through the inductive elaboration of detailed case-specific data, quantitative research aims to generalize from time and context and develops knowledge through the lens of deductive reasoning. Nonetheless, as also highlighted previously, knowledge enhancement can be acquired through the application of inductive-deductive logic, also known as abductive reasoning.

In light of the above, the quantitative data collected will help to develop and support the qualitative analysis, which will be the core method of the present study. In doing so, the researchers' purpose will be to ensure the validity and credibility of the analysis, as well as overcome the problem of the limited amount of pre-existing data.

### 3.4.2. Research Strategy

Research Strategy defines the plan to investigate and develop an answer to the research question. It is the methodological connection between the research philosophy and the data collection methods and analysis (Denzin & Lincoln, 2011).

In the following project, to collect, gather, and analyze data, the Grounded theory was followed. According to Glaser and Strauss (2019), the Grounded theory relies on the idea that theories reveal pre-existing realities, and from this perspective, they allow "the relevant social organization and social-psychological organization of the people studied to be discovered, to emerge" (B. Glaser, 1992, p. 5). Indeed, Grounded Theory has been developed as a strategy to analyze, interpret and explain the reality socially constructed through the meanings that social actors ascribe to their specific experiences (Saunders et al., 2016). Even though Grounded Theory has been usually referred to as inductive research, as underlined by Charmaz (2011), its logic could be better linked to abductive reasoning. Indeed, while in the data collection process inductive reasoning is applied to develop "codes", or "collected data", deductive reasoning is subsequently applied when the researcher come across "surprising findings", in the process of constant comparison with existing theories that could provide proper and testable explanations to the latter.

In this regard, Charmaz's analytical procedure to coding (2014) has been followed by the researchers. Charmaz's approach is a simplified version of the more rigid and structured Strauss and Corbin's one (Corbin & Strauss, 2008). Indeed, while in the latter the first coding (the "Open coding", or the "Initial coding" for Charmaz) is followed by two subsequent phases, "Axial coding" and "Selective coding", in the Charmaz's approach these steps are simplified in one: "Focused coding". In particular, the "Open coding" phase consists of collecting data into conceptual units. It is the first step of the analysis and helps to organize the data, identify analytical concepts and categories, as well as develop the focus of the research question. The subsequent phase is the above-mentioned "Focused coding". According to Charmaz (2014), "Focus coding" involves the re-coding of the initial codes into a smaller number of more focused codes: the selection of the ones with most analytical potential requires a complete review of the data collected and the development of a new set of codes.

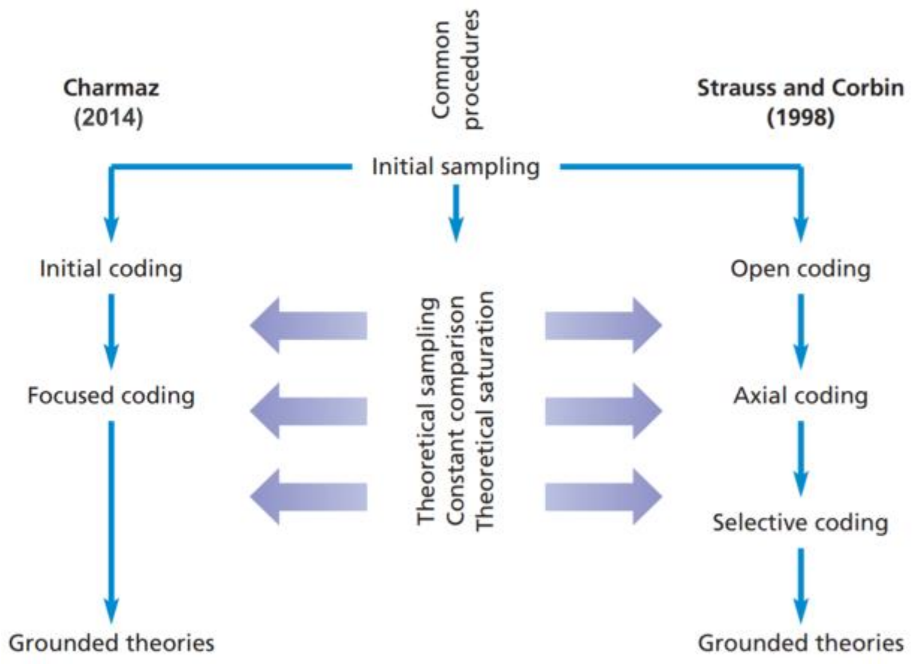


*Figure 3 - Comparing approaches to Grounded Theory. Source: Saunders* (2016)

The constructivist approach of Charmaz (2014) has been followed not only for its flexibility but also for its suitability, as mentioned above, with the abductive method applied to the research.

Regarding the data collection, to structure an analysis useful to answer the research question, primary and secondary data has been collected, the former through semi-structured interviews, while the latter in the form of documents, reports, and surveys.

#### 3.4.2.1. Semi-structured interviews – Primary data collection methods

To collect data useful to depict the current scenario and explore the future trends behind the lithium industry and market qualitative semi-structured interviews have been preferred as sources of primary data. In this regard, according to Saunders (2016), semi-structured interviews could be described as "non-standardized" interviews driven by an interview schedule, useful to collect data about pre-identified key topics and leave room for opening a discussion with the respondent.

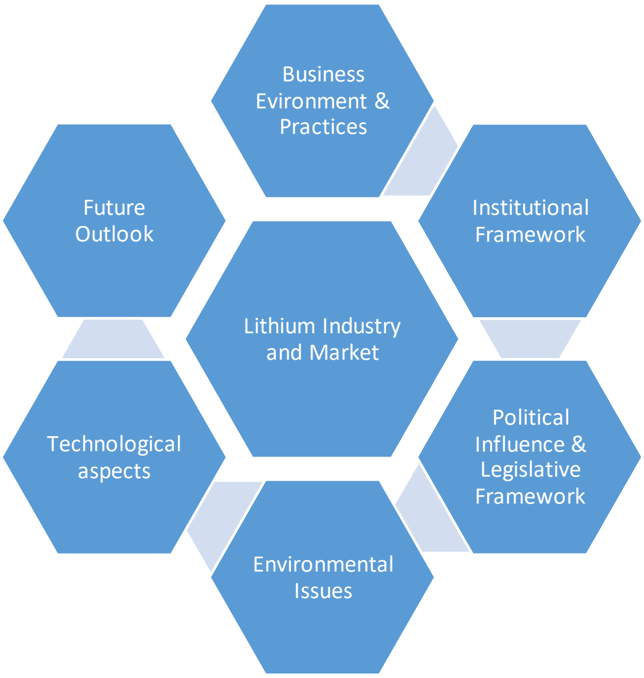


*Figure 4 - Topics of the semi-structured interviews*

The motivations in support of this data collection method rely on the willingness to get insights and information from different perspectives, overcoming the problem of the limited amount of academical research about lithium business and management.

The semi-structured interviews organized during the development of the thesis project have been three, the first via video-call, the second one via telephone call, and the last one via e-mail.

| Date and type | Interviewed | Expertise area | Subject |
|---|---|---|---|
| 24th June 2019, Video-call | Rajiv Maher, External lecturer at CBS | -Business and Human Rights<br><br>-Business Strategies in Latin America and the Caribbean | - Business practices in the Latin America mining business<br><br>- Mining companies and local communities |
| 1st September 2019, Telephone-call | Alonso Barros, lawyer (PUC) and anthropologist (Ph.D., University of Cambridge) | -Experience in advocacy and anthropology involving resource projects affecting indigenous peoples territories in Latin America. | -Lithium mining business in Latin America, with a focus on SQM, in Chile<br><br>- Future developments of the lithium industry from a governmental and community point of view |
| 2nd September 2019, e-mail | Joe Lowry, President of Global Lithium LLC | - More than twenty years of experience with the top three lithium mining companies in US, China and Japan. | - Lithium supply chain and business dynamics<br><br>- Future developments of the EVs industry, and its impact on the lithium one |

In regard of the former two interviews, to avoid interviewer and interviewee bias, the researchers have previously done an adequate research about the topics of the interview, and have reasoned about the interview process. For the e-mail interview, instead, the researchers have exhaustively explained their research process, and suggested the interviewed to openly discuss the questions.

While the validity and credibility of the interviews have been assessed through the entire process, evaluating also the transcript of the Video-call and Telephone call, in regard of the transferability of the insights obtained through the interviews, the researchers have evaluated each finding in comparison to other primary or secondary data, as well as, considering the expertise area of the interviewed.

#### 3.4.2.2. *Documents, Reports, and Surveys – Secondary data collection methods*

To extend the researchers' knowledge about the project's topic, as well as to ensure the validity of the semi-structured interviews, secondary data have been implemented in the present thesis project in the form of documents, reports, and surveys.

The sources of secondary data are various and depend on the typology of the data required: for instance, the database of SAGE Research Methods has been used for the theoretical coding, while databases like Statista and the reports from the US Geological Survey, McKinsey, or the International Energy Agency, for instance, have been used as sources of secondary data to structure the analysis.

Finally, secondary data have also been used to test the validity of the insights obtained through the primary data sources, as well as to compare and ensure the validity of the different secondary data sources.

## 4. Delimitations

Given the proposed size of this work, it becomes necessary to draw a few boundaries to the scope of the research.

First of all, the authors opted for a fixed time horizon. According to the summary drafted by BloombergNEF (2019), many institutions and market analysts drafted different forecasts over the EV sector up to 2030. While result seems fall within a restricted range up to that date, they completely diverge in the long term. Thus, the authors preferred to restrict the time frame to the 2020-2030 timeframe. It would allow basing the research on converging sources while keeping practical results more grounded into reality.

The authors will carry out a global analysis, limited to EV and the lithium production sector. The supply chain of EVs is long and complex; it crosses five continents and affects up to 6 different markets. Moreover, some of the steps of the value chain may overlap, since some business may undertake vertical integration strategies in order to improve their supply chain. For example, the largest lithium mining companies also produce basic lithium chemical compounds. For this reason, by "lithium producers" the authors will mostly refer to large companies involved in the mining sector. In some cases the authors will also explain the effects of value chain intermediary markets on the mining sector. However, they will only take into account those dynamics moved by the EV sector in the first place.

The study focuses on the possible strategies available for lithium producers. Therefore, it will only focus on the effects of developments in the EV sector on the Lithium market. Even though some instances in the analysis may offer interesting suggestions for further research, they will not be taken into account in this work.

Lastly, the authors will rely on the most recent data in terms of mining estimates. The latter vary along with technology. Better instruments allow mining explorers to improve their estimates: they enable researchers to identify new mining reserves, while the latest machinery equipment could turn reserves into exploitable economic reserves. The reader should be aware that this year data may be updated next year.

# 5. Theoretical foundation

This section will introduce all those international business theories that will be helpful to frame justify and develop the topic of this work. It will also describe the theoretical tools and frameworks that will be crucial to develop this analysis.

International business theories alone won´t explain what course of action should lithium buyers take to respond to market pressure. However, they will be helpful to frame the issue under a theoretical perspective.

## 5.1. Stakeholder theory

The theory, originally proposed by and Freeman (1983) explores the relationship between a firm and all of those organizations and other entities around it, or using Freeman´s words, "*The principle of Who or What counts*".

There is no unique definition of what a stakeholder is: Mitchel, Agle, and Wood (1997) identify over 27 definition given between the ´60s and the ´80s only. Therefore, in order to reconcile opposite views, they cluster all these definitions in 2 subgroups: narrow views and broad views. Narrow viewers identify stakeholders as those entities having "*direct relevance to the firm´s core economic interest*". Clarkson (1994) for example defines stakeholders as *"those who bear some form of risk having invested some form of capital, human or financial, … in a firm"*. Broad viewers, on the other hand, base their definitions on the assumption that with their activity companies can affect "*almost anyone*". "Broadly viewed stakeholders" may or may not have "*legitimate claims*" over the firm, however, they can potentially affect it or be affected anyway. Thompson, Wartick, and Smith (1991)´s definition place itself in the second group as they consider stakeholders "*Those in a relationship with an organization".*

Mitchel, Agle, and Wood (1997) analyze three attributes characterizing stakeholder that emerge in both the sets of definitions:

- Legitimacy: stakeholders have some claim over the company. This claim is related to "*something at risk, moral claims or some other constructs*"

- Urgency: defined as the "*degree to which stakeholders claim call for immediate attention*". Urgency depends mainly on two elements: the "*time sensitivity*" of the claim itself and the "*criticality*" of the claim for the stakeholder itself;

- Power: Pfeffer (1981) defines power as "a relationship among social actors in which one social actor A can get another social actor, B, to do something that would not otherwise have done". Stakeholders can, therefore, influence up to a certain degree the actions of an organization.

The relevance of this theory will emerge in later discussion: multinational companies such as lithium producers, cross many borders thanks to their business and interact with a wide range of stakeholders all over the world. Their relationship with local governments, customers but also local communities living close to their mining sites are extremely important for the success of their business activity.

### 5.2. Resource Dependence Theory

Similarly to Pfeffer (1981), Enderson (1962) proposes a definition of power revolving around two hypothetical organizations A and B. The relevance of this earlier definition for this thesis is the identification of "dependency" as the opposite of power. According to his definition, organization A has power over organization B whereas it controls a resource that B is dependent on (and cannot obtain elsewhere). Taking this concept as a starting point will make it easier to understand the relevance of the theory in the context of the lithium sector. According to the theory, a company can´t generate internally all the resources it needs to carry out its business activity. Caves (1980) identifies "resources" as tangible/intangible assets "semi-permanently" tied to the firm. In other words, they are all those items a firm can extract competitive advantage from. Therefore, a company must establish relationships with other institutions that could provide these "resources or services". According to the theory, companies are active organizations capable of responding to the environment and influencing it to a certain degree. On the other hand, external institutions will exercise their power to affect the company´s access to said resources. (Aldrich & Pfeffer, 1976).

The problem of RBV and material availability appears to be a problem of political economy as well, and thus crucial for the survival of a company. Locket and Thompson (2001) analyze the link between RBV and path-dependence and how the firms manage relations with other stakeholders in order to secure strategic inputs. The authors conclude that a firm´s future opportunities depend on today´s decision. Oliver (1991) remarks that firms seek "stability and predictability" throughout their business life. Thus, they will try to exercise their influence over the environment and partner institutions in order to reduce uncertainty of material availability.

Therefore, which courses of action can a firm take to reduce dependence from other institutions? Pfeffer and Salancik (1978), Hillman, Withers, Collins (2009) explain what these strategies are:

- Mergers & Acquisitions: M&As serve multiple managerial objectives, often more than one at a time (Walter and Barney 1990). These objectives may be for example increasing market share, exploiting synergies, penetrating new markets, others… and last (but not the least) securing the supply risk of a specific good or product supplied by the target company;

- Interorganizational Relationships: in other words, joint ventures, consortia, trade associations, etc… (Barringer and Harrison 2000). These agreements help reducing interdependencies between firms, even though the supply risk´s reduction is lower in this case concerning M&As (Hillman, Withers, Collins (2009) );

- Boards of Directors: as Pfeffer and Salancik (1978) report, boards of directors cover different function in a firm such as providing counsel, legitimacy, and procurement of critical resources. The scholars argue that the composition of the board of directors is not casual but precisely responds to changes in the outside environment. Hillman, Withers, Collins (2009) recognize that the agency theory is generally more suitable to understand Boards, even though the implications for RDT are undeniable.

- Executive succession: according to Pfeffer and Salancik (1978), Hillman, Withers, Collins (2009), poor firm performance may be related to discrepancies between the environment´s state and the company´s response. In particular, environment contingencies may affect boards in appointing those administrators who may be more capable of responding to such imbalances.

Political Action: Pfeffer and Salancik (1978) argue that firms could be able to reduce interdependencies by shaping their external environment through political mechanisms. Subsequent research seems to support their argument. Meznar and Nigh (1995) suggest that companies depending on resources controlled by the government are those more likely to undertake political activities. Mullery, Brenner, and Perrin (1995) contribute noting that companies facing similar constraints, follow similar patterns in contributing to political campaign. Finally, two studies (Hillman, Zardkoohi and Bierman (1999), Peng and Luo (2000)) find that companies (respectively in US and China) whose official cover government position, may experience abnormal returns.

The authors of this paper argue for the relevance of this theory in explaining dynamics in the lithium sector. Lutsey & Nicholas (2019) when breaking down the cost of EVs, pose significant attention over the lithium-ion battery pack as the main driver of the EV cost. Baker (2019) argues further that the lithium-ion battery will probably be the preferred energy storage system for at least another ten years. Therefore, it is clear how the EV business depends on lithium components and how this material is crucial for the success of their business.

## 5.3. Global Environmental Analysis

The first chapters of this work will focus on two crucial questions: "How does the environment our firm look like?" and "How is it likely to change in the future?". As Burt, Wright et all. (2006) argue that the success and longevity of a firm lie in its ability to adapt to the contextual environment. Gupta (2013) asserts that all the functions of a firm, need to be coherent with the general strategic approach of the firm: only a strong environmental analysis enables to design an appropriate business strategy. According to Parnell (2003), since organizations and industries exist within a complex environment shaped by different forces, macro environmental analysis is the best approach to capture these effects.

This framework is subdivided into two main sections: the environmental analysis (**Step1**) and the scenario planning (**Step2-4**). Given the high heterogeneity of the players in the lithium sector and the complexity of the dynamics that are shaping its outline, we are moved by the need of presenting our analysis in the broadest and clearest way possible. Therefore, while this model originally was designed to focus on a firm and the environment around it, we will instead develop its structure and predictive power focusing on a product and its derivatives: lithium itself. In this way it will be possible to analyze all the relevant parties extensively playing a role in the lithium sector all around the globe. However, since different version of this model exists, it will be necessary first to present the theory behind it and the reason why one of this version will be more suitable for this kind of study. The reader should also be aware now of the fact that in this case the Environmental Analysis place itself as the first step of the Scenario Analysis.

### 5.3.1. Environmental Analysis

As Gupta (2013) notes, there are various methods to carry out an environmental analysis. The authors of this paper opted for a two perspectives approach in order to provide a complete picture of the markets to be studied. In particular, they opted for a combination of the Porter analysis and the PESTEL model. The authors believe that given the heterogeneity of the Lithium Business – Automotive sector, the combination of these two approaches provides a better structure to display all the relevant data.

### 5.3.2. Porter analysis

Michael E. Porter´s five forces approach (1979) was the first to push managers to rethink the way they approached strategically the industry they operated in (Grundy 2006). The model is built around five forces:

- Internal Competition: this force examines the intensity and the structure of the competition within the industry to be studied. It focuses the players competing for market share and how they influence each other;

- Power of Suppliers: every industry seeks external outputs to run its business. In this section, researchers examine the power balance between the industry and its suppliers, since the latter may affect profitability by rising cost and quality of inputs supplied;

- Power of Buyers: conversely, powerful groups of suppliers can force companies to lower their prices and rising quality, undermining profitability. This force examines which are the elements customers base their power on;

- Barriers to Entry: high entrance barriers in an industry may prevent new competitors from entering and fighting for market share. The higher these forces, the fewer the possibilities of new companies entering the market and joining the competition;

- Threat of Substitutes: finally, a new product or service has the power of stealing customers. This section explores possible substitute products and their capability of impacting on the focus industry's profitability.

The combined effect and the intensity of these five elements ultimately determine the attractiveness of an industry. Grundy (2006) asserts that among others, this theory has the merit of simplifying the microeconomic theory of an industry by reducing everything to 5 main influences. Moreover, it emphasized the importance of power relations within the industry as determinants of its attractiveness.

The porter analysis will be useful also in the final discussion part: since competitive "*forces shape strategies*" (Porter, 1979), the Porter Analysis framework could offer a suitable structure to develop managerial implications for companies working in the lithium business.

### 5.3.3. PEST analysis

However, as Samson (2017) notes, this model presents some major flaws that limit its application in strategy formulation. First of all, the process of categorizing the various forces as "Favorable" or "Unfavorable" is merely subjective and tied to the subjective point of view of those carrying out the analysis. The model doesn´t provide any indication on how to measure and compare the forces, nor the drivers within the forces. Secondly, the model doesn´t allow for dynamic analysis: it treats the different forces as if they were independent one another, while certain events could affect more than one at the same time. Finally, it doesn´t take into account other factors that are crucial as well as Porter´s while designing a strategy (for example legal frameworks, business implication of social factors, political interferences in business and so on).

So, Porter's model alone is not able to explain all the elements needed for this dissertation. However, scholars seem to agree over the appropriateness of the PESTEL framework in order to carry out a Global Environmental Analysis (Grünig & Khün (2018), Gupta (2013), Burt et al. (2014)). As Rapidbi (2012) recalls, various versions of this model were developed during the 80s, reportedly "PEST, PESTEL, STEEPLE" and so on. In this case, a PESTEL could be the most appropriate. Even though some elements belonging to different dimensions may overlap (in particular P&L and S&E, economic), they will be treated separately in order to provide distinct inputs.

Before going through the components of this model, there´s an important remark that needs to be made. Grünig & Khün (2018) outline three important remarks about the PESTEL analysis:

- Only elements relevant for future strategies need to be included;
- If the PEST analysis doesn't lead to one single probable outcome, it must be paired with a scenario analysis;
- Elements of the PEST analysis should be examined in parallel, and their interdependencies are highlighted.

While point 2. will be discussed in the next paragraph, point 1. and 3. Require to make a premise about the elements to be included in the analysis. Since the lithium sector crosses five continents and affects various industries, this study will cover only those "PESTEL" elements that are more likely to have an impact on the future outlook of the market in the future, in particular those that may have a greater impact over the supply and demand of lithium products. Moreover, the analysis will follow a "from mine to market" structure: it will start by focusing on those elements closer to the mining and shift down to the lithium market itself.

Here is a list of the elements that will be assessed for every PESTEL component (Grünig & Khün, 2018).

#### 5.3.3.1. Political Environment

It refers to all those political factors affecting the life of the industry or the company we are going to study. It comprises national policies as well as those international treaties or trading agreements (such as the EU or the NAFTA) and general trading strategies. It covers incentives and other public benefits (in this case) for lithium and EVs producers. It also includes relevant political indexes that assess various dimension of the political situation of a country:

The corruption perception industry is an annual rank published by "Transparency International". According to the organization (2019), corruption is "an abuse of entrusted power for private gain". It can emerge at every level, from the highest levels of a local government (distorted policies, misallocation of public resources), to lower levels of the state administration. As reported by Transparency International (2017), the mining sector is particularly subjected to corruption risk, no matter the country we are dealing with: this risk may emerge on various grounds, such as licensing, land allocation, environmental and social impact assessments and so on. This is why this index will be extremely useful in the analysis.

The "Ease of doing business index", published yearly by the World Bank Group will be useful as well in this section: it ranks countries according to various scores such as taxation regime, export/import policies, legal and credit efficiency and so on.

For this work, the "P" environment will also include a brief overview of those elements that traditionally belong to the legal ("L") dimension of the PESTEL model, whereas these elements will help to provide a better picture of the environment itself.

#### *5.3.3.2. Economic Environment*

It includes various elements: first of all, it entails an analysis over the leading economic indicators of a country, such as GDP, inflation rate, employment rate and so on. However, since these indicators have little explanatory power when it comes to lithium supply and demand, it will be taken into account only their impact on lithium trading. Thus, the analysis will also focus on other elements such as supply and demand determinants, price trends and so on.

#### *5.3.3.3. Social Environment*

It refers to all the demographic indicators that could be relevant for the company or the industry: lifestyle trends, distribution of income, level of education, age of the population, consumption patterns and so on. Once again, the focus will be on those indicators influencing the lithium sector and consume patterns of EVs.

##### *5.3.3.4. Technological Environment*

It includes the state of technology as well as eventual publicly or privately funded R&D to improve it, IP protection, and eventual presence of alternatives. In this case, the analysis will focus on those technological elements that are likely to have a greater impact on the lithium mining and EV sector. In particular, it will include technological trends as well as cost and demand determinants.

### 5.3.4. Scenario Analysis

The PESTEL analysis is a powerful tool to describe a complex system such an entire industry, but it has poor to none predictive power when it comes to drawing predictions from its result. Burt, Wright et all. (2006) argue that the PESTEL´s sole purpose is to describe a static system, without exploring the reasons behind the present state of things nor what the future of this system may be. Moreover, it doesn´t provide any structure to identify trends and dynamics working to shape the environment analyzed. In order to reinforce their claim, the scholars bring the example of rising oil prices: this trend may be the result of an imbalance between supply and demand, but the PESTEL framework doesn´t provide explanation for that. Similar reasoning can be applied to the lithium case since the elements listed in the model would not be enough to explain the trends in the industry.

This is exactly why in order to explore the possible future developments in the lithium sector, a Scenario Analysis would be more appropriate. As Burt, Wright et all. (2006, p. 60) explain, the assumption behind scenario development is that the environment is characterized by an intrinsic uncertainty over future developments. Therefore, it *"… can be best understood from the perspective of multiple and plausible futures"*. The purpose of the analysis is not to obtain exact numbers, nor to guess what the future will look like: instead, it explores possibilities that may have an impact over the future of a firm. Instead, it supports decision making by reducing future complexity to a set of mutually exclusive possible outcomes. According to Postman and Liebel (2003, p. 167), *"Scenario analysis is not aimed at obtaining forecasts but advocates the creation of alternative images of the future development of the external environment. In doing so, scenarios highlight crucial uncertainties, with impact on the (strategic) decisions managers have to make"*.

According to Grünig & Khün (2018), scenario analysis can be carried out following two approaches:

Analytical approach: researchers link together those relevant uncertain variables and develop a possible outcome accordingly. In this case, variables are attached numerical values taken from past trends or future forecasts. This method enables researchers to develop multiple scenarios based on these values. However, the analytical approach is more costly with respect to the qualitative approach: it requires a greater amount of data and its more time-consuming. The two authors report that even larger companies sometimes avoid analytical approach;

Qualitative approach: similarly, researchers identify uncertain variables and attached them to possible future values. The main difference here is that the combination of qualitative variables produces alternative scenarios. The path leading to these alternative versions of the future is usually excluded from the analysis. Even though the literature body offers various methods to put this approach in practice, scholars (Grünig & Khün (2018), Burt, Wright et all. (2006, p. 60), Postman and Liebel (2003)) present the final outlook of this method in a similar way.

For this work, the authors preferred a "qualitative scenario analysis". The reason is the following: the analytical approach offers one or a series of multiple numerical outcomes based on the values selected by researchers. In the case of the supply of lithium, it would be hard to produce reliable outcomes from this analysis since its numbers are subjected to a high degree of uncertainty. The MICA (2019) explains that the estimation of resources depends on various factors: method of estimation, extractive technology, economic factors etc... and they change over time according to technology improvements. Therefore, any estimation made today, may not be reliable next year and any result obtained from the analytical approach would lose its value. On the other hand, qualitative approach would produce broader results as it would explore different possible plausible outcomes, and thus still be useful in the strategy formulation process.

#### 5.3.4.1. Procedure

Scenario analysis requires researchers to follow a step by step procedure in order to carry out the task. The academic literature is rich with different procedures: some procedures count a few steps, some others propose up to 14 steps (Duus 2016). However, many different procedures seem to rely on the same assumptions and seem to follow the same rationale. Moreover, the final structure of the qualitative approach seems to be consistent across various papers from different authors ((Grünig & Khün (2018), Burt, Wright et all. (2006), Aswath (2015), Postman and Liebel (2003), Duus (2016)). Thus, the authors of this study opted for Aswath (2015) method since it has simpler structure with respect to others and it better fits the objectives of this study.

***Step1****: Identify areas of concern.* Researchers identify the main areas of concern and use the environmental analysis in order to "take a picture" of the system they are going to analyze and to identify those elements, actors, and trends that constitute the base of the scenario. Postman and Liebel (2003, p. 163) suggest criteria to distinguish important factors from those "not useful for the analysis":

- Constant factors: factors that are most unlikely to change in the future --> not important;
- Predetermined factors: trends whose outcome is "largely predictable" --> not important;
- Uncertain factors: those element with known (or predictable at least) impact on the system but unknown probability.

Duus (2016, p. 15) suggests further considerations to keep in mind when brainstorming uncertainties:

- Decide a time horizon and select only those uncertainties falling within its range;
- Distinguish **trends**, as "developments over time", from **drivers**, as "factors contributing to one or more trend development";
- Eliminate those trends and drivers not useful for the analysis.

In this way, researchers focus only on those sources of uncertainty that are more likely to have an impact on the subject of the analysis.

**Step2**: *Decide the number of scenarios*. Decide the appropriate number of scenarios to develop in order to assess the research problem. A small number of scenarios has a low predictive value, while a higher number is more time consuming and requires a greater amount of data. This choice heavily relies on the areas of concern identified during **Step1**. Different scenarios explore different values attached to the uncertain factors selected from the analysis.

**Step3**: *Estimation of the scenarios*. At this point, researchers can draw scenarios. This section should focus on the uncertain variables: the outcome of the scenarios should show the effects of attaching different attached to the uncertain factor. Duus (2016,) on the other hand suggests double-checking every single scenario developed here in order to spot unseen impossible covariations, unimportant elements or other predictable values (in the case of scenarios depending on multiple uncertain variables). Duus (2016, p. 15) encourages to enrich the scenarios to seek information from other sources in order to improve the four solutions obtained. Moreover, he suggests to run them through a "*7-point consistency test*" as described in the table.

| **7-point consistency test** |
|---|
| 1) Deviate from the present, I.e. they should show a future reality that differs from the present;<br><br>2) Be consistent with present-day reality, I.e. they should present a narrative that could be argued to follow from the world of today;<br><br>3) Be probable, I.e. they should not be unrealistic;<br><br>4) be of somewhat equal probability, I.e. all scenarios should be equally realistic;<br><br>5) Be internally consistent, I.e. the elements describing the scenarios should have a logical relation to each other;<br><br>6) Be distinct from each other;<br><br>7) take all influential trends/drivers into account |

**Step4**: *Attach probability to scenarios*. Finally, researchers can draw conclusions about the probability of different scenarios, for example by consulting third parties and expert in the subject of study.

Burt, Wright et all. (2006) propose other steps that may improve the solution to this kind of analysis:

- Scenarios should be then confronted in order to identify those structural elements that would be consistent in more alternate future, but also to spot the key differences. These differences could be important for strategy formulation.

- The final solution should be also used in order to understand the key dynamics behind the variables studied so far, to gain a greater understanding of the system´s behavior.

#### 5.3.4.2. *Scope and Limitations of the Global* Environmental Analysis

As Burt, Wright et all. (2006) explain, even though the PEST analysis has limitations, such as poor predictive power or lack of understanding of the interaction between the variables, the scenario analysis reduces these drawbacks to a certain extent. Therefore, the limitation analysis on the Global Environmental Analysis will mostly focus on the second section of the model.

Postman and Liebel (2003) highlight two main drawbacks for scenario planning. First of all, scenario planning focuses on predetermined and uncertain elements. However, unknown elements risk to undermine the validity of the result: these elements can´t be identified at the moment of the research as they could emerge at any point within the time horizon of the scenario and undermine the final result. Secondly, scenarios are not perfect forecasts of reality. Researchers may put all their best effort in formulating plausible alternatives, but reality may still beat their imagination. Actual outcomes, for example, may happen even though they were previously excluded as "*inconsistent*" or "*logically impossible*" (Postman and Liebel (2003, p. 167)).

## 6. Five Forces Analysis: Lithium mining business in the global context

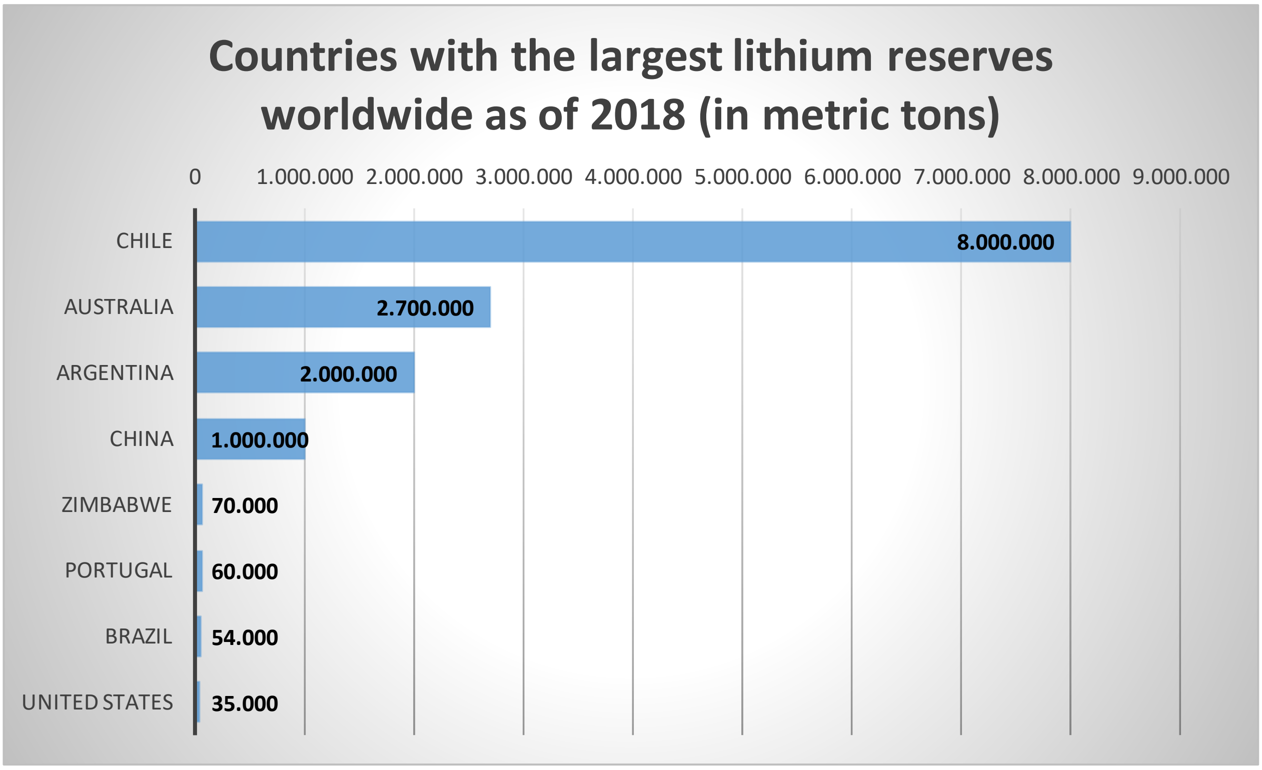


*Figure 5 – Compiled by the Authors. Reserves in metric tons. Source: USGS (2019)*

In terms of known reserves, Chile gains the first place in the rankings, holding 8 million tons of lithium, followed by Australia (2,7 million t), Argentina (2 million t) and China (1 million t) (USGS, 2019). Other relevant reserves can be found in Zimbabwe, Portugal, Brazil, and the USA. Bolivia is an exceptional case in this picture as the country may hold up to 9 million t of lithium in its underground reserve: however, lithium extractive industry it is barely at its initial state and business risks are higher with respect to neighbouring countries, as it will be shown (Barros, Appendix 2).

In terms of lithium production, Australia is leading the rankings, with 18,700 t produced in 2017, followed by Chile (14,100 t), Argentina (5,500 t) and China (3,000 t) (USGS, 2019). Even though Australia alone produces more than any other country, the combined South American production brings to the international market a more considerable amount of lithium.

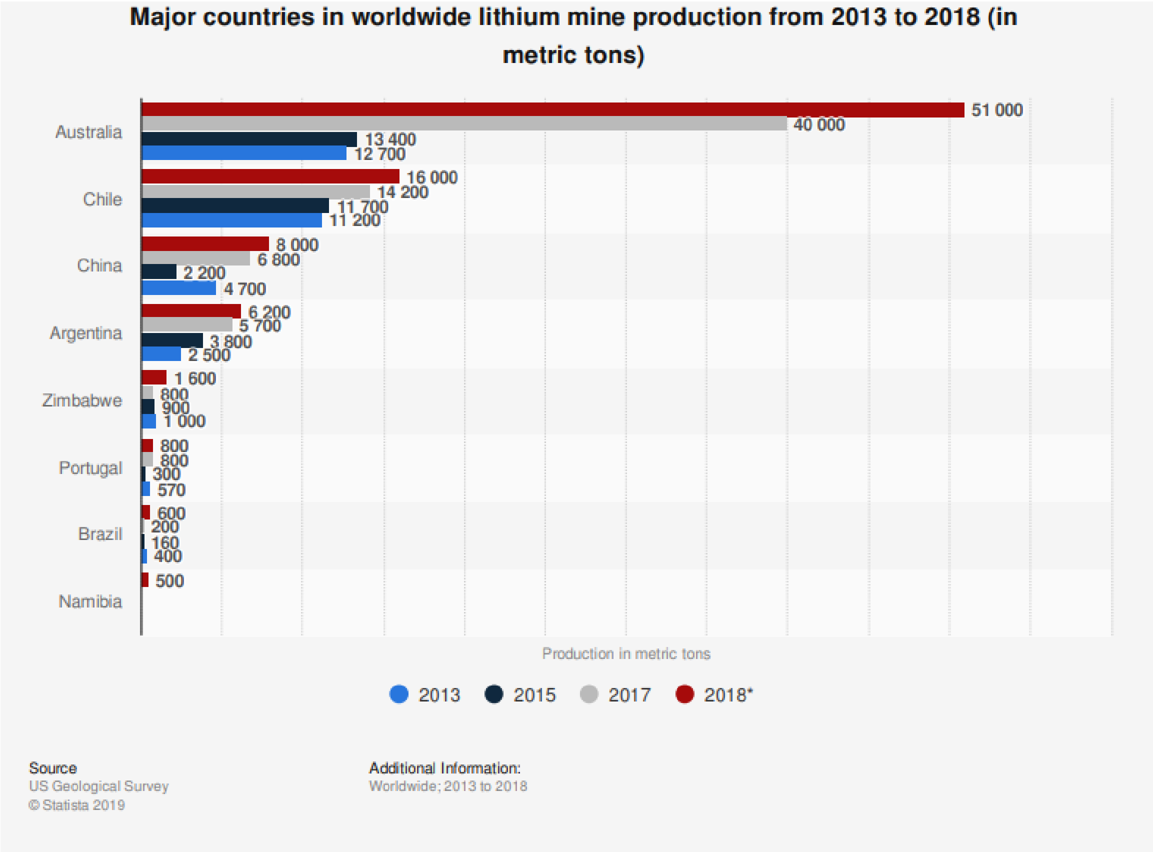


*Figure 6 - Compiled by Statista (2019). Source: USGS (2018)*

As reported by Martin, Rentsch et al. (2017) the lithium market is dominated by two lithium by-products: lithium carbonate and lithium hydroxide, respectively 46% and 19% of total worldwide lithium-based production. These two by-products are the main ingredients for lithium-ion batteries destined to the automotive sector. Other lithium by-products such as lithium concentrate and lithium chloride are used in various industries such as ceramics, polymers, and pharmaceuticals.

Sun, Hao et al. (2017) traced the global lithium supply chain from mine to its ultimate business buyer (EV producers in this case). Chile, Australia, China, and Argentina are the leading producers of lithium minerals and lithium chemicals such as carbonate (Chile, China, and Argentina), chloride (Argentina) and lithium concentrate (Australia). China, South Korea, and Japan are among the biggest importers of lithium compounds as these countries are world leaders in the production of cathode components for lithium-ion batteries. China and South Korea are also significant exporters of lithium-ion batteries, while on the other hand, the US, EU, and China itself are the major importers. The reason of China being on both sides of the lithium-ion battery trade is the fact that South Korea and

Japan produce higher qualities batteries: thus, China imports better batteries from these countries, while being able to mass-produce cheaper lower quality batteries and re-export them to western countries.

### 6.1. Industry Internal Competition

According Bohlsen (Bohlsen, 2016), the lithium industry is an oligopoly dominated by four large companies accounting for 60% of the market share (MS) of lithium production (Lowry (Appendix 3) asserts a higher percentage, 75%). At the top of the list, we find the American Albemarle (18% MS), followed by the Chinese Ganfeng (17% MS), the Chilean SQM (14% MS) and the Chinese Tianqi (12% MS). Moreover, numerous business ties exist among these companies. Thus, while competing for market share, on the one hand, these companies operate "de facto" as a cartel, controlling prices and supply (Barros, Appendix 2). This business dynamic is the first critical element to assess internal competition since high industry concentration (resulting from the oligopolistic competitive structure) reduces rivalry within an industry.

All the top lithium producing companies belong either to the producing countries (the Chilean SQM) or to the world's two biggest economies (China and USA). The Diplomat (2019) reports that in the past years, China has pushed to ramp up its dominant position in the world lithium rush. Reuters (2019) reports that on December 2018, Tianqi Lithium Corp acquired 23.8% percent of its Chilean rival SQM to bring "Price stability" in the market. According to the contract clauses between the parties, Tianqi is not entitled to any production of SQM, nor to appoint any of its executives or employees at the board of directors. On the other hand, it managed to appoint 3 "fair and responsible toward shareholders" directors to the board (Jamasmie, 2019).

Thanks to the latest investments (Jamasmie, 2019), SQM expects to boost its production capacity up to 120,000 mt and hopefully catch up with its most direct competitor, the American Albemarle. The interesting fact is that meanwhile, Tianqi has close ties with Albemarle somewhere else in the world: Australia. Forbes (2019) reports that the two companies invested for the creation of a Joint Venture, Talison lithium (Tianqi 51%, Albemarle 49%). The JV operates the Greenbushes mine, the Australian site.

Other factors in assessing internal rivalry could be product differentiation and switching cost. In the case of lithium products, these two elements are both rather low: commodities present little variations among producers. Therefore, companies can easily switch from a supplier to another as the latter compete mainly on prices. Maxwell (2015) explains how lithium producers commonly determine prices and quantities with customers through bilateral contracts. The reader will find more details about contracting practices at the "Power of Buyers" section: what is important here is that somewhat similar products and standard business practices tend to reduce the degree of rivalry among competitors in an industry.

Usually, slow industry growth is associated with intense internal rivalry (Porter, 1979): in this case, slow growth forces companies to compete on edge to expand. In the case of lithium, it does not seem to be the case. Grand View Research Analysis (2019) reports how investments in mining exploration both in China and Australia are expected to increase current production up to 70% by 2025. Mordor Intelligence (2019) forecasts a CAGR of 10.1% for the market up to 2025.


*Figure 7 - Morgan Stanley Research analysis of lithium supply. Compiled by Bloomberg (2019).*

Oversupply in the market usually suggests a high degree of competition. If on the one hand, the lithium market is growing; on the other hand, its growth rate is outpacing the growth of the electric automotive sector (Lombrana, 2019). Market oversupply has the effect of putting pressure on the prices, pushing them down and thus raising the competition. As the picture shows, even though excess supply is expected to expand in the next few years, it will ultimately shrink in 2025 when the automotive industry catches up. For this reason, rivalry degree could be deemed as intermediate here.

To sum up, the degree of competition among lithium producers seems low. The nature of commodity products itself calls for a lower degree of competition. Standard business practices and high growth contribute to keeping rivalry under control. Industry consolidation and oligopoly limit the aggressive expansion of single companies. Players may compete in securing new extraction site, expanding their capacity and thus benefitting of economies of scale. However, as shown in the case of Tianqi, high integration among companies and high upfront costs slow down expansion, reducing once again the degree of competition. Finally, keeping into account the expected reduction of oversupply, the overall degree of competition can be deemed low.

## 6.2. Buyer Power

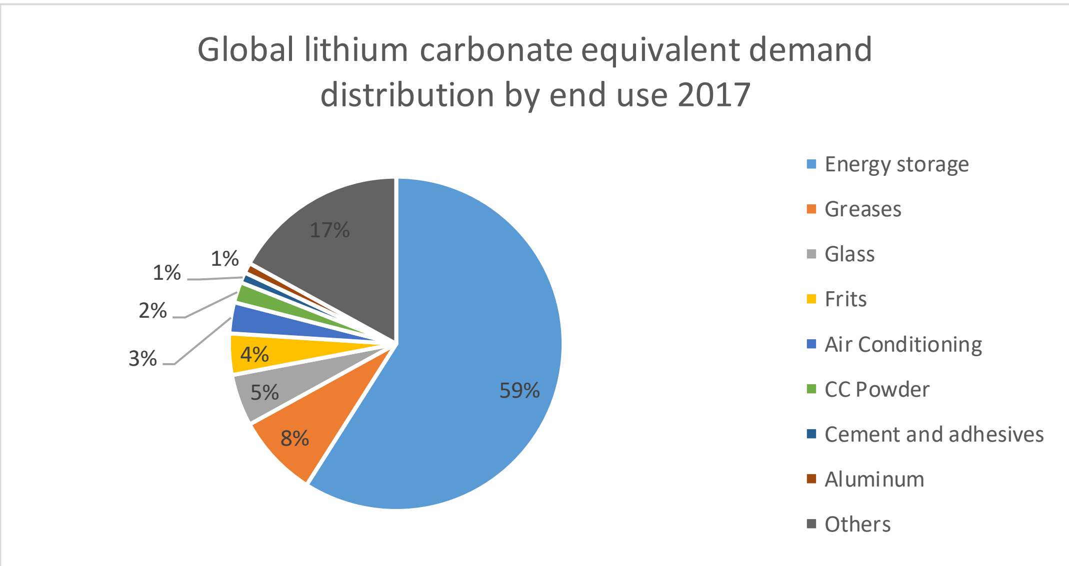


*Figure 8 - Compiled by the authors. Source: Jimenez (2018)*

The group of lithium buyers is vast and heterogeneous; thus, it comes necessary to outline two facts. As already mentioned, the group of buyers ranges from battery producers to pharmaceutical companies, grease, polymers producers and others. According to Jimenez (2018), in 2017 the energy storage sector accounts for 59% of the global lithium demand. Sun, Hao et al. (2017) argue that demand for EVs accounts for one fourth (14,17%) of the latter.

In order to produce batteries, lithium compounds need to be refined into further derivatives and then sold to producers. Refiners are many and mainly distributed around Japan, China, South Korea, and the US, while the lithium product offering is quite standardized. Moreover, as shown by Maxwell (2015), generally buyers of lithium products negotiate bilateral contracts with lithium producers, causing opacity around lithium pricing practices. To stabilize market practices, the London Metal Exchange proposed to create a Lithium price index (Ernest Scheyder, 2019). However, Albemarle itself opposed the initiative: such an initiative would "support a commodity market, and that is not what we believe this (lithium market) is about" company officials claimed (Ernest Scheyder, 2019). The refusal of Albemarle, the world leader in the sector, to share pricing information relies on the fact that these elements contribute to keeping the buyer power low. Customers source undifferentiated products from a smaller group of sellers, while pricing strategies remain confined to (often confidential) bilateral contracts. An official index, in this regard, could change the power balance in the market.

Profit margin is another figure to look at here: according to Qnovo (2016), the profit margin of lithium batteries tend to be "single-digit". Lowe, Gereffi, and Tokuoka (2010) point out that China disposes of cost advantage with respect to US competitors due to labor-intensive production facilities: the downside of this strategy is mass production of non-customized products, leading to shrinking profit margins. Low-profit margins tend to increase buyer power, as the latter will actively try to negotiate better deals for its purchases. However, this is not the case for batteries since, as Goldie-Scot (2019) explains, their cost is quite insensitive to shifts in the lithium price. For example, a 50% increase in the price of lithium would result in a 4% increase in the cost of batteries (Logan Goldie-Scot, 2019).

Lastly, one could look at the chances of buyers to integrate their supply chain upward. Sun, Hao, et al. (2017) point out that refining processes and battery manufacturing belong to different industries. Moreover, top lithium producers already integrated downward their value chain: as reported by Maxwell (2015), FMC and Albemarle entered the refining sector by producing higher value lithium products themselves. Therefore, buyer power can be deemed quite low once again.

In light of the above, at the present state of things, the buyer power could be considered moderate-low. Industry concentration, business practices, and low risk of backward integration contribute together to keep the buyer power under control.

## 6.3. Supplier Power

Barriers prevent potential new entrants from entering the market. Porter (1979) cites economies of scale as one of these possible barriers. Economies of scale force potential entrants to come at the table in “large scale or to accept a cost disadvantage” (Porter, 1979). Ebensperger, Maxwell, and Moscoso (2005) asserts that remote location of the mines, combined with the presence of economies of scale prevents new companies from entering the market and favours the present oligopolistic structure of the market.

Product differentiation plays once again a role in the game: low differentiation makes it difficult for new entrants customize their offering and stand out against the present competition.

In the case of lithium mining, the upfront capital requirement may be one of the highest walls to be overcome. Porter himself (1979) in describing what threat of new entrants are, describes the mining industry as one with the most significant upfront capital required. Even before the actual investment, mining business requires the obtainment of mineral rights from the State authorities for mineral exploration. Firms need to conduct feasibility study and verify that the resource they have identified is economically exploitable. Moreover, they have to test and verify that the project preserves the welfare of the environment and local communities (Geology fo Investors, 2019). No number has been mentioned so far. The cost of setting a mine is undoubtedly high: according to Kanellos (2016), for example, setting up a mine may cost up to $200 million to develop. However, the CAPEX of the major lithium companies may provide a clearer idea about what competing with the top four means. Albemarle itself (2019) reports it increased its CAPEX from $317 million in 2017 to $700 million in 2018 to fund mineral exploration. SQM reports a CAPEX of $360 million in Chile to run its mining sites (SQM, 2018).

Conversely, as explained by Maher (Appendix 1), local Governments generally favour investments in the mining sector of their country. These actions particularly true for developing countries: these countries need foreign investments to foster their economic development. They earn on mining rights, on the creation of jobs for local communities at mining sites and from other externalities. South American countries have a long history of mining activities, and they are well endowed with the infrastructure mining companies need to carry out their activities. Moreover, countries such as Chile (Reuters, 2019) and Argentina (Reuters, 2018) are already investing heavily to expand their lithium production capacity. The Bolivian government granted the German ACI Systems the right to explore its soil to expand its mining activities. German government officials backed the company certifying the credibility of the bid, easing the negotiation process (Nienaber, 2018).

However, despite local governments supporting the development of mining activities, barriers to entry remain huge in the lithium mining sector: complex mining processes, huge upfront capital investment and the strong influence of a few big companies already dominating the market makes it very difficult for new-comers to emerge and gain their stake in the market (Kahiry, 2018).

## 6.4. Bargaining power of Suppliers

In general, the mining industry is supplied by players offering a wide range of different inputs. They could be divided between providers of material and non-material inputs.

Probably one of the most critical supplies in the mining business is legitimacy, in the form of an agreement signed directly with the local authorities. As Allen & Overy (2013) explain, Mining Exploration and Development Agreements (MEDA) grant firms the right to undertake explorations, mining activities and to gain profits from the commercialization of mining products, within a confined area. Different objectives lie on the table of negotiations between the contracting firm and the state. The firm would want to keep the local government's influence at the minimum level, together with the taxation regime and its overall costs in negotiating the deal. On the other hand, the state would try to extend its control over the project as much as possible. It would ensure that the contracting company invests as much as possible in the development of the mining site, and it would try to obtain the highest return possible in the form of royalties. Finally, it would ensure to preserve the welfare of local communities, for example, imposing to the company to hire local workers.

Speaking of other suppliers, power, and other utilities are a critical component of a mine's supply process (Ernest & Young, 2017). These processes often come at a high cost for mining firms: in Australia mining company are currently facing rising power tariffs to conduct their operations. In Chile, the lithium mining sector competes with the copper one, second being the consumer of one-third of the overall Chilean power production. Recently, in 2018, the Chilean Government imposed restrictions over the operations of SQM and Albemarle in the country, in particular over the consumption of water needed to run their extraction plants (Sherwood, 2018). Argentina's government seems looser in its regulations regarding water extraction for mining activity, even though in some instances local communities managed to force authorities to block mining operations due to water consumption concerns (Roth, 2019).

The market for heavy equipment of mining activities is characterized by a few large players and many other companies of different size. Historically, northern countries such as the US and Europe have been the major exporter of heavy equipment for mining activities. However, the 2000s witnessed a shift in their export share in the global market. Between 2000 and 2010, USA and EU shares fell respectively from 34% to 12.7% and from 17.5% to 10.4%, while East Asia (China) and Pacific's rose from 15.7% to 39.6%. Countries like Brazil, Canada, and South Korea increased their shares as well (Farooki, 2012). The decrease in share of USA and EU was mainly due to the intensification of mining activities away from their established exporting markets such as EU itself and Japan (Farooki, 2012). Thus, it can be concluded that the market is highly competitive, lowering the power of its players.

On the other hand, heavy mining equipment represents a large portion of a total firms cost. Albemarle reported $3 billion of fixed assets on its balance sheet for 2018, out $7 billion of total assets (NASDAQ, 2019a). SQM shows relevant figures as its fixed costs for the same year amounted to nearly $1.5 billion against $4 billion in total assets (NASDAQ, 2019b). As Porter explains (1979), highly specialized equipment comes with high switching costs, making it difficult for firms to switch from a supplier to another.

Finally, as modern miners are pushing toward mechanization of mining sites, many companies have increased their demand for mining equipment in the past year, increasing supplier power.

Summing up, the power of suppliers in the mining sector, in general, appear to be moderate-high. Firms must comply with the government's regulations to start their activity, while high fixed costs and specialized equipment shift power in the hands of material suppliers. Finally, the growth of the lithium industry brought along environmental and social concerns in the top producing countries, forcing local authorities to take actions to protect local communities, affecting business practices at times. On the other hand, despite the recent rising demand for mining equipment, supplier business mostly depends on the economic cycle and miner's demand, mitigating their power.

## 6.5. Threat of substitutes

This section will mainly focus on the possible substitutes for lithium as an ingredient of energy storage systems. Possible alternatives for other products (such as polymers and greases) certainly play a role and could potentially affect the lithium sector, however, research in this sense would deviate from the objectives of this thesis project. Moreover, the USGS (2009) explains that lithium destined to these alternative sectors could be substituted with other materials such as calcium or aluminium, even though Hunt (2015) points out that in some of these cases resource constraint may still be an issue.

Since its launch in 1991, the lithium-ion battery has ruled the market of energy storage systems and enjoyed sustaining innovation up to date. However, concerns over the supply capacity of the lithium industry, together with the need of better alternatives, pushed research toward possible new technologies in the energy storage field (Beltrop, Beuker, Heckmann, Winter, & Placke, 2017). The scholars explain how potassium batteries development is quickly catching up, proving to be a valid alternative to lithium-ion batteries in the future. Zhang, Liu, and Guo (2019) assert that due to low cost, superior conductivity, and high operating voltage, these batteries have recently attracted huge attention, despite significant flaws that obstruct for now their larger-scale development.

Zhang, Liu, and Guo (2019), on the other hand, explains that problems such as heat dissipation, risk of short circuit low diffusion remain critical "roadblocks" slowing down the development of such technology. Liu, Tai et al. (2018) explain how low capacity and low cyclical stability of potassium batteries are some of the issues being addressed by current research. Cyclical stability refers to the capacity of the material to maintain its properties after several cycles of power charge–release: according to the study, the integrity of potassium components eventually gets compromised after several charge cycles. Zhang, Liu, and Guo (2019) argue that even though research may ultimately solve these technical problems, it may take up to 20 years to see the results.

The sodium-ion battery could be another plausible alternative to the lithium-ion battery in the future (Mochane et al., 2018). Gao (2015) asserts that sodium-ion batteries have an advantage in terms of high power density, long lifespan - up to 10 years, while others claim they may work up to 15 (Dell, Moseley, & Rand, 2014) - and high efficiency. On the other hand, they operate at high temperature as these batteries require liquefied sodium to function. Sodium melts at 350°C: this causes two main problems with these batteries, such as high operating costs and safety. Tanibata et al. (2018) argue these batteries theoretically may last that long; however further research is needed to improve the actual performance of the battery, as sodium compounds run the risk to deteriorate toward the final charging stages. Conversely, Baker (2019) argues that despite research in alternative technologies, the lithium-ion battery is going to maintain their leading position mainly due to cost reasons. The increasing exports from countries such as China and Thailand since 2010 reduced the price of batteries up to 85%. In terms of cost/performance, Baker reports that while in 2010 battery's pack cost averaged around $1160 kilowatt-hour, it fell to $176 kWh in 2018 and it may reach $100 kWh in 2024. Up to date, most players in the sector believe that falling costs of lithium batteries are still calling for sustaining innovation and that the market is yet to be disrupted.

In conclusion, the threat of substitutes appears to be low to moderate. To date, lithium is the most cost-effective ingredient to power batteries. There is much research going on around possible substitutes; however, no one seems to beat the performance and the cost-effectiveness of lithium batteries today. But this does not mean that the lithium-ion battery will maintain its leadership forever as technology keeps up.

# 7. PEST analysis: Lithium mining business and its environment

## 7.1. Political Factors

### 7.1.1. South American_Countries

The mining sector is strategic for South American countries: mining and mining-related products amount to almost 50% of Chile's, 12% of Argentina's and 80% of Bolivia's exports (OEC, 2019). Maher (Appendix 1) explained how these countries see the exploitation of their natural resources as the fastest way to develop. South America is not just about lithium, but it is about also iron, gold, silver, and copper. In 2013 it produced 45% of global copper (one-third of global copper reserves are in Chile) and 20% of global gold supply (Mining.com, 2015). And the list could go on. Even though these countries compete for the production, their normative framework toward mining differs from one another.

#### *7.1.1.1. Chile*

In Chile, the mining business is subjected to 3 legal bodies (ICLG, 2019b):

- The constitution, according to which mining site's ownership exclusively belong to the state. Locals and foreign firms can nevertheless acquire concessions and the right to exploit the land for mining purposes. It also provides durable protection of property rights of privates over concession;
- The mining concession act, regulating mining concessions, extinctions, rights and duties of privates;
- The mining act, outlining regulations of mining activities.

The Mining Ministry oversees the development of mining projects in the country, ensuring they conform to public policies toward the development of the country. In general, mining activity is subjected to a 35% tax rate, while royalties are negotiated case by case between the state and the company (ICLG, 2019b).

The Chilean government keeps the lithium mining industry under its rigid control. Selman (2019) points out that despite the easing mining policies in Chile since lithium is classified as a strategic material, only State-owned companies or private ones partnering with the

Chilean Production Development Corporation can enter the business in the country (in the form of Public-Private Partnership). Due to the possible utilization of lithium in the nuclear sector, concession must gain approval also of the Chilean Commission for Nuclear energy (Reuters, 2019). Moreover, the Chilean government imposes production quotas to companies for policy reason. Sherwood (2018) reports how in 2018 SQM struck a deal with the Chilean government, allowing the company to increase its production up to 349,553 mt of lithium equivalent products until 2030. In exchange, the Chilean government will receive $7.5 billion in the form of royalties. Moreover, the SQM will sell 25% of its production at a discounted price to local producers of battery components (Iturrieta, 2018; Sherwood, 2019).

In conclusion, Chile has a high "Corruption Index" score (27/180) (Transparency International, 2018b), showing low levels of corruption in the country as well as proper enforcement of anti-trust and anti-corruption laws. This index, paired with a satisfactory 56/190 score (Transparency International, 2018b) for the "ease doing business," suggests the idea of an open and business-friendly country. Nevertheless, Boddenberg (2018) reported that SQM and Chilean politicians are currently under investigation allegedly charged of money laundering, tax evasion, and illegal campaign financing. According to prosecutors, politicians received large amount of money in exchange of generous industrial policies approved in the parliament. The case is still going on.

#### 7.1.1.2. Argentina

The country, sitting on its 2 million ton reserves of lithium is among the most endowed nations in terms of the white mineral. Argentina is a federal republic, and its mining system is regulated in the following way (Heredia & Martinez, 2019):

- The national congress promulgates the Argentinian Mining Code - the code oversees over federal mining regulations;

- Provinces have the power to enact local regulations regarding mining procedures and other complementary regulations.

Companies are subjected to federal tax payments and local royalties. Moreover, in 2018, the government set a temporary export duty on exports, for the amount of 5% of the FOB price of minerals such as lithium. The measure will be valid until the end of 2020 (Heredia & Martinez, 2019).

Argentinian legal system grants investors - mostly foreign ones - to engage in exploration and exploitation activities, in exchange of a fee and compliance with an investment plan. The investor has the right to explore all the mineral reserves in that territory until expiry of the reserve. For Argentinian law, there is no distinction between foreign and local investors as both can be granted the right to mine in the form of mineral concession. Jurisdiction over this concession belongs to provinces and it is administered under their laws and the AMC (Heredia & Martinez, 2019).

As Barros (Appendix 2) explains, Argentina's mining strategy is similar to that of other South American countries: lithium is a valuable resource to provide additional income to the State and provinces, so the country welcomes international investors. One of the main issues is that the legislative framework lack completion: for example there is no central authority overseeing over the official registration of the mining reserves, leaving exploration procedures up to investors (Heredia & Martinez, 2019). Castilla (2018) explains how incomplete legislation and overlapping jurisdiction is a reason preventing companies from establishing long term investments in the country. Gilbert (2017) describes how a lack of local expertise slows down the development of a competitive mining sector on the international level, despite President Macri's efforts. Indexes confirm these issues: Argentina scores 119/190 and 85/180 for the Ease of doing business and Corruption index respectively (The World Bank, 2019b; Transparency International, 2018a).

#### 7.1.1.3. Bolivia

In South America, another country aims to join in the lithium business: Bolivia. The poorest South American country sits on the second-largest lithium reserve of the world. Since its election in 2006, President Evo Morales managed to raise the GDP growth of the country up to an average of 5% per year (the highest in the continent) by undertaking an anti-liberal set of reforms (COHA, 2018). For the mining sector, it meant greater participation of the state in the mining activity of the country, together with the boom of the country's mineral output (Andreucci & Radhuber, 2017). In 2014, Morales' signed the new Mining Law, according to which any foreign mining activity in the country must be undertaken under the COMIBOL -

the wholly state-owned Bolivian Mining Corporation. The law was designed according to socialist principles and with the intent to give the control of the natural resources to the people of Bolivia, and thus the State.

As far as lithium is concerned, the Bolivian Government invested for the creation of a first extraction plant in the Uyuni Salar flat, and it's estimated it will eventually be able to produce 150,000 tons of lithium in 5 years. Unfortunately, it is located "500km and a border crossing away" (Lombrana, 2018). Access to main trading routes, however, is not the primary concern for Bolivia's mining sector: Bolivia lacks infrastructure, expertise, and financial resources to develop the previous two within the country. Partnering with foreign investors is part of this strategy (Hopper, 2009).

In this sense, Bolivia's approach to its underground resources is similar to that of Chile: by partnering with German and Chinese firms, the country secured future trade agreements with two of the leading global competitors in the production of electric cars (Andreas Cremer, 2017; Ramos, 2019), thus securing income in the form of taxes and royalties (Westlaw, 2019).

Even though the country obtained considerable success in terms of growth and mining expansion, Stratfor (2018) argues that nationalization threats to suffocate further development of the sector in Bolivia. President Morales' reform forces foreign companies to partner with YLB, thus limiting FDI in the country. The future of Bolivia's nationalization policies lies in the elections of the 20$^{th}$ of October 2019: Morales will run for the third mandate, and even though he lost popularity, his consensus remains strong. If elected, Bolivia will probably continue on the path it had been following since 2006.

156/190 and 132/180 scores in terms of Ease of Doing Business and Corruption index make the country less appetible for international investors to put money in the lithium sector in the country (The World Bank, 2019a; Transparency International, 2019b).

#### 7.1.2. Australia

Being Australia Federal Parliamentary Constitutional Monarchy, each Federal State can enact separate legislative regimes concerning mining law. The 95% of lithium mining activities occur in Western Australia (Champion, 2019), where they are regulated under the

Offshore Mineral Act (2003) and the Mining Act (1978). In Western Australia (WA) (ICLG, 2019a), the jurisdiction over mining activities falls under the competence of the Minister of Mining and Petroleum: the ministry grants mining rights to the licensee in the form of mining leasing. There are no significant restrictions to foreign investment and foreign ownership; nevertheless international applicants must receive the authorization of the Foreign Investment Review Board to be granted the right to undertake mining activities (ICLG, 2019a). Finally, foreign companies are generally subjected to generally applicable taxation regime, while royalties are applied following the State royalty regime. Royalties are tax-deductible from income taxes at Commonwealth level. Lithium is subjected to a 5% royalty rate in Western Australia Legislation.

Lithium plays a central role in the development strategy of WA (Western Australia). First of all, as in other parts of the world, the mining sector supports the local economy. Secondly, it contributes to the Country's ambition to become a world leader in the production of lithium-ion batteries. To put it in the words of the current Minister of Mining, Bill Johnston, "Our ambition goes beyond mining. [...] Establishing a strong foundation at the precursor stages of the supply chain will create favorable conditions for further downstream manufacturing activities). According to Klinken, Western Australia has a unique opportunity in terms of location, manufacturing, and workforce capabilities to lead the world shift toward lithium-based technology (Government of Western Australia, 2019).

According to the Australian Trade and Investment Commision (2018), Australia holds the potential to become to integrate downward by processing the manufacturing of essential battery components in the country. Currently, most of the lithium produced in the country is sold to Chinese companies for processing and then sold to Japanese and Korean companies for the manufacturing of battery cells. Subsequently, cells are sold once again to Australian companies for other applications. The government's strategy hopes with its plan to integrate the refining process in the national lithium value chain.

In order to facilitate the process, the WA government declared it will support all the relevant sectors associated with lithium and batteries, not only by providing the necessary logistic/power infrastructure for mining extraction but also by supporting economically the "Future Battery Industry Cooperative Research Centre", while exploring and facilitating the adoption of lithium battery technologies in other sectors in the State. Moreover, the government declared it would invest in the improvement of recycling processes (Australia Trade and Investment Commission, 2018).

Australia is well placed in the top tear countries in terms of Ease of Doing Business Index and Corruption Index, 18th and 13th, respectively (The World Bank, 2019c; Transparency International, 2019a). The country disposes of strong institutions that would contribute to, eventually, successful business expansion.

#### 7.1.3. The People's Republic of China

As reported by ICLG (2019c), the Chinese mining sector is regulated under the Mineral Resource Law (MRL). Administration of mining activity falls primary under the competence of the Ministry of Natural Resources. Moreover, other ministries regulate the mining aspect that falls under their competence (for example, the Ministry of Ecology and Environment regulates the environmental impact of mining activity). In China, only corporate entities can own mining rights, and formally the state is the owner of all minable resources. Foreign corporations can own mining rights with two constraints:

- They can not be granted mining rights over rare earths and radioactive materials;
- They must enter into a joint venture or other forms of equity investments with Chinese entities.

Companies exploiting mining sites in China are subjected to local tax and royalty payments. They are also subjected to local law (apart of the MRL) where they apply.

The importance of the mining sector in for the development of the Chinese economy can be easily spotted from the current "Five years Plan". According to the current plan (Koleski, 2017), China is currently investing in developing its mining sector: for China, it is not just about the natural resources, but it is also an opportunity to strengthen rural economies in the more internal regions.

China set the course to drive the world away from the combustion engine vehicle, becoming the world leader in the electric automotive sector. According to Ramos (2019), the country will need at least 800,000 kTs of lithium to sustain its battery production. Brennan and Yu

(2018) assert that to do so, the country will likely pursue a three-step strategy. The first step is to develop the domestic lithium mining industry, with government support. It will probably remain a long-term strategy due to the cost advantages of South America and Australia in terms of extraction costs. Chinese brines present a lower density of lithium, while Chinese spodumene's deposits are located in remote areas, making it costly to set up mining facilities.

Nevertheless, China is already pushing to make its resources count. The Asia time reports that the Chinese Academy of Sciences developed a new method to separate lithium from other elements in brines sites. The technique could lower extraction cost up to $2180 per ton, reducing the gap with the average cost in the industry. Chinese companies are also pushing to improve production from new spodumene mining sites (Reuters, 2019): General Lithium, the country 4$^{th}$ biggest producers, has announced the opening of a new mine in the Hubei's province. According to the company, the plan would boost its production from current 22,000 tons per year to 82,000 tons, challenging Tianqi's leadership in the market (Reuters, 2019).

Secondly, China depends almost exclusively on Australia, Argentina, and Chile for its lithium imports. It would then make sense for the country to diversify by sourcing from alternative emerging suppliers such as Brazil, Bolivia, and Canada (Brennan & Guo, 2018).

Thirdly, China will expand its influence internationally over the global supply chain of lithium, by backing its companies with finance and diplomat support to secure supply and control prices (Brennan & Guo, 2018). Ganfeng Lithium Corp. acquired 37.5% of Cauchari-Oraloz's lithium project in Argentina (Lithium Americas, 2018). Chazan (2019) confirms that Chinese acquisition of 24% of SQM and 51% of Greenbushes operation are two sides of the same strategy, as the country expands its sphere of influence in the two world's most rich lithium sites. As of 2019, the lithium mining sector is barely developed, and the country is starting now to export its lithium resources. In Bolivia, Xijiang TBEA Group Co LTD managed to secure a deal with Bolivian State's company YLB from the Coipasa and Pastos Grande (Ramos, 2019). The agreement came after China lost the Uyuni deal opportunity against the German ACI Systems (Chazan, 2019).

#### 7.1.4. US

US's position concerning lithium production is similar to China's one: the country can not match the extraction of other countries such as Chile's and Australia's; however, it is a leader in the production of lithium products for batteries (Bell 2019). According to Lithiummine.com (2018), demand for lithium in the US will reach 320,000 tons per year in 2020, but the country's current production can match 5% of that amount only, while the rest of it must be imported from other countries such as Chile and Australia. To avoid supply crunches, private US companies are currently exploring new ways to obtain the supply they need. Simbol Materials claims to have developed a new filtering technology that would allow brine extractors to match Chilean extraction costs - $1500 to $1800 per ton. While major extraction sites are located in Nevada, further mineral exploration has been undertaken in Wyoming (Daly, 2013). NetworkNewsWire (2018) reports that Standard Lithium is currently setting up a new brines mining site in Calfornia and is undertaking exploration projects in the Smackover Formation area, a piece of land extending over Texas, Arkansas, and Louisiana.

Despite that, no new mine will enter into function in the States before at least 2022, and China is already producing domestically eight times the quantities produced in the US. The country is currently trying to catch up in the race with China for the supremacy in the electric car sector, but China disposes of significant advantage in terms of internal production. Thus, since the market of batteries and EVs is expected to grow in the next few years, the US must start investing now to be ready to compete (Lombrana and Deaux, 2019).

### 7.2. Economic Factors

This section will mainly focus on two main economic aspects affecting the lithium business. The first one is the business economic cycle, while the second one is the current outlook of supply and demand.

As MarketLine (2014) explains, the commodity business - lithium included (National Minerals Information Center, 2011) - is a cyclical one: during economic expansion demand for raw materials rises, increasing the price of commodities. On the other hand, during economic crunches, demand shrinks and the price of commodities goes down. This development is valid for all raw materials since they serve as inputs for any manufacturing activity. In the case of lithium, Mo and Jeon (2018) show the correlation between the EV demand and the price of lithium, being the most critical raw materials for batteries.

First of all, Mo and Jeon (2018) show how the price of lithium batteries is directly linked to the price of lithium: as the price of the commodity goes up, the price of batteries goes up. Secondly, they show that higher demand for EVs drives up the price of lithium; conversely, a shock in the demand of EVs has been found to have a little impact on the demand of lithium: demand for renewable resource storage system is projected to increase, and it would mitigate the negative effect of shocks on lithium prices.

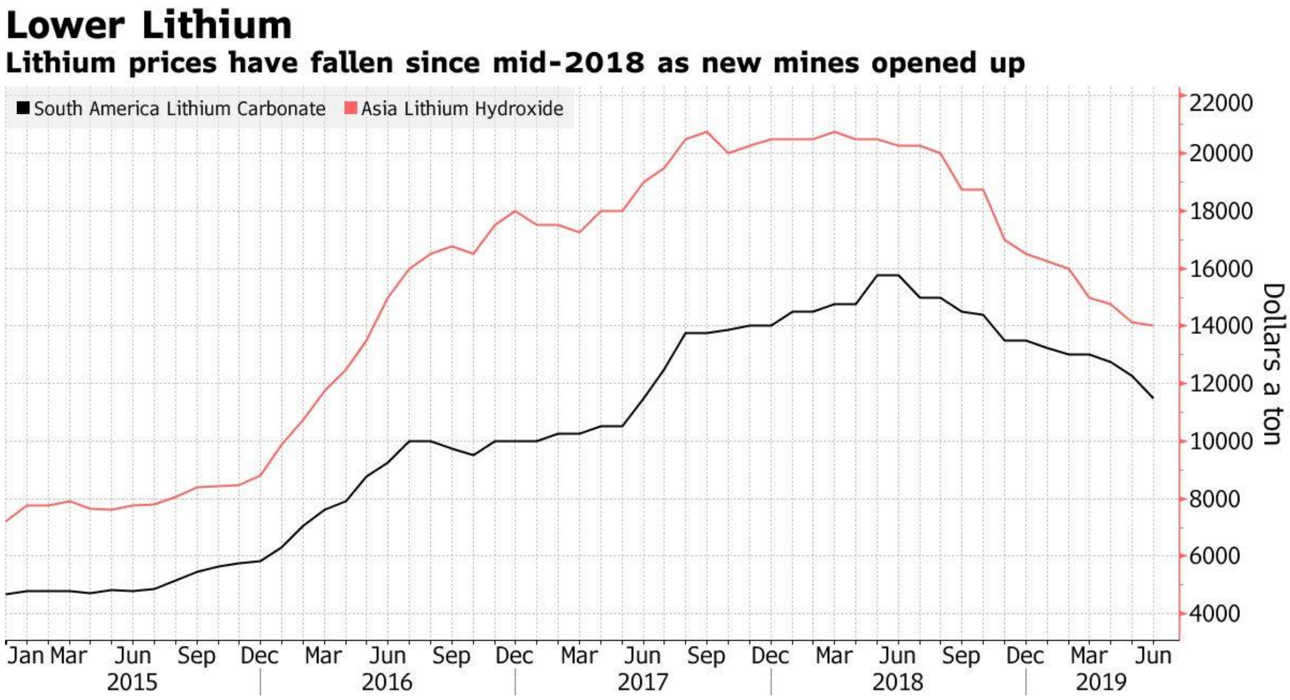


*Figure 9 - Compiled by Bloomberg (2019). Source: Bloomberg (2019)*

Nevertheless, lithium prices have experienced a significant drop since mid-2018. Lombrana (2019) shows how after three years of steady price increase (2015 to 2018), the price of lithium has dropped drastically from over $20,000 to $14,000 per ton for lithium carbonate and from $16,000 to $12,000 for lithium hydroxide. According to Lombrana and Stringer (2019), this drop is due to oversupply on the lithium side: in the past years' production steadily increased, so did mining exploration (in Australia alone six new mines have opened since 2017).

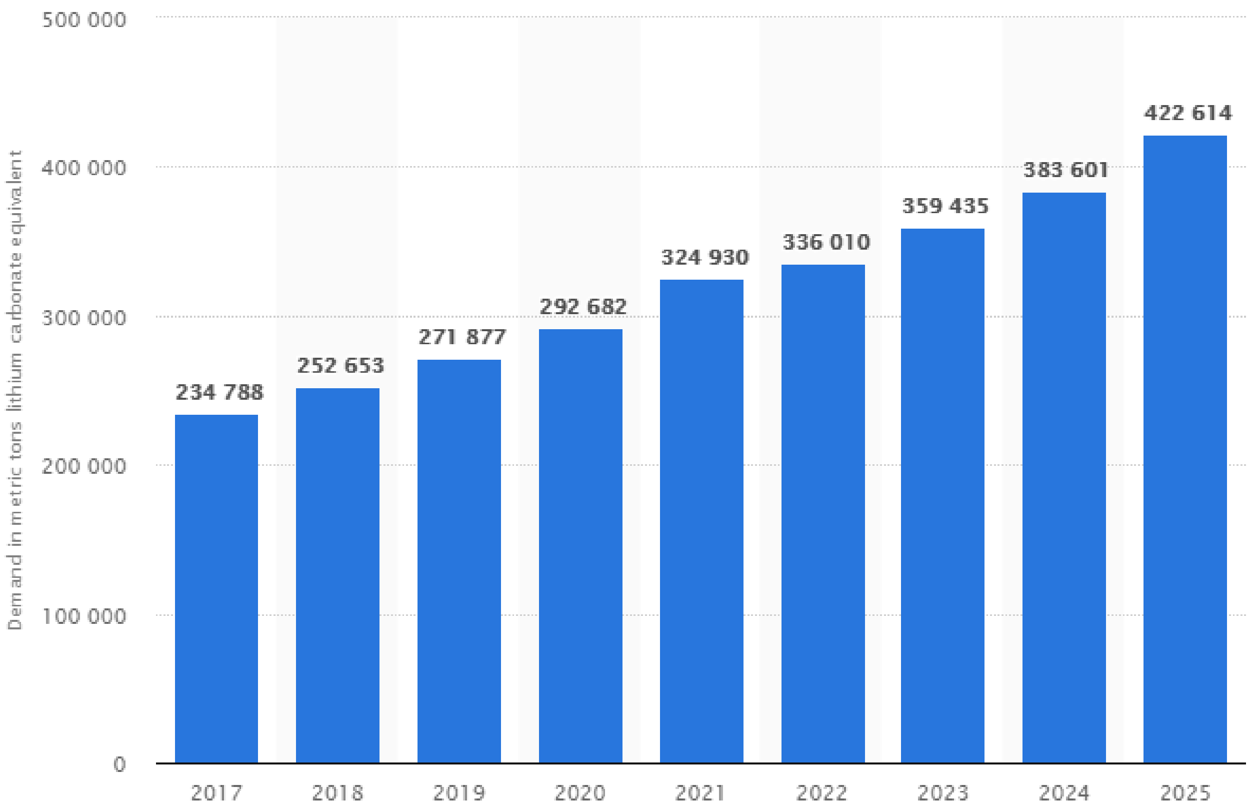


*Figure 10 - Demand in metric tons of LCE. Compiled by Statista (2019). Source: Statista (2019)*

USGS (2019) reports that between 2017 and 2018, global production of lithium jumped from 69,000t to 85,000t of lithium content products (+23%). By comparing 2018 production with 2018 total lithium demand (both expressed in lithium carbonate quantity), we obtain 450500t and 252653t respectively. In other words, lithium producers supplied the market with almost double the amount demanded. This quantity could be sufficient also to satisfy the market in 2025 (if forecasts are reliable) when EVs are expected to boom. This without taking into account possible production improvements.

Barros (Appendix 2) asserts that even though the capabilities of some countries to effectively serve the market - Bolivia and Argentina, despite the hype gathered around their endowment of resources - lithium shortage in the future is not a source of concern. The world is full of minable lithium, and suppliers can quickly expand their production to serve the market. Chile, for example, has a quota system in place to control production - and keep the prices tight - at the moment, but in the past Albemarle and SQM reportedly requested the government to lift these quotas, thus signaling that potentially they could produce more (Sherwood and Scheyder, 2018).

According to Lombrana (2019), surging production and falling prices could, therefore, be explained as the effects of ”trade-off” faced by producers: lower margins today in exchange for a better business layout when the EV market will finally boom. In other words, producers are currently gaining as much influence as possible in the market to be prepared for the perspective increase of lithium demand thanks to the booming EV market.

## 7.3. Social Factors

To briefly assess the “S” dimension of the PEST model, this paragraph will mostly focus on the relationship between lithium mines with the communities living around the sites. Other traditional elements falling under the “S” dimension of the PEST, such as demographics and cultural overview of the customer base, will be kept aside in this section. Being the mining business a B2B business, demand for lithium products is highly dependent on demand from other sectors and demographics become less relevant.

Humphreys (2000) stresses the importance of good relationships between mining companies and local communities due to the nature of the mining business itself: the mining business is a capital intensive one, it is generally not very profitable, and it can hardly afford extra costs due to community relations mismanagement. Unnecessary disruptions can be extremely costly for mining companies, sometimes up to millions and firms need to avoid them. Davis and Frank (2011) show how socially irresponsible behavior can increase stakeholder risk and cause high costs and delay to mining firms.

Fallis (2013) explains how mining activities have a significant impact on the socio-economic structures of local communities and the environment.

The first social aspect where mining activities have a strong influence on is the creation of new jobs close to mining facilities. Fallis (2013) shows how the opening of a mining site - often in a remote location - generates a sudden movement of people as the site itself becomes “the single most important economic activity”. Deller and Schreiber (2012) report that after the Great Recession, rising prices of commodities pushed mineral exploration in the US, creating job and development opportunities for rural communities. For example, Borden and Harris (2017) estimated that the newly discovered Humboldt lithium deposit in Nevada could eventually generate over 1000 jobs in the area. Maher (Appendix 1), explains this effect is at the core of South American countries strategy for rural development. He explains how the mining business in these countries brings a lot of people - mine's stakeholders at all levels - to these sites, creating not only new job opportunities for mining labor force, but also the service sector in these areas. New workers still need housing, restaurants and other services, creating new sources of income for the inhabitants of these territories.

Job creation opportunities, however, do not always come without conflicts. The case of Albemarle in Australia is a good one to set an example. In early 2019 (Jacqueline Lynch, 2019), Australian labor unions threatened the company to disrupt the construction of the new facility due to conflicts with the local labor force, when the company opened a new facility near the city of Bunbury and residents expected 500 newly created jobs. However, according to local labor unions, 70% of these jobs benefitted Perth residents and other workers from eastern Australia. Following the protests, Albemarle was forced to release a statement promising to offer more jobs to those workers living close to the plant.

Environmental impact is the other crucial aspect of mining sector influence. Firms must carefully plan each step of their mining activity to reduce their impact on the local environment to the minimum, from the exploration to the construction of roads to bring equipment to the site, to the excavation of the pit, the mining activities themselves (Fallis, 2013). In the case of lithium, there are a few worrisome trends that have affected the mining activities in the past and have the potential to affect them again in the future.

South American countries are known for suffering for water shortage in average condition (Vidal, 2017). Maher (Appendix 1) shows how lithium mining activities worsened the situation during the past years in South America. Lithium mining from "salars" require miners to pump underground water from the brines into evaporation pools to extract lithium. According to Maher (Appendix 1), the policy of South American governments is substantially uniform: as long as foreign companies bring their investments in the country developing the country, creating jobs and paying taxes and royalties for mineral activities, they are mostly free to carry out their activities.

Moreover, there are other reasons behind the conflicts for water. In Chile, for example, there is a jurisdiction problem (Sherwood, 2018): while mineral activities fall under environment authorities' competence, water authorities oversee over the pumping of fresh water. Lack of communication between the two different administrations, combined with the effects of water privatization in the country (Baer & Baer, 2014), create a jurisdiction void that mostly harms indigenous communities. In Bolivia, the poorest country in South America, the government faced protests from representatives of indigenous communities as foreign investors, such as the German K-UTEK and the Chinese Li Yi Dake Trade, proposed plans to local authorities disregarding local communities interests (Szarek, 2018). Argentina faced the same protests (Roth, 2019), as North Eastern Indigenous communities filed injunctions to block mineral activities in the region. The case is currently under examination by the Inter-American Court of Human rights.

There are more examples than the ones cited in this section. The important thing is that mining activities have a considerable impact on the economy of the countries where they take place, and companies run a high risk of getting their business disrupted whenever they end up affecting negatively local communities.

## 7.4. Technological Factors

"Technology" has a significant impact on the mining business in general: technological improvement improve production enhancing mining output while reducing unit production costs over time (Sohn, 2005). This paragraph will first compare various lithium extraction methods and their cost determinant. Then it will examine major industry trends related to innovation and their implications for the firm's strategy.

### *7.4.1.* Extraction processes

Extraction processes deserve to be fully explained in this section. As will be shown, not all lithium mines are the same, and extraction methods have a high cost for companies.

Lithium can be found in different kinds of deposits (Samco, 2018b), such as brines - surface or underground water - mineral deposits, or clays.

**Brines extraction** is the most common extraction method around the world, especially in South America. It is cheaper with respect to other methods but quite lengthy. Brines are water deposit naturally containing a high concentration of diluted minerals. They can be found underground (sometimes below evaporated lakes) or on the surface of earth´s crust.

At first, brine is pumped into an evaporation point, and additional water may be pumped. When the evaporation point contains brine with a sufficiently high concentration of lithium diluted in it, the brine is transferred to a separate facility for extraction;

Alternatively, lithium can be extracted from **Spodumenes**: among 100 lithium minerals, only 5 of them have a satisfactory lithium grade and spodumene is the most common on the earth crust. Australia (Reuters, 2018) is the first country using this method to extract lithium. Mineral deposits have a higher concentration of lithium with respect to brines, but due to higher setting costs, this extraction method is less widespread.

There are many **other** methods of extraction, such as extraction from clays, seawater, or recycled electronics. However, despite the substantial increase in investments in the past years (Samco, 2018), they are not a viable economic alternative yet with respect to the previous two methods.

Of course, the extraction method depends on the nature of the deposit. For example, while South America is rich in "salar" flats (Chilean Atacama Flat is the world´s richest brine deposit), Australia is endowed with more hard rock deposits. China is rich in both brine and hard rock deposits (Golden Dragon Capital, 2019).

Various factors are affecting the cost of the first two extraction methods (Samco, 2018):

- **Contaminants**: when extracting lithium from brines and minerals, the latter need to be purified from other unwanted elements such as potassium and sodium for brines. In fact, for this method there´s usually a higher presence of impurities, resulting in higher purification cost;

- **Concentration**: the higher the concentration of lithium, the lower the relative processing cost in the processing facility. Moreover, higher concentration means less waste production and waste disposal costs;

- **Flow rate**: the higher the flow rate of lithium, the higher the setting cost of the equipment needed to carry out the process;

There are other technical elements influencing the extraction cost.

Upfront planning (patents, authorizations, specific engineering, and mechanical design of the extraction site) may absorb up to 15% of the total extraction cost (Samco, 2018a):

- Installation rates and space requirements also play a role in the determination of the total cost, and they are once again specific to the kind of targeted deposit for extraction;

- The level of automation of the plant determines the balance between physical capital (machines) and the needed workforce needed to operate the facility. More automated plants require higher upfront cost with respect to manpower-intensive ones. However, the latter may result in higher costs in the long run due to the higher probability of human error and lower efficiency;

- There are many other cost factors such as operating costs, exploration costs, additional fees, or shipping of the setting up materials to the extraction site.

After taking into account all the possible factors affecting extraction costs, Investing News (2018) concludes that extraction from brines is cheaper with respect to extraction from spodumenes. While in the past mineral extraction was more popular, after 1990, improvements in brine extraction methods pushed production countries to switch from one to another. Up to date, the cost of extracting one ton of lithium from mineral ores amounts to 5000$, while it amounts to only 1800$ from brines. Setting up a brine extraction site is also cheaper due to lower exploration and setting up costs: it is way easier to set up roads and bring electric power to flat terrains where "salars" are usually set up. Finally, brine deposits are often associated with softer ground and smaller depths, facilitating preliminary exploration and setting up costs. On the other hand, extraction from minerals requires higher setting costs since these deposits can often be found in remote mountain locations. Moreover, refining processes need more expensive processing products to separate lithium from other elements (Samco, 2018a).

### 7.4.2. Innovation and tech trends

Bliss (2018) explains how technology improvements in the mining sector can help companies to improve efficiency, reducing operations costs together with maintenance costs, while reducing accidents risks, and improving the safety of workers. Moreover, they would help companies in reducing labor costs: while on the one hand, this is positive for companies, Bliss also points out that government should be paying attention to preserve the welfare of those workers affected.

TechNexus (2017) remarks about how mining firms are "data-hungry ones" and how technology can improve their data collection processes. By precisely locating the position of a mineral vein firms can reduce risks for their workers and cut significant portion of their costs: in fact, thanks to better data sources they can reduce exploration processes, design better mining facilities and achieve greater efficiency during the operative stage of the mining activity. Better data collection capabilities and extractive technologies can bring significant benefits also to the mining sector as a whole: as already mentioned, the MICA (2019) explains how better technology brings better estimation over total resource in a potential mining site and enables firms to exploit veins of mineral that would otherwise be unexploitable due to technical reasons.

But how do mining companies innovate? Urzua (2012) stresses the increasing importance of Knowledge Intensive Mining Services providers (KIMS) as one of the main contributors to the mining industry's innovation. Due to the high costs generally incurred by mining firms, KIMS contribution to R&D processes helps mining firms to upgrade their capabilities while keeping their costs under control. As explained by Urzua (2012), the KIMS market is characterized by large and small consulting firms, together with small providers of specific technology solutions for the mining business. Bartos (2007) compares the innovation rate of mining companies with that of high-tech firms and other manufacturing firms: he finds that mining firms do not show significant deviation from the average innovation rate of traditional manufacturing sector, while they remain far from the results obtained from more high-tech industries. Fernandez (2010) conducted a study over the Australian mining sector: her findings show that 40% of firms in her sample outsourced innovation from external sources. Among these, firms prefer private sources (50%), against public sources (41%) such as scientific publications or universities. Thank outsourcing processes, firms can achieve significant cost reductions, as inhouse technology development may be more expensive, especially if the capability to be outsourced is not directly related to the core business of the firm - like mining software development.

The increasing importance of KIMS and outsourcing of innovation is a relevant trend for the lithium sector too. ABB (2017) reports its involvement in the Nemaska Lithium project in the Bay Region in Quebec. The company would provide Nemaska Lithium with electrification and software services, together with other equipment automation systems. ABB worked closely with Nemaska in the designing process of the entire infrastructure to optimize the process.

### 7.5. Key findings - *"What is the lithium sector outlook to date?"*

From a competitive perspective, the lithium sector appears to be tight and stable, at least until the EV sector finally takes off. Monopolistic competition, low threat of substitution and integration, and government support contribute to safeguarding the leading position of existing firms. However, government support works in both ways, and while Chile and Australia are currently leading the lithium run, other countries such as Bolivia, Argentina, and the US are trying to scale up their production. Technologic developments and social issues can influence the lithium sector to a certain extent - technological factor have more considerable influence. Being lithium a commodity, its demand depends on other sector's demand: lithium sells to a multitude of different industries; however their outlook appears to be quite stable in the future. On the other hand, EV demand may dwarf demand from all the other sectors: producers and governments know this very well, in fact they are currently shaping their layouts to gain the most from EV growth.

# 8. Five Forces Analysis: Electric Vehicles Manufacturers in the Global Context

The Electric Vehicle Manufacturers (EVMs) will be analyzed taking the car manufacturers as players in the competitive environment. Moreover, being the lithium's flow the focus of the analysis and connection between the mines and the EVMs, the battery manufacturers will be taken as key suppliers, while consumers and fleet operators as key buyers.

## 8.1. Industry Internal Competition

The EV market is a concentrated one where a small number of car manufacturers are competing, involving seven leading car manufacturers (BMW, Chevrolet, Ford, Kia, Nissan, Tesla, and Volkswagen) and other minor companies. The reasons behind this market structure can be identified in the high cost of research and development of the EVs, as also due to the elevated fixed cost to start up the car production (McKinsey, 2019c).

While the offer of the EVs is not the same across the globe, presenting different competitive scenarios among regions, the internal competition is mitigated by the short product range of vehicles in the market, allowing different brands to compete in different niches. The competition structure, indeed, varies from country to country, depending partially on the infrastructure development of the latter. Indeed, while in North America, Europe, China and Japan the EVs are an establishing model of vehicle (Nick Routley, 2019), in the emerging markets the technical infrastructure is barely present, and the offer limited to a small range of cars, provoking an increasing competition.

Besides, from a consumer behavior perspective, the attitudes and purchasing preferences change from market to market, and so the competition:

- According to Larson et al. (2014), an analysis on the willingness-to-pay reveals that consumers with no experience or exposure (a) to EVs are unwilling to pay significant premiums for the purchase of an electric car, in contrast with the experienced consumers group (b) where almost the 25% demonstrated a willingness to pay a premium up to 10 000 $. As suggested by the results of research of Larson et al. (2014), in fact, markets where governments and institutional departments have implemented policies aimed to raise the awareness of EVs present consumers of the second group (b);

- Market development and cultural differences also play an essential role in the customer decision process, moving the competition from a matter of price to a matter of brand identity, customer benefits, or product differentiation.

Furthermore, Tesla is currently the only player in the market to be an EV only car manufacturer. While this competitive strategy increments the learning rate of Tesla, which is currently leading the market in terms of technical and business innovation (Ahmad & Khan, 2019), players with more financial capacities have defined investment plans to compete in a market where innovation plays a crucial role for company success. In this regard, car manufacturers such as Volkswagen has allocated $40 billion for the development of electric cars and autonomous driving (Andreas Cremer, 2017), while Ford planned to increase its investments in EVs to $11 billion by 2022, with the willingness to bring to the market over 40 new models of electric and hybrid cars (Nick Carey, 2019).

Finally, considering the high operating costs and the exit barriers of the market, we can consider the internal degree of rivalry as moderate-high. While, indeed, the current market is going through a phase of adaptation to the new technologies, infrastructures, and business dynamics, the near future appears to be subjected to increasing competition. Major companies will soon present more EVs, and while the global market growth rate will probably slow down, new business opportunities could appear to the ones that will be able to adapt their strategies to the new market dynamics of the sharing economy and vehicular automation.

## 8.2. Buyer power

Due to its recent explosion in the market, the current offer of EVs is still limited. Moreover, in terms of product range, the models produced nowadays can be classified among the city cars and luxury cars, not covering different market segments such as the multi-purpose cars (i.e., vans) and large cars.

From the consumer perspective, the decision to buy a car depends on different factors. Far from developing a consumer behavior analysis, and study the intentions and attitudes of the customers, it is possible to highlight the dynamics behind the customer decision to buy an EV and derive from it the customers' bargain power.

While previous studies suggested greater cross-price elasticity depending on vehicle characteristics and physical availability (Moraga Gonzalez, Sandor, & Wildenbeest, 2015), the customer's decision about the acquisition of an EV can also be influenced by the limited range and lack of charging infrastructures in certain countries (Engel, Hensley, Knupfer, & Sahdev, 2018). In this regard, both companies and governments are currently investing in developing a proper charging infrastructure:

- According to Reuters (David Shepardson, 2019b), even though the EVs represent a minor share of the sales of companies, car manufacturers are heavily investing in the industry, as also demonstrated by the €250 million invested by Volkswagen Group to install over 36 000 charging points all around Europe (Volkswagen, 2019b);

- Governments have approved different charging infrastructures policies in the USA, Europe, and Asia, most of them with the target to deploy an appropriate number of charging stations for the upcoming EVs. In this respect, in 2015, the Government of China has established the objective to install over 500 000 public accessible chargers by 2020, while the European Commission, in 2014, planned to deploy an appropriate charging infrastructure, setting the goal of installing one public charger per 10 electric cars (Energy Agency, 2019).

In addition, charging stations represent not only a switching cost for the buyers coming from a petrol vehicle, but also among the EVs owners: due to the constant innovation in the industry, charging stations have been subjected to a series of technical upgrades, defining the current four charging modes, and relative plug types, as established by the International Electrotechnical Commission (2014a, 2014b, 2016):

- Mode 1 – slow charging from a single or three-phase socket;

- Mode 2 – slow charging from regular sockets following safety standards;

- Mode 3 – slow and fast charging using multi-pin sockets;

- Mode 4 – fast charging using direct current through particular charging technologies such as CHAdeMO and CCS Combo.

While the disposable income of the buyers drives the sales of electric luxury vehicles, also growing in emerging countries such as China (National Bureau of Statistics of China, 2019), the inclination to buy an electric car from price-sensitive consumers also depends on the price of gasoline fuel. In this regard, 2018 has been characterized by a continuous rise in oil prices, exaggerated by significant political events such as Iran sanctions, while the prospects about the future remain linked to the future geopolitical outlook and its effects on market uncertainty (McKinsey, 2019b). So, even though it is not viable to provide a reliable forecast of the oil prices for the upcoming years, it is possible to highlight the current downward trend of the costs linked to green energy sources, supported by the global shift to these new production technologies (Orsted, 2019) (McKinsey, 2019a). In this way, the buyer power is somewhat reduced by the decreasing prices of green energy and the related financial appeal of the EVs.

In conclusion, while the customer base for electric cars is still limited to a small share of the entire market, the bargaining power of the buyers is mitigated by the lower price sensitivity of the targeted customers. Moreover, as previously mentioned, the future developments for greener and cheaper sources of energy, as well as the government incentives, will help the electric cars to become more accessible and financially attractive. In light of the above, buyer power can be classified as moderate.

### 8.3. Supplier power

Electric and fuel-powered vehicles share several parts, such as tires, lights and windows, partly fabricated in-house and partially produced by other companies. However, due to the new engines and technologies installed in the EVs, the car manufacturers were pushed to implement new processes, sometimes outsourcing ones or creating joint ventures with other players. Some examples of this phenomenon are the joint venture between Tesla and Panasonic for the construction of the Tesla Gigafactory (Tesla, 2014), and Blue Energy Ltd., a joint venture between GS Yuasa and Honda to provide batteries to the latter (Blue Energy, 2012).

While a wide range of suppliers can provide the necessary raw materials for EVMs, the quality of the latter and the components acquired in outsourcing increases the importance of the suppliers, and so, their bargain power. The quality of rechargeable battery components, for instance, plays a crucial role in delivering safety vehicles with optimal performances. For this reason, some EVMs as Tesla and Volkswagen (Ellen R. Wald, 2019) started a backward integration of strategical manufacturing operations, such as the production of their batteries, to limit their dependence on suppliers.

Besides, more players are investing in the electric storage sector, following the general trend of the electrification of the automotive industry, and increasing so the internal competitivity:

- The Chinese Contemporary Amperex Technology (CATL), second-largest lithium battery manufacturer in the world, has recently announced to open a new battery factory in Germany, increasing its production capacity and shorting the distance with clients such as BMW, with which the company has a contract of 4 billion euros (Irene Preisinger, 2018);

- The German privately-owned ACI Systems has built up a joint venture with the Bolivian state company YLB to develop a lithium plant in the Salar de Uyuni region and a factory for EVs batteries. The objective of the joint venture is to secure access to this raw material for the German car manufacturers, as well as to explore a vital sector for the development of the Bolivian country (Nienaber, 2018);

- With the willingness to improve its supplier power for the automotive industry, Samsung acquired in 2017 the American company Harman International, involved in the manufacturing of electronics parts for the automotive sector (Samsung, 2017).

From a cost analysis perspective, the price of EVs depends in a large extent from the costs of the battery packs installed in the vehicles and the price of the components of the latter, such as the lithium carbonate. In this regard, however, the Bloomberg columnist Nathaniel Bullard (2019) highlights the shrinking in cost of batteries along with the EV price tags. If in 2015 the battery

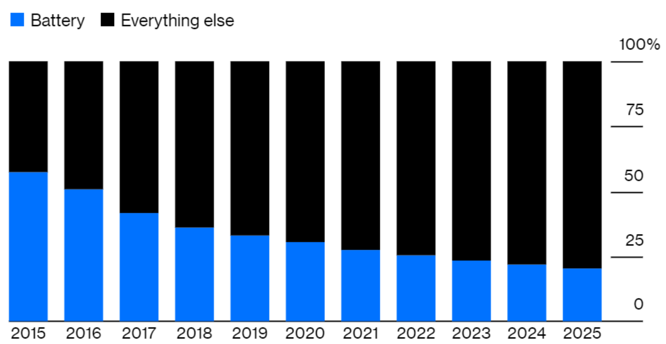


*Figure 11 -Battery cost on total cost for EVs. Source: BloombergNEF (2019)*

Note: Includes profit margins and costs other than direct manufacturing costs.

cost accounted for 57% of the total cost of an EV, in 2019 it is 33%. This continuous and drastic cost reduction was possible thanks to improvements in the battery manufacturing, as well as to economies of scale which are bringing the EVs to cost as much as their combustion engines equivalents by 2022 (Nathaniel Bullard, 2019). The result is that while the battery packs will continue to decrease in price thanks to a high learning rate (Logan Goldie-Scot, 2019), supplier power will be mitigated and held only by those suppliers that will be able to satisfy the increasing demand of batteries of the upcoming years.

The same reasoning could be carried out considering other raw materials such as steel, aluminum, or cobalt, which have been fluctuating in price during the past few years. While the impact of cobalt on the total cost of the car is not significant (Dieter Quartier, 2019), it is not possible to state the same for steel and aluminium which will continue to contribute significantly on the final cost of the vehicles, being part of around the 20 to 40 per cent of the car (Aubron, 2017). Moreover, with the increasing production of EVs, minerals and metals with limit availability such as lithium, mainly sourced in Chile and Australia, and cobalt, mainly sourced in the Democratic Republic of Congo, could enhance the supplier power.

Finally, regarding the EVs, charging stations producers can be considered as essential suppliers. Currently, only Tesla has succeeded in developing its network of Tesla Superchargers, suggesting the difficulty for the EVs manufacturers to develop and integrate such part of the value chain. In light of the presented analysis, the supplier power can be classified as moderate, even though future developments could shift the power balance.

## 8.4. Threat of New Entrants

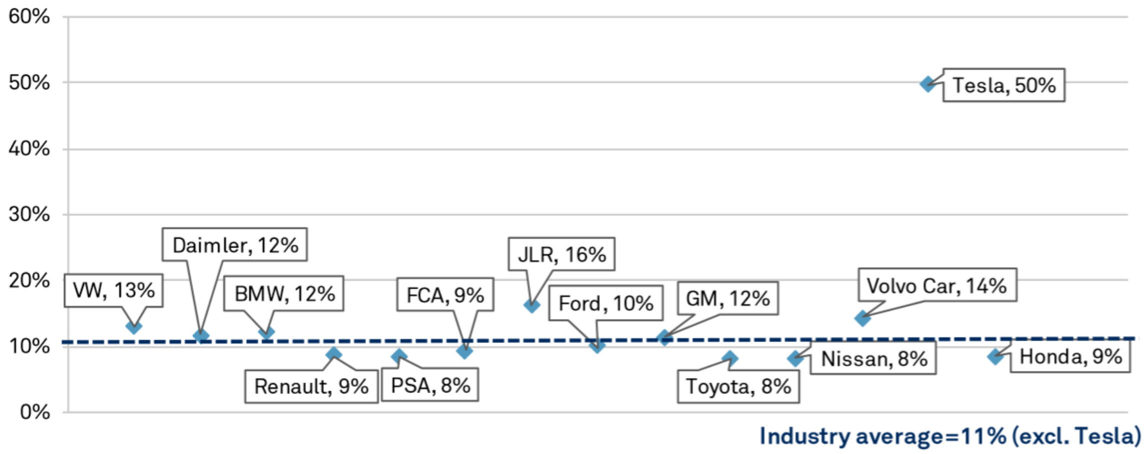


*Figure 12 - OEMs' Capex (% of Automotive Revenues). Source: 2017 Annual reports. | S&P Reports*

The automotive industry is well known for being characterized by high capital requirements, both to overcome the high expenditure in manufacturing and R&D. From a financial point of view, the capital expenditure (CAPEX) in the automotive industry is, indeed, of about 10%-11% of the revenues on average, while if we consider Tesla, the only company with an offer of only EVs, the rate goes up to 50%, of the over 11$ billion company revenues (Ferraris, Madlani, & Nakai, 2018). Being a new entry in the automotive industry, Tesla can be considered as an example of a newcomer in the automotive industry. The challenges faced by Tesla can help us to understand the difficulty for a New Entrant to take part in the competition: while indeed, the CAPEX to revenues rate is incredibly high for Tesla in consideration of the other players, in absolute terms the company is far behind the other players in the market. The capital expenditure of Volkswagen, for instance, amounts for 2018 to $14.14 billion (Volkswagen, 2019a), while Toyota enhanced its CAPEX to 1.5 trillion yen to boost the R&D in EVs (Toyota, 2018), figures that are more than double the expenditure of Tesla.

On the other hand, the exceptional and unique growth of Tesla suggests the vital role played by Brand strength and reputation for the players competing in the automotive industry. According to Mortiz et al. (2015), part of the success of Tesla, in fact, relies on the ability of the company and of its CEO, Elon Musk, to get the attention of the media and of the public, creating a positive perception among customers and investors (MarketLine, 2019).

Furthermore, the constant and high growth of the EVs market has attracted and incentivized corporate investors to finance new startups in the field: according to Cruchbase (2019), more than 390 startups involved in the EVs industry have been financed with over $8 billion. These investments could change the business dynamics in the industry, facilitating the entry of new players and, potentially, increasing the competition. Moreover, the more considerable attention by the governments around the world to sustainability challenges and climate change issues could incentivize investments for the adoption of the greener EVs and the startup of new companies in the sector.

Although the EVs market is still a fraction of the entire automotive one, with 0,3% of market share (OPEC, 2019) and just 3% of the entire vehicle sales with a forecasted 18% by 2030 (JPMorgan Chase, 2018), as previously mentioned, different incumbents of the industry have planned huge investments to produce EVs. While, indeed, a new entrant should overcome the high barriers to entry, such as the high capital requirements, the establishment of distribution channels, and manufacturing difficulties, for the incumbent, with considerable financial resources, moving the production to EVs is just a matter of planning and strategy.

Finally, if room for expansion exists for the EVs market, it is highly probable that the future of the electric automotive industry will be dominated by the leading companies of today, along with Tesla, unique case of success for a new entrant. In light of our analysis, the chances to succeed in the market for new entrants can be considered scarce, but with potential changes in the future.

## 8.5. Threat of Substitutes

There are different personal means of transport available nowadays, which besides including hybrid cars and cars with internal combustion engines (ICE), include alternative forms of transportation, as bicycles for instance, and public means of transport.

While the usage of the latter depends on different factors, such as the quality of the public services, the geographical location of the users, as well as other costumers' characteristics such as the presence of minors in their families and their income, the private mean of transports are preferred for their better accessibility and convenience (Chiou, Jou, & Yang, 2015).

On the other hand, more considerable attention to the environmental impact of cars is given by costumers and governments, in particular after the Dieselgate scandal which affected the U.S. and European market and interested several car brands of the Volkswagen Group in 2015 (Ewing, 2017). Although events like the latter incentivize customers who want to become environmentally friendly to use the public means of transport and alternative ones, EVs also represent a solution for these costumers, offering them the flexibility of a car with a low impact on the environment. Furthermore, new trends are catching on the industry, summarized in the CASE paradigm: Connected, Autonomous, Shared, and Electric. Through Artificial Intelligence and the application of sharing mobility concepts, the EVs could be at the center of a new way of use and perceive the city mobility. In this regard, Tesla announced to launch its driverless taxi service in 2020 (Korosec, 2019) and Uber has recently raised $1 billion for its corporate entity involved in the development of self-driving cars (Alison Griswold, 2019).

Finally, when analyzing the threat of substitutes we should also consider the above-mentioned hybrid and ICE cars, which are part of the current offer of the automotive manufacturers, and so, the competition among vehicle segments is limited. Furthermore, while there continue to be performance gaps between EVs and its substitutes, none of the alternatives has reached the same results in terms of emissions, direct and indirect, than electric cars.

In light of the analysis, we can evaluate the current threat of substitutes as moderate-high, considering, on the other hand, the ongoing efforts and investments of the leading manufacturing companies for the development of the EVs market.

# 9. PEST analysis of the Automotive Industry

## 9.1. Political factors

To depict the political factors that influence the competitive environment in the automotive industry, the analysis will highlight the alternatives that Governments have to influence the industries and their dynamics: the Government regulations and Government incentives.

While Government regulations affect directly the industries and the stakeholders involved through the application of new rules, the Government incentives are an indirect-mean to influence the supply and demand of industry towards pre-determined objectives.

Behind this worldwide attention to EVs, there are different drivers that move each government to promote greener mobility:

- In 2015, the members of the United Nations Framework Convention on Climate Change (UNFCCC) had negotiated the Paris Agreement, which set a global plan to reduce the greenhouse gas (GHG) emissions and deal with climate adaptation. The long term objective of the Paris Agreement is to maintain the increase in global average temperature below 2 °C, pursuing a limit of 1.5 °C. In 2018, according to the "Emissions Gap Report 2018" (Olhoff & Christensen, 2017), 195 countries had signed the agreement. While the agreement does not establish any penalty for non-compliance, it can be considered as a treaty under the internal law (Center for Climate and Energy Solutions, 2019). By 2018, according to UN Environment (Olhoff & Christensen, 2017), the implementation of Nationally Determined Contributions(NDCs) targets are contributing to limit the global warming but are still inconsistent with the target of 2°C/1.5 °C. Increasing attention and efforts are so required by all Nations to avoid and stop climate change;

- Also, the electrification of the Automotive industry is promoted by the countries involved in the production of EVs, from the mining of lithium, cobalt, and steel, to the manufacturing of batteries and cars. Wherever the development of EVs is strategical for the country development plans, regulations and incentives have a more significant impact.

### 9.1.1. The People's Republic of China

China is one of the most active countries in the transition from ICE to electric and hybrid vehicles, with over 2,2 EVs in the country (Mark Kane, 2018). On the other hand, China is the largest GHGs emitter and the largest consumer of coal in the world, with a total coal capacity under construction of 235 GW (Climate Action Tracker, 2019a). For these reasons, even though China is the largest solar technology manufacturer, and it has ambitious plans for the development of greener sources of energy, according to the IPCC Special Report the Chinese policies are "Highly insufficient" to reach the target of the Paris Agreement of 1.5 °C without a drastic interruption plan to eliminate coal as an energy source.

In May 2015 the Chinese Premier Li Keqiang revealed the strategic development plan "Made in China 2025", a structured program to upgrade the Chinese industry and develop ten key sectors, such as next-generation information technology, new materials, and new energy vehicles. In this regard, the roadmap of the plan aims to increase the market share of new Chinese energy vehicles to 80 percent by 2025 (Koleski, 2017). As a result, in 2018, the New Energy Vehicle (NEV) credit mandate went into effect, setting a minimum requirement for the production of electric and hybrid vehicles, with certain privileges for the manufacturing of battery electric vehicles (BEVs) with high performances. (Cui, 2018). The purpose of the NEV credit mandate is to create a national supply chain of EVs, supporting the establishment and development of manufacturing companies of EVs, as well as of its key components, such as the batteries. Moreover, China is the first country to have set a national standard for the energy consumption of EVs, and a maximum energy consumption requirement in kilowatt-hours per 100 kilometers for each vehicle class with a weight up to 3500 kilograms (State Administration of Markets and China National Standardization Administration, 2018). Furthermore, to counteract the development of ICE vehicles, from January 2019 the National Development and Reform Commission (2019) has forbidden any investment in new fossil-fuel car factories and banned every ICE car company with low energy consumption performances.

Besides, in terms of charging infrastructure, the Chinese plans are ambitious: with a current infrastructure of 214 000 charging stations all around the country, the Industry and Information Technology Minister Miao Wei has announced the willingness to build up the infrastructure to 500 000 public charging points by 2020 (Reuters, 2018). In terms of incentives, the National Chinese NEV Subsidy Program has adopted new rules and requirements for the allocation of subsidies: from 2019 the program will cut more than 50% of the subsidies to gradually shift the industry from policy-driven to market-driven (Reuters, 2018). In addition, to push the innovation forward, the program will continue to finance subsidies for battery EVs with high driving ranges, setting as a prerequisite a range of 250 km, one hundred more than the previous requirement of 150 km (Bloomber News, 2019).

### 9.1.2. The United States of America

The United States of America is the second market in terms of EV adoption, with over 1,1 million electric cars (Mark Kane, 2018). After the first series of measures implemented during the Obama Administration following the "Climate Action Plan", his successor, President Donal Trump, has moved back the US federal climate policy. In June 2017, President Trump announced the withdraw of the United States from the Paris Agreement, arguing that the accord was unfair for the country and could threaten the American economy with a cost of $3 trillion in lost GDP, and over 6.5 million jobs (BBC, 2017). While according to the Article 28 of the Paris Agreement the United States will not be able to withdraw the accord before the 4th of November 2020 (UNFCCC, 2015), the plans of the country towards a greener economy have undoubtedly changed during the Trump Administration, supporting the leading position of the US as oil producer (John C. Roper, 2018).

In April 2018, the Environmental Protection Agency (EPA) of the United States announced a review of the GHG emissions standards for the Light Duty Vehicles (LDVs) sold between 2021 and 2026 to provide "…a much-needed time-out from further costly increases" (US EPA, OA, OPA, 2018). In response to this proposal of freezing of the standards, twenty states, led by California, have declared to sue in case of advancements by the federal regulators. Moreover, most automakers expressed support for the opposition of California, and propose a 2.5 percent annual reduction in carbon emissions – half of the target imposed during the Obama Administration – to moderate the competition, set a single regulatory environment, and reduce the uncertainty (David Shepardson, 2019c).

On the other hand, the supportive actions for the EVs development by the Government and the singles States in the country are varied and diverse. In this regard, California has implemented an ambitious "Zero-Emission Vehicle program" to achieve 5 million of EVs on the road by 2030, along with a GHG emission reduction target of 40 percent below the 1990 levels. With the modification of 2012 the program has set a series of requirements, based on percent credits of ZEVs, for the auto manufacturers that want to commercialize their cars in the state of California: in 2018 the requirement was fixed to 4.5 percent of the total sales from each automaker, and it is expected to grow to 22 percent by 2025. Also, each electric and hybrid car contributes differently to the credit earnings of the car manufacturer, so that electric cars with high performances can earn up to 4 credits for each vehicle sold, almost four times the credits acquired through the sale of a hybrid car (California Air Resources Board, 2019). The ZEV mandate has also been implemented by other ten US States, and most recently also by the State of Colorado (David Shepardson, 2019a).

Furthermore, the United States supports the development of batteries and EVs with the Vehicle Technologies Office (VTO), part of US Department of Energy. VTO collaborates with laboratories, research centers, and key stakeholders with the ultimate purpose of developing new battery chemistries and technologies that can (Office of Energy Efficiency & Renewable Energy, 2019):

- Increase range of EVs to 300 miles;
- Decrease charge time to 15 minutes or less;
- Reduce the cost of EV batteries to less than $100/kWh-$80/kWh.

In regard of charging infrastructure, California is the most active State: along with its objective to introduce 5 million EVs in the market, the Government of the State founded its charging infrastructure with over $900 million (The Department of Finance, 2018). Moreover, with the Electrify America Plan, more than $1.2 billion will be invested in charging stations around the United States (Electrify America, 2018). Finally, in terms of incentives to buy EVs, all the jurisdiction of the country have an incentive for the EVs costumers in terms of loans and leases, rebates, grants or tax incentives (U.S. Department of Energy, 2019).

### 9.1.3. The European Union

The European Union represents 28 countries, and a market of over 1,3 million EVs (Mark Kane, 2018). The efforts of the European Union to support cleaner vehicles have a long history that goes back to the first group of emissions standards EURO I of 1993 (Coucil Directive, 1993). Nowadays, these efforts continue to exist under the European Green Vehicles Initiative, a contractual Public-Private Partnership (cPPP) focused on delivering greener vehicles and mobility system solutions, overcoming the environmental and economic challenges since 2013 (European Green Vehicles Initiative Association, 2019). Moreover, in February 2019 the European Commission has reiterated its commitment to strengthening the green mobility, defining the "Connected, clean and autonomous vehicles" and "Batteries" as two of the nine critical strategic value chains for the success of the European industries as leaders in innovation (European Commission, 2019). In terms of policies to limit the GHGs emissions, and fulfill the Nationally Determined Contribution (NDC) goals discussed in the Paris Agreement, the European Union is moving towards a 55% of reduction of GHGs overall emissions by 2030. A good improvement, according to the Climate Action Tracker (2019b), but not enough to avoid the 2°C climate change.

Regarding the automotive industry and electric mobility, the most recent regulation approved by the European Parliament has set a target for emissions reductions for vehicles sold in 2030 (European Parliament, 2019):

- A 37.5% reduction for new cars, in comparison to the requirement of 95 g $CO_2$/km for the ones sold in 2021;
- A 31% reduction for new vans, in comparison to the requirement of 147 g $CO_2$/km for the ones sold in 2020.

In addition, with the revision of the Clean Vehicles Directive of 2009 in February 2019 (Council of the European Union, 2019), the European Union supports the zero-and-low emissions vehicles in public procurements, establishing binding requirements expressed as minimum percentages of clean vehicles (electric, hybrid and natural gas ones) on total contracted procurements for public services. The minimum percentages are established country by country, and can range as follow:

- For Light-Duty Vehicles (LDVs), member states have to establish a share between 17.6% and 38.5% by 2025;
- For buses, member states have to set a target from 24% to 45% by 2025, and from 33% to 65% by 2030;
- For trucks, the minimum requirement range between 6% to 10% by 2025, and from 7% to 15% by 2030.

Moreover, in regard of incentives promoted inside the European Union, several countries have implemented incentive schemes for EVs, which majority follow a "bonus-malus" policy: Italy, for instance, at the end of 2018, has proposed a subsidy of €6 000 for the purchase of a vehicle emitting less than 20 g $CO_2$/km, and a malus of €2 500 for the ones with emissions over 250 g $CO_2$/km (Gazzetta Ufficiale, 2019).

Finally, regarding the charging infrastructure, the European countries are adapting their national policy frameworks to two directives of the European Union:

- The Alternative Fuels Infrastructure Directive (The European Parliament, 2014), which define the development targets for publicly accessible chargers in the European Countries in 2020, 2025 and 2030;
- The Energy Performance Buildings Directive (European Parliament, 2018), which set the requirement for national building codes concerning charging infrastructure in new and renovated buildings by March 2021.

## 9.2. Economic factors

The EV sector is part of a broader industry which is the automotive one. While the EVs can be considered as part of the future developments of the industry (Kuhnert, Stürmer, & Koster, 2018), there are aspects which are essential to consider, such as the economic factors that will impact on the electrification shift.

Vehicles sales have been, for a long time, considered as a leading economic indicator for the business cycle for the following reasons:

- Cars have a high sticker price in comparison to other products in the market basket of costumers (Office for National Statistics, 2019);

- Cars sales are sensitive to interest rates (Ludvigson & Sydney, 1998);

- Cars, like other durable goods, are subjected to "pent-up" demand: differently to other goods, their demand is particularly strong until recessions or depressions. When the economic scenario is uncertain, the consumers tend to postpone the purchasing of such goods, increasing their savings and waiting for better times. As it is possible to observe in the following chart, for instance, the estimates of average ages of autos raise after the Great Recession in U.S. until 2012. The same pattern is observed after 2015, suggesting that the "pent-up" demand has likely been exhausted (U.S. Bureau of Economic Analysis, 2019b, 2019a).

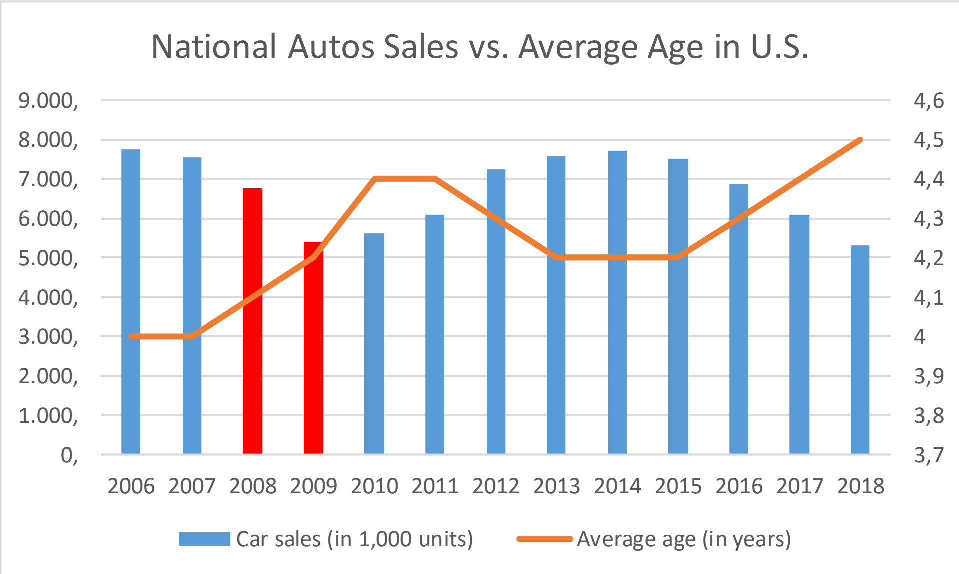


*Figure 13 - Compiled by the authors. Sources: BEA, 2019a, 2019b. "Average age" is a weighted average with the historical value of the Autos at the time of the initial investment.*

Along with the latter, reducing demand is also observable after 2015, indicating negative economic conjunction in the upcoming years for the United States. So, while the automotive industry could be considered directly affected by the economic and political outlook of a country, as studied by academics (Lahiri & Moore, 1991) and professionals (Yamarone, 2012) when analyzing the EVs sector, there are specific considerations to take into account.

The EVs are part of an innovation that is moving towards a take-off phase: according to Geels (2013), this shift will require additional efforts to overcome multi-dimensional struggles. While, indeed, several reports, from Bloomberg NEF (2019) to OPEC (2019), suggest an increasing penetration of the EVs in the market, it is still in doubt how strong the latter will be, and how the future global economic outlook will influence the electrification of the automotive industry.

In this regard, Geels (2013) suggest that, while economic and financial negative conjunctions affect negatively the establishment of "green innovations", in these periods the success of the latter depends on three groups of stakeholders: Governments, private investors and public audience. Although the influence of the Governments and the public audience seems to lose relevance when the crisis is incumbent, due to the decline in attention for climate change, their active actions could play a decisive role to support the sustainability transitions. These stakeholders could support "green innovations" in three ways:

- First, Governments could kick-start the recovery of their economies through the support of these transitions, such as the electrification of the automotive sector. Indeed, private spending and investments could be stimulated by a series of legislative maneuvers aimed at creating confidence and certainty around these new market opportunities. According to Zenghelis (2012), private investors and firms are used to hoard cash for better times, in search of profitable opportunities which, in this scenario, could be represented by incentives and policies towards low-carbon investments;

- Secondly, investing in public infrastructures, such as charging stations, Governments could provide exciting business opportunities for private investors and firms which, in a period of uncertainty, aim to get stable and predictable profits;

- Finally, public attention and media could put pressure on policymakers to take action towards "green investments". As noted by Geels (2013), however, these kinds of movements emerge, usually, after new scientific findings, shock events or, more generally, after the climate system has moved into unsustainable trajectories.

Moving attention to other economic factors that could influence the automotive electrification, it is essential to mention the oil prices and the derived fuel cost. The latter, as studied by Lane and Potter (2007), together with the fuel consumption of the vehicles, are used by consumers as proxy of environmental impact and vehicle cost. For this reason, future oil demand is strictly connected to future developments of EVs adoption. In this regard, as mentioned in Porter's Analysis, the forecasts of the oil prices vary widely depending on the geopolitical dynamics that will develop in the future. However, as underlined by McKinsey (McKinsey, 2019a), oil demand growth is expected to slow after a peak in the early 2030s at 108 million barrels per day. The same report suggests that while the demand of oil will be supported by chemicals sectors, slower plastics demand, increased plastic recycling, and automotive electrification could anticipate the peak to 2025 and halve the demand by 2050. Finally, although these trends are shaping the future of the oil industry, the lower prices determined by the reduced demand will probably delay the cost parity of EVs with conventional fuel vehicles, but are not expected to reverse the trend.

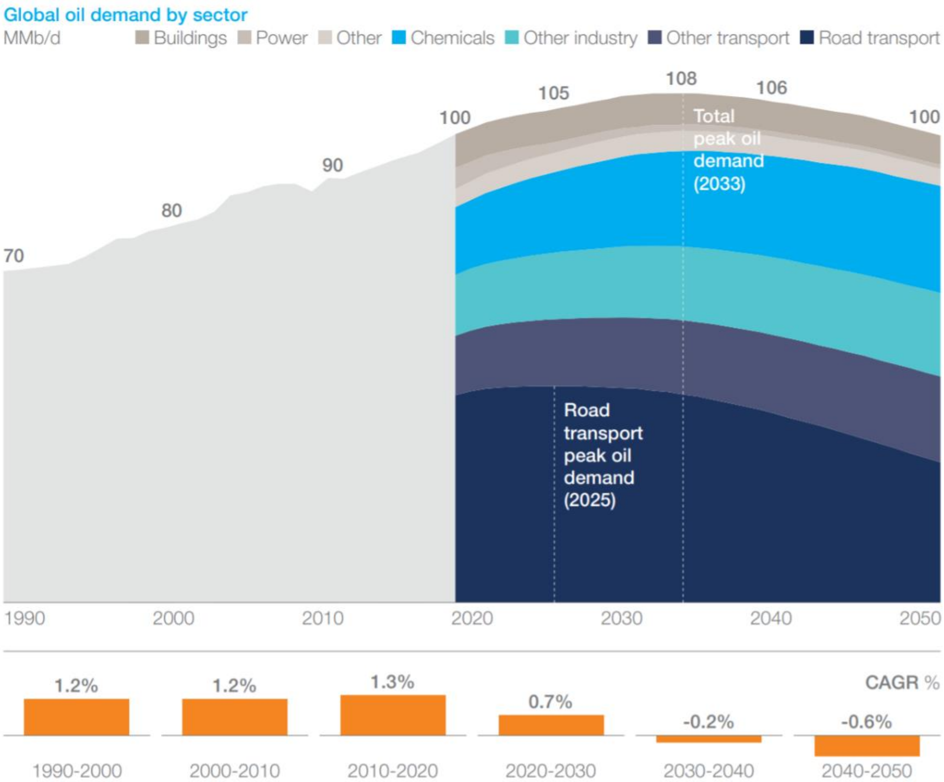


*Figure 14 - Global oil demand by sector | Expected scenario. Source: McKinsey (2019a)*

### 9.3. Social factors

Over the past decades, environmental awareness and attention to emissions have significantly increased. In regard of the automotive industry, the public scandal connected to different brands of the Volkswagen Group, the so-called "Dieselgate", had a massive impact on public audience, opening a debate on the role of automakers in the fight against the Climate Change, and the responsibilities of control subjects (Ewing, 2017).

The increasing environmental consciousness and the development of new technologies, such as the Artificial Intelligence (AI) and the Internet of Things (IoT), have raised the attention to a new idea of mobility, that puts the EVs at the centre of a technological transition, and summarized in the CASE paradigm (Marcos Martinez, 2018): Connected, Autonomous, Shared, and Electric. Regarding the first two points of the paradigm, the concept of a connected and autonomous car has gotten the attention of the public and policymakers due to the higher safety of the vehicles for drivers and pedestrians: a smarter car could bring to zero the reaction time to potential collisions. Moreover, while the current state-of-the-art of autonomous vehicles presents large room for improvements, according to Dixit et al. (2016), the current driver-assistance systems have demonstrated to considerably reduce the possibility of fatal collisions.

In regard of the sharing mobility, instead, the business connected to the concept of Mobility-as-a-Service (MaaS) is growing at high rates, with a forecasted +34% over 2016-2024 (Market Insider, 2017). These services could represent the solution for greener and better-organized cities: considering that parking areas on-street represents the 20% of the kerb-to-kerb space in cities and that the average car sits unused for more than 90% of its life cycle (OECD, 2016), sharing mobility services could optimize the mobility in the cities, and create possibilities to re-allocate spaces for more infrastructures.

Finally, while these services narrow the demand of vehicles, according to McKinsey (2012), the sharing mobility could also represent a business opportunity for those players which will adapt their offer to the new requirements of the market: purpose-built vehicles, less powerful, easier to build but more adapt for shared usage.

## 9.4. Technological Factors

Technological improvements are one of the critical factors that will determine the competitive position of electric cars in the automotive sector in the future. Improving the performance of electric cars is a must. Most of R&D progress in recent years focused on three different components of the electric cars in order to improve their competitiveness and technological appeal: power train, battery and charging infrastructure (Yong, Ramachandaramurthy, Tan, & Mithulananthan, 2015). Weiller (2019) explains how market's demand, in terms of power and efficiency, drives the technological upgrades in the industry (batteries, charging stations and engines).

It will be briefly explained the state of the art of these three main technological components (Yong et al., 2015):

- Power trains: they can be subdivided into hybrid electric vehicles (HEV), plug-in electric vehicles (PHEV) and battery electric vehicles (BEV). While the first two groups share similar features, such as running both an internal combustion system and an electric motor, they differ in the way they can be recharged. HEV can be charged through the internal combustion engine or regenerative braking, while PHEV can be charged through external power stations. BEVs, on the other hand, are fully powered by electric propulsion systems. The main difference between HEVs / PHEVs and BEVs is that the latter has a lower autonomy and lower operating costs with respect to the other two;

- Electric battery: is the core of the EV innovation. EVs have not taken over the automotive sector mainly due to their limited autonomy with respect to ICEs. State of the art lithium-battery has a relatively low energy density, resulting in lower driving distance with respect to other vehicles. A Hyundai Ioniq, for example, can drive up to 300km with a full charge, same for Renault Zoe and 530 for Tesla Model 3 (the top performer in the category). There are different kinds of lithium batteries available for electric car producers. There is the "classic" lithium-ion battery, followed by the lithium-ion polymer (an upgrade of the lithium-ion offering a better packaging layout) and the lithium-ion phosphate battery (longer life cycle and more safety, but lower energy density). Other batteries based on sodium, potassium, and zinc are currently being studied, but according to Lowry (Appendix 3) no alternative technology will step from niches to the mainstream market at least for another 15 years;

- Charger: PHEV and BEV depend on battery chargers. Batteries are designed to be charged through direct current (DC), while chargers are generally plugged in alternative current power grids (AC). Thus, EV chargers are generally produced as AC/DC converters. There are different kinds of charger available on the market: slow charging on-vehicles chargers and off-vehicles chargers (offer a faster-charging service.

Oussama (2018) further argues that technological improvements help reducing barriers to entry in the sector and influence outsourcing decisions: since raw material costs and autonomy range (especially) may represent barriers to entry for new companies, investing in R&D is the best way to improve EV attractiveness with respect to ICEFs. Engel, Hensley, et al. (2018) hold a specular position: the authors argue that from a consumer perspective, price, driving range and availability of charging stations represent the three significant barriers preventing them from purchasing EVs.

Technology may eventually overcome the first issues in the coming years. As argued by Bullard (2019), by 2022, the price of EVs may match the prices of ICEs. McHugh (2019) similarly argues that EVs may become accessible to mainstream market by 2025. In this regard, Spector (2017) shows that the price parity between ICEs and EVs will be reached when the price of battery packs will fall between $125 and $150 per kWh. While according to the author, similarly to previous, this result may be achieved in the coming years, Curry (2017) shows that by 2030 this value may further be reduced up to $73 per kWh.

In terms of driving range, the picture shows how the figure steadily increased in the past years, improving from an average of 200km up to an expected average of 500km with a full charge in 2021. Scholars argue that despite their limited range, EVs may suit consumer's expectations for day to day driving needs. According to Lebau, Mierlo et al. (2013), European customers may be satisfied with a driving range of 400km. Pearre, Kempton et al. (2011) argue that low range EVs can gain a market share to satisfy day to day driving needs of customers. Kenally (2019) asserts that a driving range of 200km may be already satisfactory for most customers: about 80% of driving activities of day to day drivers amount to 60km.

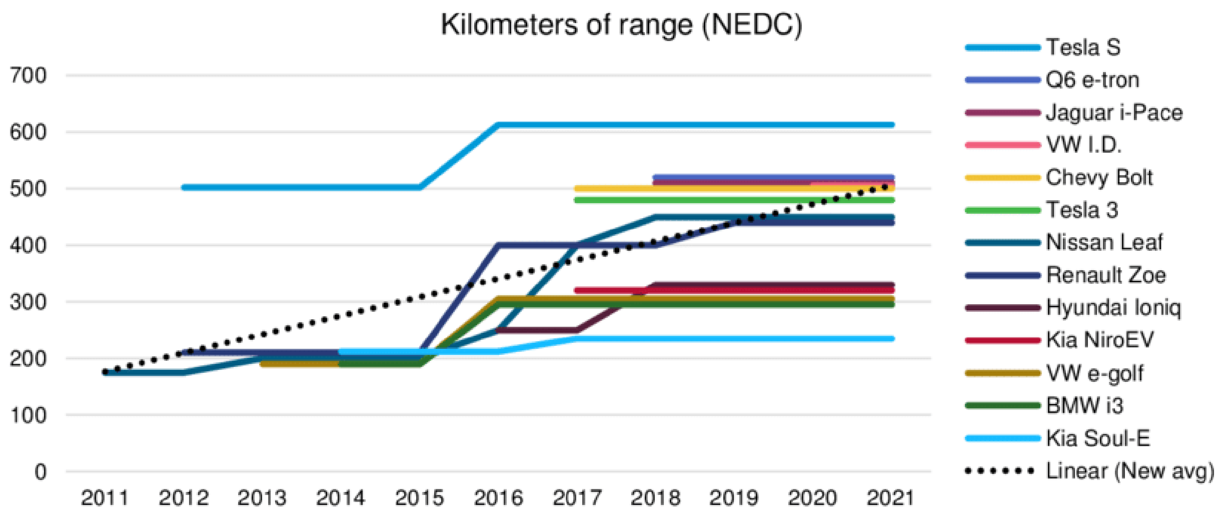


*Figure 15 - Kilometers of driving range of EVs. Source: Utgard and Araya (2017).*

Availability of charging station remains a question mark speaking of the development of EVs. In their report, Engel, Hensley, et al. (2018) trace the needs of EVs in terms of charging stations and compare them with infrastructure available in 3 key markets for EVs: USA, EU, and China. The authors note that residential electricity is cheaper with respect to public/industrial electricity and that single-family homes facilitate home charging:

- In the US, the high presence of single-family homes will facilitate the penetration of EVs. By 2030, 13 million public chargers will be needed with a total investment of $11 billion;

- In the EU, the relevance of home charging will likely decline from the current 75% to 40% of total charging options by 2030. The EU will need 15 million public chargers, with a total investment of $17 billion by 2030;

- Conversely, in China, public chargers will gain much more importance, surging from the current 60% up to 80% of total charging options by 2030. In order to sustain this growth, China will approximately need 14 million chargers with a total investment of $19 billion by 2030.

From a charger count perspective, public chargers will be 5% of the total, but they will absorb almost 30% of the total investment share, mainly due to the higher cost of fast charging facilities with respect to slower home charging devices. Investment in charging facilities are expected to grow as the EVs take ground in the market. According to Mathieu (2018), charging stations will likely develop around major motorways in the first place and the extent to other secondary locations.

Despite the potential of the EV market, Deaton (2019) notes that to date the market still lacks investments: even though the projections for the growth of this sector are promising, the private sector is not investing enough to build the infrastructure EVs need. Eckhouse, Stringer, and Hodges (2019) point out that even though some countries in the world are better equipped for the expansion of the EV market (China and California in the US), the sector suffers for proper investments in charging station. Charging the car remains the main problem for car owners. Geels (2013) argues that stronger public involvement in setting infrastructure would attract more private investments, thus allowing for a more organic development of charging systems.

## 9.5. Key findings - "What is the EVs sector outlook to date?"

Nowadays, in the automotive industry the main stakeholders have been identified in the local governments, in the customer base, and in the car manufacturers. In this regard, however, the balance in power among stakeholders change from region to region, and while the relationship between customers and EVs manufacturers relies on market dynamics, the influence of local governments is exerted through regulations and policies that reflect the development plans of the countries and their environmental targets.

In this connection, the Paris Agreement, and the previous works of the UNFCCC, have had an impact on the regulations of the nations involved, as shown in the PEST analysis. However, as highlighted on the latter, and according to the Climate Action Tracker (2019c), additional efforts are necessary to avoid the 2°C climate change, and stay under 1.5°C target.

In addition, the EVs can be considered in a take-off phase, having attracted the attention of the incumbent players of the automotive sector, as well as, the one of the public attention. Customers, in fact, are being more aware of the advantages of EVs. Nevertheless, current charging infrastructure and sticker prices over the average resulted as critical impediments for a greater adoption of the electric cars.

## 10. Scenario Analysis

The purpose of this work is to determine the impact of EV development on the lithium mining business: however, since a certain degree of uncertainty exists in the former, a scenario analysis will be useful to produce forecasts over its future. This paragraph will outline the most critical variables, obtained from both the Porter analysis and the PESTs, to be included in the scenario analysis. The scenarios explore the demand composition of lithium from 2019 to 2030 and they are based on data obtained from 3 different professional reports. They were labelled in the following way:

- **Restrictive scenario**: this scenario, based on ExxonMobil (2019) depicts a future where oil maintains a leading position in the mobility sector thanks to improvements in fuel efficient technology. In this case, the EV grows at a slow pace, with 50 million EVs running in 2030. This scenario has been evaluated by the researchers as "restrictive" due to the low expectations in the developments of the EVs market. The forecasted scenario by ExxonMobil, indeed, accounts for the factors and trends described in the Porter and PEST analysis, but it predicts a more limited impact of the EVs on the automotive industry due to the higher efficiency of the ICE vehicles;

- **Expected scenario**: The International Energy Agency (IEA) is an intergovernmental organization, part of the OECD framework: the organization has been publishing reports about the present state of EV sector since 2013 (IEA, 2019). According to their report, the global automotive sector will account 130 million EVs. This report has been evaluated as "expected" by the researchers due to its alignment with the policies announced by the governments, as well as for accounting the new trends and developments in the automotive industry ;
- **Optimistic scenario**: the last scenario will be modeled around the guidelines suggested by Climate Action Tracker (2019c) to limit the Climate change below the 1.5 °C, target of the Paris Agreement. In this scenario car emissions need to be reduced at least by 25% by 2030. Thus, the authors designed a scenario assuming full compliance with this objective: in car sales terms, this translates in a complete

substitution of 25% of ICE sales with fully EVs powered only with zero-emissions energy sources. This scenario has been evaluated as "optimistic" due to its high expectations in terms of EVs market penetration. Comparing this scenario with the previous analysis, it requires a drastic change in terms of regulations, policies, and market dynamics.

All the tree scenarios pitch the outlook of the supply/demand balance of lithium by 2030. These forecasted outcomes rely on common assumptions:

- **Timeframe:** scenarios cover the period 2019-2030. This limited choice was based on the comparison offered by Bloomberg NEF (2019) of different reports about the future outlook of the electric EVs sector. They all seem to reach similar conclusions up to 2030, and then they tend to diverge. Thus, the authors felt confident to base their forecasts on more qualified opinions other than their own's;

- **Constant supply:** since the purpose of this work is to study the effect of the automotive sector on the lithium market, scenarios were developed comparing different levels of demand while keeping supply constant. Thus, forecasted supply developments will not be affected by different scenarios. Moreover, the supply forecast obtained is coherent with previous findings in the analysis;

- **Lithium content per battery**: the estimated value is 7.05kg. This finding was obtained from two converging reports. First, IEA (2019) reports that the average price of an electric battery for vehicles in 2030 will contain 7.05kg on average. Secondly, Gaines and Nelson (2009) report that the lithium content of the Lithium Phosphate Graphite (LFP) battery amounts to 7.7kg. The LFP-ion battery is among the most common batteries available on the market for EVs (Battery University, 2019). The authors felt confident in picking the 7.05kg since both the reports converged to a similar value. Stumpf (2018) and Rapier (2019) report that newly introduced lithium batteries tend to be lighter than their present alternatives, thus it could be assumed that batteries will tend to be lighter in the future in order to improve vehicle performance;

- **Impact of recycling**: as explained by Miles (2019), a lithium ion battery has eight-to-ten years lifespan. Even though recycling would be an important source of lithium in the future, it will be probably become relevant for supply chain purposes after 2030. Thus, the effects of recycling won't be taken into account in the scenario;

- **Other constant factors**: in order to capture the effect of different levels of sales of EVs in the scenarios, other two factors (and relative developments) will remain constant:

  1) The composition of demand for lithium (other than that of EVs);

  2) Overall sales of the global automotive sector.

### 10.1. Restrictive Scenario

According to ExxonMobil (2018), the future outlook for the automotive industry will continue to be mainly driven by conventional ICEs vehicles. In this scenario, in fact, the firm shows a conservative outlook for the global energy demand, and for the developments of key sectors, such as transportation. The timeframe considered by ExxonMobil ranges between 2020 and 2040, and relies on three major assumptions:

- Improved living standards in emerging countries will expand the world's economic middle class from 3 billion to 5 billion people, resulting in rising energy use, with a 25% increase in energy demand, and more spending capacity for vehicles and other high-valuable goods;

- Chemical and transportation sectors will continue to increase the demand of oil for plastics and conventional light-duty vehicles;

- Decarbonization of the energy sources, together with the expansion of the green energy supplier sector will contribute to reduce GHGs emissions but will not take over the leadership of oil industry and the expansion of natural gas use.

Considering the above, the EV sector is forecasted to reach a global fleet of about 50 million cars by 2030, with a stable growth rate of 20% in the decade 2020-2030. From the company perspective, a crucial role in the mobility-related energy demand will be played by the major gains in the fuel efficiency of conventional vehicles. Technology improvements, indeed, according to ExxonMobil, will have a larger impact than EVs and HEVs in the automotive industry.

The influence of Governments regulations and policies is seen as uncertain, and unable to develop an effective multi-dimensional strategy for a complete transition to a greener global scenario. Moreover, assessing the targets of the Paris Agreement of 1.5°C/2 °C limits to Climate Change, ExxonMobil highlights the importance of new technologies, and their important role to reduce the carbon intensity of the world's energy mix, as well as in boosting the energy efficiency of products and services.

These future perspectives are taken into account in the forecast of oil, gas and electricity fuel industrial demand. According to ExxonMobil, in fact, the oil demand will continue to grow, and will probably not reach the peak before 2040, while natural gas supply appears to be the next leading sector in the energy production and supply. Furthermore, sensitivity test of the liquids demand by ExxonMobil, with respect to the electrification of LDVs, suggests that only a complete transition to electric mobility by 2040 could affect negatively the demand of liquids, anticipating the peak in 2025.

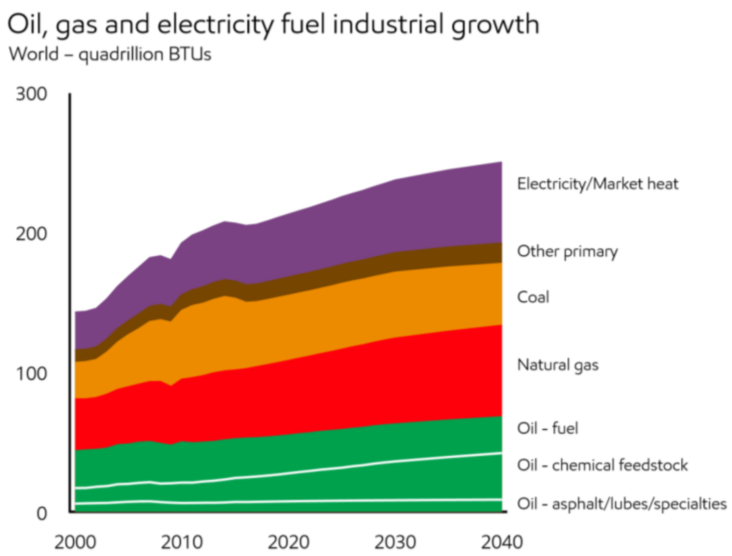


*Figure 16 - Source: ExxonMobil (2018)*

Finally, comparing the ExxonMobil scenario with the one for 2030 of the International Energy Agency (2019), it is possible to highlight how in terms of market penetration, a similar scenario is forecasted by ExxonMobil only in 2040. In other words, the two

#### 10.1.1. Implications for lithium business

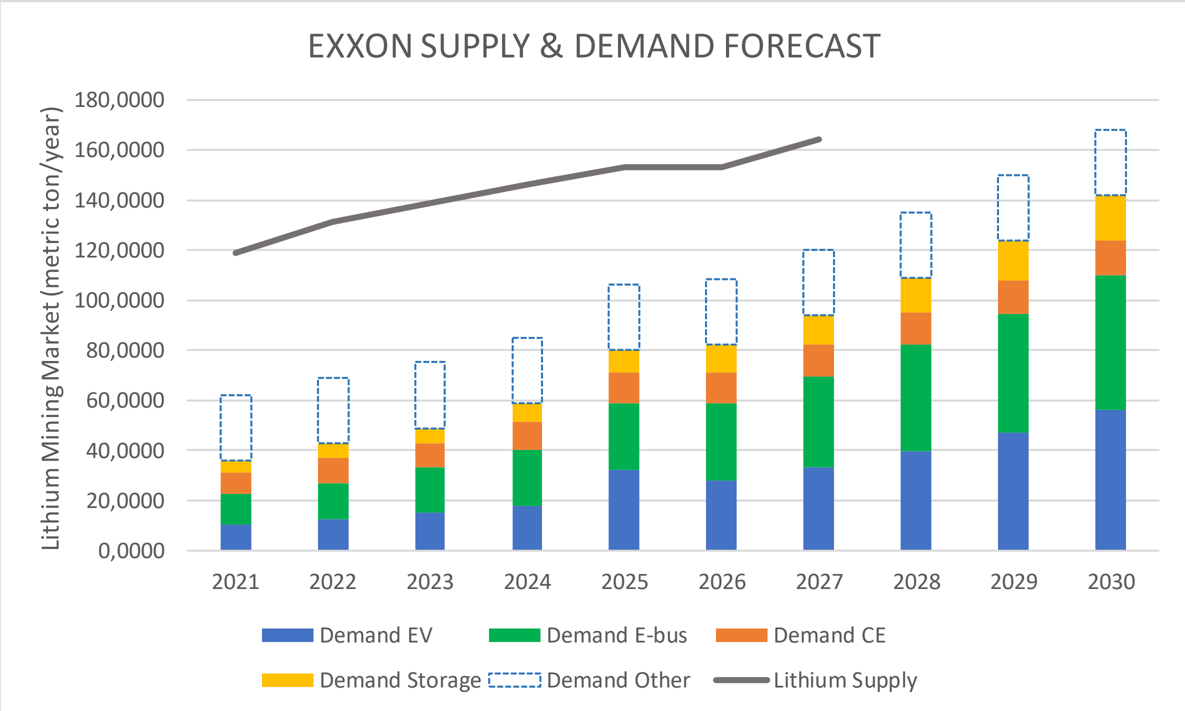


*Figure 17 - Compiled by the authors. Multiple Data Sources: Bloomberg NEF (2019), Altura Mining (2018), ExxonMobil Outlook for Energy (2018)*

Data projections in this scenario show how lower than expected EV demand will keep the lithium market in an oversupply prolonged state. Low oil prices and improved fuel consumption will make it harder for EV to penetrate the market successfully. It does not mean that the EV will not boom, but as just mentioned, the EV will successfully penetrate the automotive sector only in the following decade.

In terms of competition within the lithium industry, producers will suffer for pressure on prices and they will see their margins shrink. On one hand, low margins will negatively impact mineral exploration, given its high costs. Lithium producers such as Chile and Australia will keep their leading position in terms of output: economies of scale and previous investments in infrastructure could easily support production. Conversely, smaller producing countries, such as Argentina and Brazil, or emerging ones, such as Bolivia, will struggle to accelerate their production. In particular, Argentina and Bolivia starve for foreign expertise and investments: investors will probably find the country less attractive.

On the other, larger firms could have a chance to consolidate their position in the market. Tianqi, Albemarle and SQM run mining sites across the globe, enabling economies scale in terms of production. Their greater financial resources (with respect to competition) could enable them to take on further mining projects at a cheaper cost, expanding their influence worldwide, and improving their layout for future demand spikes.

### 10.2. Expected Scenario

For 2019, the IEA have presented two scenarios, the “New Policies Scenario” which includes the impact of the announced policies, and the “EV30@30 Scenario” which presents a global automotive industry outlook where the EVs have reached the 30% of market share, with 43 million of EV sales in 2030.

For the following scenario, the researchers have decided to present and discuss the “New Policies Scenario” of IEA, which accounts for the dynamics and developments explained in the Porter and PEST analysis for the automotive industry.

The IEA “New Policies Scenario” is multi-dimensional study about the impact of EVs in the global scenario, in a timeframe between 2019 and 2030. In this scenario, it is expected that in 2030 28% of new vehicles global sales will be electric and the stock will exceed 130 million vehicles. Such scenario is based in the following assumption:

- Electric mobility will continue to develop at a rapid pace, and the electrification of the automotive industry is seen as an irreversible trend.;
- Policies and regulations will be vital for the development of electric mobility. In this regard, the IEA underlines the importance of economic stimulations by the governments to increase the availability of EVs in the portfolio of products of automakers, as well as, investments to develop a proper public infrastructure;
- The private sector will continue to respond proactively to the EVs development. While different car manufacturers have already announced investments plans for the development of EVs, such as Volkswagen, BMW, and Toyota, new investments will come from other players to different parts of the EVs value chain. In this connection, the report highlights the investments in the battery manufacturing sector, and the

charging hardware manufacturing one, which are gaining the attention of a larger pool of companies;

- Technology developments will gain an increasing strategic importance, not only for improving the EVs performances in terms of autonomy range and battery charging times, but also for contributing to cost cuts, aligning the price of EVs to the one of the conventional and hybrid vehicles.

According to IEA (2019), China will lead the industry, with the highest level of EVs in the market: new EVs will account for 28% of the expected sales. The European market will follow it, with a forecasted 26% of EVs share of sales, while the third market will be represented by Japan, with a 21% share by 2030. Due to the policies and regulations adopted by the US in recent years (as shown in the PEST analysis), the US market will be slow in the adoption of EVs, with an expected 8% of EVs share of sales by 2030. Exceptions to this forecasted outlook for North America will be represented by California and the ten US States that adopted the zero-emissions vehicle (ZEV) mandate, which will help to align the markets with the above-mentioned scenarios.

In terms of energy demand, the IEA estimates an overall impact of the EVs development on oil demand quantified in a reduction of 127 million tonnes of oil equivalent in 2030. In this connection, however, the IEA underlines that while with the current state-of-the-art the EVs save more energy than they use, it is still in doubt if such efficiencies will be obtained in terms of GHGs emissions.

The IEA asserts that to reach environmental targets of reduction of GHGs emissions, it will be necessary to include the electrification of the automotive industry in an overall strategy that aims to obtain the necessary energy for the cities and cars of the future from not-carbon intensive energy sources. Only with such strategies it will be possible to gain advantage by the decarbonisation of cars, with an almost 50% of reduction in GHGs in comparison to a scenario with only conventional ICE vehicles, which would emit 450 Mt $CO_2$-eq.

### 10.2.1. Implications for lithium business

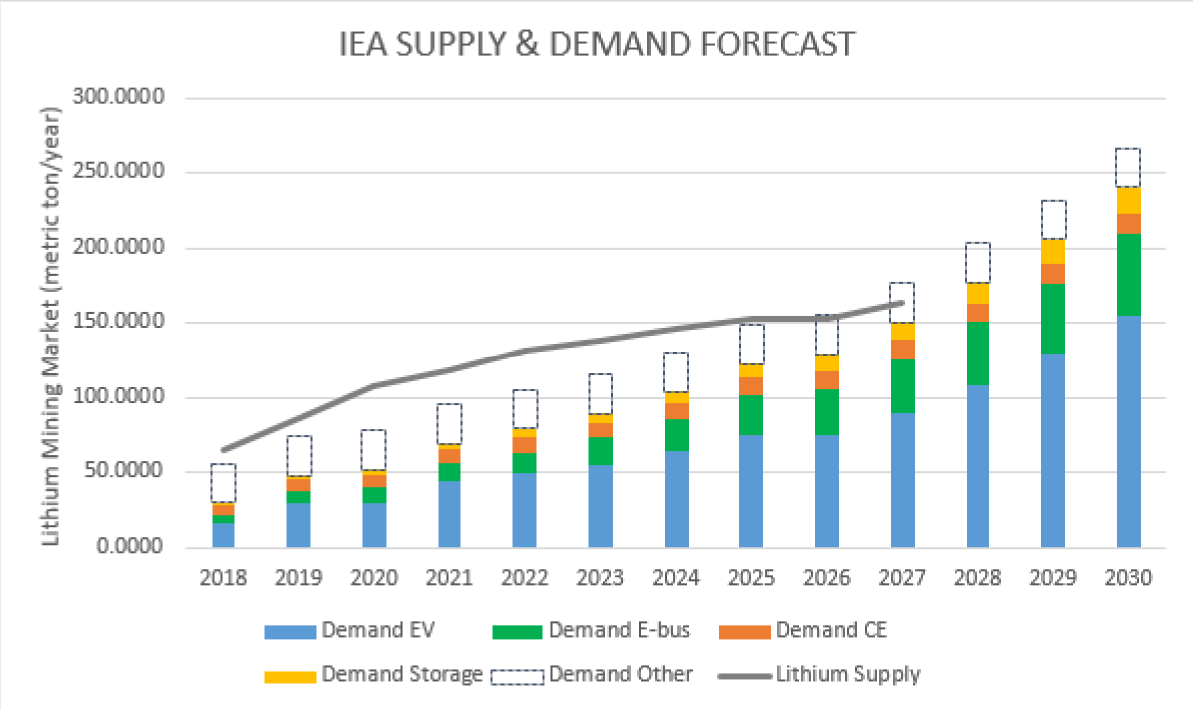


*Figure 18 - Compiled by the authors. Multiple Data Sources: Bloomberg NEF (2019), Altura Mining (2018), Global EV Outlook, IEA (2019).*

In this case, oversupply will remain in place until 2024: demand for EVs will start rising, so will demand for lithium, driving up its price. While forecasts show that supply demand match will persist until 2025, data available infer that demand will overshoot supply by 2026. The capacity of the market to remain supplied depend at least on two factors (Bloomberg, 2017).

First, it depends on the capacity of producers to expand their production: it would be easier in the case of brine extractors, since adding additional evaporation ponds is cheaper than increasing the capacity of a hard rock production plant.

Secondly, it depends on the number of new entrants joining the industry. Many new firms may join the market pushing for further mineral exploration (Bloomberg, 2017). According to Adams and Facada (2019), a large number of smaller new firm already entered the market since 2017, launching several mining exploration projects around the world (Argentina, Brazil, Australia). Thus, mineral exploration is likely to keep on expanding as the economy approaches the boom. Countries investing to upgrade their internal production such as China and US will likely benefit as well. It may take longer time for Bolivia instead, since the country still lacks proper mining infrastructure on one hand. The re-election of President Morales in October could be a positive sign on one hand, but it's still unclear whether he will be able to deliver his promises if elected (Barros Appendix 2).

Higher prices could also improve the lithium business in Chile and Australia: as Stringer and Lombrana (2019) report, the two countries are currently investing to boost their own refining sector, challenging China's leadership. This could be a great opportunity for these countries in the first place, since they currently export raw materials and re-import them in the form of battery components, batteries or car themselves, at a much higher price. It is clear then how government have an incentive in developing such an industry. For lithium producer (Albemarle and SQM), this would mean a larger customer base on one hand, while they could sell more easily their products within the country the produce in. Australia would be a better customer than Chile, since the country reportedly allowed producers to expand capacity with the condition of selling 25% of their output at lower price to Chilean companies.

### 10.3. Optimistic Scenario

The Climate Action Tracker is an independent scientific analysis produced by three research organisations. Among its publication, there is the "CAT Decarbonisation Memo Series" (Climate Action Tracker, 2019c), an analysis about the transformation points of different industries to achieve the targets of the Paris Agreement, and avoid the Climate Change of 1.5 °C/2 °C. For 2019, the Climate Action Tracker has develop a model which sets the electric cars as the key innovation for the complete decarbonisation of the transport sector by 2050.

In this scenario, the Climate Action Tracker has set the following targets for 2030:

- An in increase in share of sales of EVs from 20% by 2020 to 75% by 2030;
- A share of EVs in the global market of 25%, which will lead to a 25% reduction of GHGs emissions. The EVs are seen, indeed, as the most efficient and innovative way to cut the emissions from the mobility sector.

To make it possible, the Climate Action Tracker has identified two stakeholder which could play a fundamental role in the electrification of the automotive industry: the governments and the customers. Regarding the latter, the Climate Action Tracker highlights the importance of information campaigns to help customers to understand the advantages of EVs and their future potentials, ensuring them about the support by government and companies. Most of customers, indeed, have been identified as unaware of the availability of EVs, as well as, sceptics about the development of a proper charging infrastructure. In this regard, the role of the Government is crucial not only to ensure the customers of the development of this infrastructure, but also to support the investments in this sector. The Governments, in fact, should design a financial incentive plan to boost both the demand of EVs, and the investments in the sector.

Finally, as suggested also by IEA (2019), the Climate Action Tracker suggests that the plan to electrify the automotive sector should be part of an overall strategy to reduce dramatically the global GHGs emissions, disincentivizing the development of ICE vehicles through Carbon Taxes, for instance, and developing a sustainable energy supply chain.

#### 10.3.1. Implications for Lithium Business

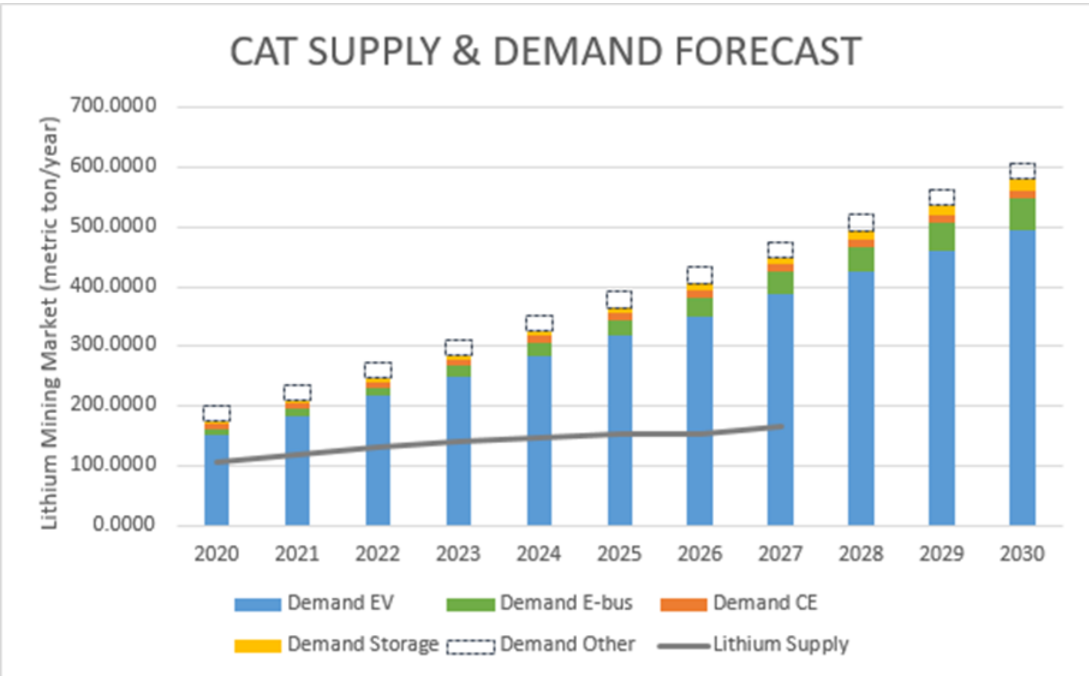


*Figure 19 - Compiled by the authors. Multiple Data Sources: Bloomberg NEF (2019), Altura Mining (2018), Global EV Outlook, Climate Action Tracker (2019c).*

The optimistic scenario is certainly the most aggressive in terms of demand as forecasted future would already fall short to meet EV growth. To meet such a demand, prices would skyrocket. The implications of this scenario will be similar to those of the expected, with the differences that the effect on rising demand on prices and quantity of lithium will have much greater power.

From a mining perspective, producers and government will rush to increase their mining activities and mining exploration. High prices will make mineral make economically exploitable previously inaccessible reserves, while better exploration techniques could identify new reserves the world didn't know about yet. Mineral output will have to double by next year already and it would need to quintuple by 2030.

Competition will soar, as producers will rush to satisfy as many clients as possible: in case supply will actually manage to keep up with demands, bigger players will enjoy the highest margins. Smaller firms will exploit new investment opportunities to gain a stake in the lithium production market. It is safe to assume that, in case supply will actually manage to match demand after an initial period of adjustment, the competitive structure will be much different from today's outlook. Even though large companies may reinvest bigger initial profits in production expansion / exploration, there are going to be many more companies competing than the ones we have today. Thus, if one hand it is difficult to forecast what the average price will be in such a scenario, its increase could be slowed down by increased competition. Of course, only if the "supply-demand match assumption" holds true in the medium term.

Higher incomes from mining and battery demand will likely accelerate the development of refining industry and other intermediate production phases in the production countries.

The authors do not expect that the market will not simply wait and see whether supply can make it or not. Alternative technology will benefit of higher EV demand as well:

- **Alternative technology**: in terms of battery technology, higher investment will accelerate the development of alternative material battery components, such as sodium or potassium. Lowry (Appendix 3) argues that at the present state of things, such technologies will not see the light of day before the next 15 years. This time horizon will most likely be reduced in case of serious lithium shortage in the market;

- **Alternative sources of lithium**: New sources of lithium (expensive at present day), could start attracting investments sooner than expected. Lithium extraction from clays (International Mining 2018), or from seawater (Yang, Zhang, et al., 2018), (E&T, 2018). At present day, these methods are costly with respect to brines and hard rock extraction, however more investments could accelerate research. According to E&T, the Australian Monash University and the University of Texas are currently developing methods to make seawater extraction a viable source of lithium. Yang, Zhang, et al., 2018 show that our oceans may contain up to 230 billion tons of lithium. If research will prove successful, both the US and Australia could reshape the entire structure of lithium market. Martin (2015) cites Japan as another potential candidate for lithium extraction from seawater, as the Atomic Energy Agency is investing in a new highly scalable method. Moreover, Japan would have great incentives to join this run, since the country is already one of the leading refiners of lithium products and batteries. Such a technology would place ahead Japan in the supply of high quality EV batteries, cutting costs all along the supply chain.

# 11. Discussion and strategic perspective

As already explained in the scenario section, rising demand will necessarily ask for higher supply volumes. Such a changing environment will necessarily require companies to adapt in order to remain competitive in the market. This paragraph will therefore put forward possible strategic responses that companies could follow to remain competitive in the market.

The underlying assumption of this section is that strategies are designed to improve the competitive position of a company. According to Investopedia (2019), competitive strategies aim to improve the margin of a company, either by selling at a higher price or reducing costs. In any case, a competitive strategy's objective is to improve profitability of a company by affecting its margin.

For sake of clarity, there are many companies operating in the sector and many more that have just started their race to join the lithium supply business: on one hand, the authors will mostly refer to the bigger firms (Tianqi, SQM, Albemarle and Ganfeng), since they still control the majority of the market. However, they will expand proposing also alternative strategies for smaller firms undertaking new mining projects in foreign countries (such as ACI System, for example).

Regarding the electrification of the automotive industry, all the scenarios accounted for a shift towards the EVs in the sector, even though the magnitude, the rate of growth, and most importantly the timing of this process is still in doubt. In this regard, considering the previous analysis, the researchers are confident to affirm that the electrification trend will be at least stronger than the pessimistic scenario. The foundations behind this statement are the following:

- First, the scenario based on the report of ExxonMobil seems to roughly consider the increasing efforts of the Governments towards environmental issues. While it is possible to highlight the current insufficient policies and regulations towards a drastic reduction of GHGs (Climate Action Tracker, 2019c), there are fewer doubts that the climate changes the global environment will face in the medium term will gain an increasing attention, not only by the public, but also by the governments. As underlined, in fact in the PEST analysis, both public attention and policymakers are key stakeholders in the adoption of "green innovations" (Geels, 2013). Nowadays, thanks to the improvements in the living standards of a wider part of the global population, underlined also by the ExxonMobil Outlook (2018), more people have access to education, getting aware of the issues connected to the Climate Change;

- Secondly, the ExxonMobil Outlook (2018) defines the EVs as niche or pre-development innovation. In this regard, however, the EVs seems to be further in the innovation path. In fact, as highlighted in the previous analysis, and confirmed by the IEA (2019), McKinsey (2019c), and Bloomberg NEF (2019), the EVs development can be assessed as in a phase of "take-off". As studied and analyzed in the Porter analysis for the automotive industry, different incumbent players have start to invest in the EVs sector, defining R&D plans, new EVs models in their portfolio of products, and adapting their supply chain to the upcoming EVs production and demand. Moreover, the EVs development, and the connected industries in their value chain, as the lithium one, object of study of this thesis project, have attracted the attention of different stakeholders, first and foremost Governments. Different policymakers have seen in the electrification of the automotive industry an opportunity for their countries to attract investments, and develop their economies;
- On the other hand, the researchers, in light of the analysis conducted through this thesis project, do not consider as completely viable the scenario modeled on the Climate Action Tracker Outlook (2019c). While the efforts towards a greener fleet of cars are increasing, they can not be consider sufficient to realize the "Optimistic scenario". In this regard, in fact, drastic changes are required in terms of policies and regulations all over the world, while a complete restructure of the EVs value chain is required to satisfy such huge demand. Finally, it is interesting to underline the possibility of immediate changes in case of dramatic natural disasters, that with the current insufficient policies to cut the GHGs emissions could become more frequent.

### 11.1. Higher capacity needs - Exploration

In order to produce more lithium, the industry as a whole will need to achieve higher capacity, for example engaging in further mineral exploration. Exploration in Australia does not seem like a good investment, at least in the short term and with current demand levels.

Jasmie (2019) reports that Tianqi and Albemarle slowed down their respective expansion plans due to shrinking prices. Maisch (2019) argues that slowing lithium sector in Australia is due also to slower economic growth in China.

Conversely, Bolivia and Argentina seem more attractive from a cost perspective, as mining from brines is cheaper on one hand and both the countries have been attracting international investors in the few years thanks to their lithium endowment. Evo Morales re-election in October could be a positive signal for perspective investors. However, Bolivia presents a major issue that companies should seriously take into consideration: transportation and access to searoutes. As Tiba (2019) reports, Iquique, Arica and Antofagasta are among the major commercial harbours in Chile. They are the closest to the Salar de Uyuni and they could be one of the best options for export purposes. The problem is that between the salar and these harbour there are no efficient ways of communication. Moreover, (Van der Berg and Laing, 2018) report that the world court stated that Chile is not obliged to grant full access to the Atlantic Ocean (not even after the War of the Pacific between the two countries), seriously undermining Bolivia export capacity. Land transportation would be the only economic alternative.

Conversely, Argentina seems a much "safer" option. The country presents high risks in terms of political and currency stability, together with lack of proper legal framework to protect firms. On the other hand investors still see it as a viable option for invesments: as Lombrana and Gilbert define it (2018), Argentina is a true "High-risk high-reward lithium bet". The country presents also a satisfactory level of infrastructure (Gilbert, 2017), easing movements of lithium to harbors for exports, after extraction. Stakeholder management would be extremely important in this case: high political risk and corruption could undermine the optimal business development for investors. At the same time, since the country lacks local talent and it is still upgrading its internal mining infrastructure, it will be strategic for firms to develop long lasting strong relationship with local government (under the assumption of lasting political stability in the coming years) in order to reduce business risk variation.

Other "mainstream" countries such as Chile and Australia may become other viable options as demand increase approaches. Similarly to what Tianqi did with SQM in Chile, JV or acquisitions may help smaller firms to explore new markets relying on expertise of local firms. Such a strategy could be beneficial in both countries, but for different reasons. Chilean control over its mining activities require foreign investors to develop stable relationships with local government in order to ease future business development. Partnering with local firms could ensure a smoother market entry and better connections. In Australia on the other hand, JV such as the Albemarle-Tianqi case would make it easier to face high upfront mineral investments due to higher cost of hard rock extraction.

### 11.2. Higher capacity needs – Expansion

Incumbents increase production in order to face higher future demand. Brine extractors can set up additional evaporation ponds, improving their extraction rates. In the past few years, Albemarle and SQM already pushed the Chilean government to increase their production quotas (not without finding its resistance in the first place). Once demand will take off however, it will be easier for them to expand. The "25% preferential treatment clause" could still remain an issue in terms of profitability. However, the firms could partially shield this profit erosion by securing deals with local firms (only in case Chile successfully manages to develop internal battery supply chain).

In the same way, hard rock miners in Australia may expand production facilities in order to produce more lithium. As explained already in the previous section, miners have the capacity and the intention of expanding production. In order to do so in an efficient way, China's growth will be a leading indicator of the status of EVs and lithium demand. Australia expansion could eventually be supported by internal development of refining industry as well: toward 2030 the country may start seeing the products of current investment plans and in that case the customer base would increase.

In such a scenario Tianqi would have an advantage with respect to Albemarle and other local miners. It can be argued that when demand will start rising again, the Chinese companies could receive preferential treatment from the mainland in terms of demand. Chinese government-backed EV industry is expected to lead the global EV market and Tianqi will have plenty of customers to sell its lithium to. At that point, it will be crucial for Albemarle extend its influence in the country in Australia in order to secure a larger portion of customers.

## 11.3. Technological factors

In terms of brine technology, Saxton (2018) reports that at least seven new emerging technology are currently under development, with the main objective of reducing costs and improving productivity. According to Song, Nghiem et al. (2017), two alternative methods are emerging as the most promising ones:

- Membrane extraction: this method has been developed in 2014 by the Chinese Academic of Science in 2014. In this process, the brine is filtered through a membrane: the latter is permeable to lithium or sodium cations, while impermeable to other organic components;

- Chemical extraction: lithium can also from brines adding phosphate-based chemicals.

The advantage of investing in such methods is that companies could achieve higher production while lowering costs. They would also reduce layout costs for firms since they don't require evaporation ponds. They would also shield from risks of delay due to adverse weather: brine extraction could suffer significant delays in case of heavy rain (Frik, 2019), (Gilbert, 2017). It can be argued that Chinese firms would benefit the most from technologies such as membrane extraction. Internal production in China could benefit greatly from large scale application and it can be argued that since this technology was developed there (Song, Nghiem et al., 2017), Chinese local firms will implement it in the first place in order to increase internal production. Ganfeng may obtain this technology as well in order to expand its production in Argentina.

According to Adams and Facada (2019), hard rock exploration will benefit as well from future expected demand. Most of hard rock sites can be found in Australia. On one hand the country is enacting facilitating policies to expand its mining sector, on the other Australia is located close to China, one of the world's most lithium hungry country for its manufacturing process.

Technology improvements could play a major role in this case as well. Saxton (2018) reports that one of the major cost components for hard rock extractor is the mineral separation process. New methods are currently focusing on developing alternative chemical reagents used to separate lithium from other elements in minerals. These methods would also make extraction from alternative minerals economically feasible enabling firms to exploit new reserves.

Longer term feasibility of technological-upgrading strategies can be inferred not just from expected demand patterns, but also from outsourcing strategies of firms. It has been shown earlier in the analysis that mining firms often outsource R&D services to outside consultants: therefore, it can be inferred that internal upgrading the technological outlook is not part of the strategy of those companies that have lower R&D expenditure. SQM (Yahoo! Finance, 2018) for example showed zero-to-non expenditure in R&D: this is in line with the company's reliance on brines for extraction of raw material, since it is a low-cost extraction method. In the longer term, the company may seek other more efficient ways to extract lithium from brines. For example, it could exploit its alliance with Tianqi to exploit new Chinese extraction methods such as membrane extraction in its plants in Chile.

While such a strategy could greatly benefit SQM, from Tianqi's perspective it could be an opportunity to leverage further penetrate the Chilean market or extending its share of control over SQM itself.

### 11.4. Alternative sources

As discussed, at present state the market is oversupplied and the length of this stage will largely depend on EV demand. Even though scenarios suggest high demand, EV growth may still hit the market later than expected. A possible way to shield at least a portion of profits, could be to target alternative sectors. Among other, the authors opted for the one offering the highest growth perspective in the nearest future.

One sector to look at is the e-bus sector: Nightangale (2019) and Sustainable Bus (2019) asserts that the sector will boom respectively in China and the US in the nearest future. According to Sustainable Bus (2019), the market will enjoy a 18.5% growth between 2018 and 2024, reaching a total market value of almost $2 billion.

# 12. Conclusion and further research

This thesis provided a broad overview over the EV and the lithium sector in order to study their most important features and to study how they interact with each other.

From the lithium sector analysis, it emerged that the market is dominated by 4 major companies controlling the majority of the market. These companies dispose of substantial influence to affect production and prices, at least at the present state of things. The market as a whole has accelerated is production in later years in order to be ready to supply the booming EV market.

The latter on the other hand offers a great future outlook in terms of growth. The market is greatly influenced by customer demand on one hand and by government policies on the other. Surging public attention with respect to environmental issues may accelerate market development in the coming here, especially thanks to public bodies pressure. Availability of charging station may present the major issue for the development of EVs, by accelerating demand may push governments and private investors to develop infrastructure and thus, favouring EV growth.

By combining data obtained from the two sectors, the researchers developed tree scenarios. Eventually, the "Expected" scenario produced the most reliable image for the future outlook of the two sectors. However, even the other two scenarios highlighted important dynamics that lithium producers could still take into account in order to formulate their strategies.

The latter focused on multiple alternative paths. Capacity expansion it's still a must for the industry, even though shrinking margins discourage further investments at the moment. Expanding capacity will help incumbents to maintain their position in the industry, while further mining exploration will enable new firms to step in. Technology would help firms to lower their costs while enhancing productivity. This factor ill be crucial especially in the longer term: it is difficult to asses future demand and supply much longer than the timeframe proposed by this study. It is certain that when EVs will become mainstream, the industry will require grater quantities than those produced today. Higher lithium prices could provide the necessary incentive to raise public and private investment in order to support production expansion. Looking at alternative demand sources in the near future could be another way to secure profits in case those prediction regarding delayed EV boom turn out to be true.

This work left other demands open for future research. The mining business analysis revealed how China in the past few years extended its global influence over the lithium market. While two Chinese firms appear among the leading producers, Tianqi secured its influence by securing deals in two of the most important lithium production site in the world, the Greenbushes mine and the Atacama desert. Strategic research should examine these dynamics more closely: China is expected to lead global EV growth, but such a large influence over the supply chain of lithium my have great influence over the development of the industry in other countries.

## 13. Bibliography

1. ABB, Nemaska Lithium selects ABB for new mining project in Canada, 2017.

2. William Adams and Martim Facada, Global lithium supply developing at accelerating pace on growing demand — Metal Bulletin.com, 2019.

3. a.G Fallis, Guidebook for Evaluating Mining Project EIAs, vol. 53, 2013.

4. Salma Ahmad and Mohd. Azmi Khan, Tesla: Disruptor or Sustaining Innovator: EBSCO- host, Journal of Case Research 10 (2019), no. 1, 12–24.

5. Albemarle Corporation, Albemarle ends 2018 fiscally strong — Albemarle, 2019.

6. H E Aldrich and J Pfeffer, Environments of Organizations, Annual Review of Sociology 2

(1976), no. 1, 79–105.

7. Alison Griswold, Uber secures much-needed $1 billion investment for self-driving cars unit Quartz, 2019.

8. Allen & Overy, Guide to Extractive Industries Documents-Oil & Gas World Bank Institute Governance for Extractive Industries Programme, Tech. report, 2013.

9. Altura, Altura Lithium: New significant supply to the battery market in 2018, (2018).

10. Altura Mining, ALTURA LITHIUM - NEW SIGNIFICANT SUPPLY TO THE BATTERY MARKET IN 2018, Tech. report, 2018.

11. Jan Schwart Andreas Cremer, Volkswagen accelerates push into electric cars with $40 billion

spending plan - Reuters, 2017.

12. Diego Andreucci and Isabella M. Radhuber, Limits to counter-neoliberal reform: Mining expansion and the marginalisation of post-extractivist forces in Evo Morales's Bolivia, Ge- oforum 84 (2017), 280–291.

13. Asia Time, Asia Times — China surges ahead in lithium production — Article, 2019.

14. Damodaran Aswath and International Bamboo and Rattan Organization, Towards a frame- work for rattan sector development in Asean countries, 2015.

15. Philippe Aubron, What does the move to electric vehicles mean for steel and ArcelorMittal

?, (2017).

16. Western Australia, Mining Regulations 1981 Contents, Tech. report, 2019.

17. Australian Trade and Investment Commission, Investment opportunities in Australia's lithium io, (2018).

18. Ayata IQ, Ayata IQ — Li-Ion Batteries and the Future of Hybrid, 2019.

19. Madeline Baer and M Baer, Private Water, Public Good: Water Privatization and State Capacity in Chile, St Comp Int Dev 49 (2014), 141–167.

20. David R Baker, Battery Reality: There's Nothing Better Than Lithium-Ion Coming Soon, Bloomberg (2019).

21. Bruce R. Barringer and Jeffrey S. Harrison, Walking a Tightrope: Creating Value Through Interorganizational Relationships, Journal of Management 26 (2000), no. 3, 367–403.

22. Paul J. Bartos, Is mining a high-tech industry?. Investigations into innovation and produc- tivity advance, Resources Policy 32 (2007), no. 4, 149–158.

23. Battery University, Types of Lithium-ion Batteries Battery University, 2019.

24. BBC, Trumps pulls US out of Paris climate deal, Bbc News (2017), 1.

25. Terence Bell, Commercial Lithium Production and Mining of Lithium, 2019.

26. K. Beltrop, S. Beuker, A. Heckmann, M. Winter, and T. Placke, Alternative electrochemical energy storage: Potassium-based dual-graphite batteries, Energy and Environmental Science 10 (2017), no. 10, 2090–2094.

27. Monica Araya Bjorn Utgard, Electrifying emerging markets: the case of Costa Rica, 2017.

28. Matthew Bliss, How Technological Innovation is Impacting the Mining Sector, 2018.

29. Bloomber News, China Scales Back Subsidies for Electric Cars to Spur Innovation - Bloomberg, 2019.

30. Bloomberg, End in Sight to Near-Term Lithium Supply Shortages, 2017.

31. Bloomberg NEF, Electric Vehicle Outlook 2019 — Bloomberg NEF, 2019.

32. Blue Energy, Blue Energy Co., Ltd. — corporate message, 2012.

33. Bnamericas, Chile readies PPP-driven strategy for lithium sector - BNamericas, 2019.

34. Sophia Boddenberg, Chiles lithium blessing or curse? — Environment— All topics from climate change to conservation — DW — 11.05.2018, 2018.

35. Matt Bohlsen, Top 5 Lithium Miners To Consider, 2016.

36. Buddy Borden and Tom Harris, Economic and Fiscal Impacts From New Lithium Mine and Lithium Processing Operations in Humboldt County, Nevada, Tech. report, 2017.

37. Hugo Brennan and Yu Guo, China's Lithium Supply Chain Strategy — Maplecroft, 2018.

38. George Burt, George Wright, Ron Bradfield, George Cairns, and Kees van der Heijden, The Role of Scenario Planning in Exploring the Environment in View of the Limitations of PEST and Its Derivatives, International Studies of Management & Organization 36 (2006), no. 3, 50–76.

39. Sustainable Bus, US electric bus market to grow 18.5% yearly till 2024 - Sustainable Bus, 2019.

40. California Air Resources Board, California Air Resources Board GLossary, 2019.

41. Fabian Cambero, Royalties for lithium to be set case by case in Chile: minister - Reuters, 2019.

42. Juliana Castilla, Mining companies still reluctant to tap Argentina deposits - Reuters, 2018.

43. Richard E. Caves, Industrial organization, corporate strategy and structure, Readings in Accounting for Management Control, Springer US, Boston, MA, 1980, pp. 335–370.

44. Center for Climate and Energy Solutions, Paris Climate Agreement Q&A — Center for Climate and Energy Solutions, 2019.

45. David Champion, Australian resource review: lithium 2018, Tech. report, 2019.

46. Kathy Charmaz, Grounded theory methods in social justice research, The Sage handbook of qualitative research 4 (2011), no. 1, 359–380.

47. Constructing grounded theory, Sage, 2014.

48. Yigal Chazan, China Rushes to Dominate Global Supply of Lithium, 2019.

49. China's National Development and Reform Commission, Automobile industry investment management regulations, Tech. report, 2019.

50. Yu-Chiun Chiou, Rong-Chang Jou, and Cheng-Han Yang, Factors affecting public trans- portation usage rate: Geographically weighted regression, Transportation Research Part A: Policy and Practice 78 (2015), 161–177.

51. Clarkson, Clarkson M 1994 A risk based model of stakeholder theory Proceedings of the, 1994.

52. Climate Action Tracker, China - Climate Action Tracker, 2019.

53. EU — Climate Action Tracker, 2019.

54. TRANSFORMATION POINTS: ACHIEVING THE SPEED AND SCALE RE-QUIRED FOR FULL DECARBONISATION, Tech. Report April, 2019.

55. Climate Action Traker, The ten most important short term steps to limit warming to 1.5C, (2016).

56. COHA, Eleven Years of the Process of Change in Evo Morales' Bolivia COHA, 2018.

57. James Conca, Energy's Future - Battery and Storage Technologies, 2019.

58. Juliet Corbin and Anselm Strauss, Basics of Qualitative Research (3rd ed.): Techniques and Procedures for Developing Grounded Theory, SAGE Publications, Inc., 2455 Teller Road,Thousand OaksCalifornia91320United States, 2008.

59. Coucil Directive, EUR-Lex - 31993L0059 - EN - EUR-Lex, EUR-Lex, 1993.

60. Council of the European Union, 2017/0291(COD), Tech. report, Brussels, 2019.

61. Cruchbase, List of top Electric Vehicle Startups — Crunchbase, 2019.

62. Hongyang Cui, Chinas New Energy Vehicle mandate policy (final rule) — International Council on Clean Transportation, 2018.

63. Claire Curry, Lithium-ion Battery Costs and Market Squeezed margins seek technology im- provements & new business models, Tech. report, 2017.

64. John Daly, New Wyoming Lithium Deposit could Meet all U.S. Demand — OilPrice.com, 2013.

65. David Shepardson, Automakers, Colorado reach deal on zero-emission vehicle mandate - Reuters, 2019.

66. Automakers invest heavily in electric vehicles despite still-low demand - Reuters, 2019.

67. U.S. automakers push for deal on fuel efficiency rules - Reuters, 2019.

68. Gerald F Davis, J Adam Cobb, Frank Dobbin, Amy Hillman, Jeff Pfeffer, and Flannery Stevens, Resource Dependence Theory: Past and Future We appreciate the helpful comments of, Tech. report, 2009.

69. Rachel Davis and Daniel M Dm Franks, The costs of conflict with local communities in the extractive industry, First International Seminar on Social Responsibility in Mining (2011), 19–21.

70. Jeremy Deaton, EV charging infrastructure is not being built fast enough, 2019.

71. Ronald M. Dell, Patrick T. Moseley, and David A.J. Rand, Batteries and Supercapacitors for Use in Road Vehicles, Towards Sustainable Road Transport, Elsevier, 2014, pp. 217–259.

72. Stephen Deller and Andrew Schreiber, Mining and Community Economic Growth, The Re- view of Regional Studies 42 (2012), no. 2.

73. Norman K. Denzin and Yvonna S. Lincoln, The SAGE handbook of qualitative research, 4th edition. ed., Sage, Thousand Oaks, 2011.

74. Dieter Quartier, As lithium prices plummet, will EVs become cheaper sooner? — Global Fleet, 2019.

75. Vinayak V. Dixit, Sai Chand, and Divya J. Nair, Autonomous Vehicles: Disengagements, Accidents and Reaction Times, PLOS ONE 11 (2016), no. 12, e0168054.

76. Henrik Johannsen Duus, Strategic scenario construction made easy, International Journal of Foresight and Innovation Policy 11 (2016), no. 1/2/3, 167.

77. Arlene Ebensperger, Philip Maxwell, and Christian Moscoso, The lithium industry: Its recent evolution and future prospects, Resources Policy 30 (2005), no. 3, 218–231.

78. Brian Eckhouse, David Stringer, and Jeremy Hodges, The World Still Doesn't Have Enough Places to Plug In Cars - Bloomberg, 2019.

79. Electrify America, Our Plan — Electrify America, 2018.

80. Ellen R. Wald, Volkswagen's New Battery Plant Could Be A Game Changer In Electric Vehicle Strategy, 2019.

81. Frik Els, Lithium price: Weather takes more tonnes off the market - MINING.COM, 2019.

82. International Energy Agency, Scaling-up the transition to electric mobility 2019, Tech. re- port, 2019.

83. Hauke Engel, Russel Hensley, Stefan Knupfer, and Shivika Sahdev, The basics of electric- vehicle charging infrastructure — McKinsey, 2018.

84. Ernest & Young, Top 10 business risks facing mining and metals, Tech. report, 2017.

85. Ernest Scheyder, Inside Albemarle's quest to reinvent the lithium market - Reuters, 2018.

86. Albemarle declines to participate in LME lithium contract - Reuters, 2019.

87. E&T, Salt and lithium could be filtered from seawater with next-generation material — E&T Magazine, 2018.

88. European Commission, European Commission announces the Key Strategic Value Chains - News - Smart Specialisation Platform, 2019.

89. European Green Vehicles Initiative Association, The European Green Vehicles Initiative (EGVI cPPP) - EGVI, 2019.

90. European Parliament, EUR-Lex - 32018L0844 - EN - EUR-Lex, 2018.

91. Parliament backs new CO2 emissions limits for cars and vans — News — European Parliament, 2019.

92. Jack Ewing, What really happened at VW - The Volkswagen scandal, 2017.

93. Export.gov, Bolivia - Mining — export.gov, 2019.

94. ExxonMobil, "International Outlook for energy 2018: a view to 2040", ExxonMobil (2018), 1–16.

95. Masuma Farooki, The diversification of the global mining equipment industry Going new places?, Resources Policy 37 (2012), no. 4, 417–424.

96. Kerry Faulkner, Big on batteries: government finally seizes on lithium-ion potential — Environment — The Guardian, 2018.

97. Vittoria Ferraris, Nishit Madlani, and Katsuyuki Nakai, Industry Top Trends 2019 Autos, Tech. report, 2018.

98. Nic Fildes, Beyond lithium the search for a better battery — Financial Times, 2018.

99. R. Edward Freeman, The Politics of Stakeholder Theory: Some Future Directions, Business Ethics Quarterly 4 (1994), no. 4, 409–421.

100. Strategic management: A stakeholder approach, 2015.

101. Linda Gaines and Paul Nelson, (PDF) LithiumIon Batteries: Possible Materials Issues, 2009.

102. David Wenzhong Gao, Basic Concepts and Control Architecture of Microgrids, Energy Stor- age for Sustainable Microgrid, Elsevier, 2015, pp. 1–34.

103. Gazzetta Ufficiale, Legge 30 dicembre 2018, n.145, commi 1031-1038 e 1057-1064., 2019.

104. Frank W. Geels, The impact of the financial-economic crisis on sustainability transitions: Financial investment, governance and public discourse, Environmental Innovation and So- cietal Transitions, vol. 6, mar 2013, pp. 67–95.

105. Geology fo Investors, From Exploration to Opening a Mine — Geology for Investors, 2019.

106. Jonathan Gilbert, Argentina is set on becoming a lithium superpower, but there's one big problem — Financial Post, 2017.

107. Barney G. Glaser, Anselm L Strauss, Barney G. Glaser, and Anselm L Strauss, The Discovery of Grounded Theory, The Discovery of Grounded Theory, Routledge, jul 2019, pp. 1–18.

108. BG Glaser, Basics of grounded theory analysis: Emergence vs forcing, (1992).

109. Golden Dragon Capital, Commodity Golden Dragon Capital, 2019.

110. Government of Western Australia, Future Battery Industry Strategy Western Australia, Tech. report, 2019.

111. Tony Grundy, Rethinking and reinventing Michael Porter's five forces model, Strategic Change 15 (2006), no. 5, 213–229.

112. Rethinking and reinventing Michael Porter's five forces model, Strategic Change 15 (2006), no. 5, 213–229.

113. Rudolf Gru¨nig and Richard Ku¨hn, Global Environmental Analysis, The Strategy Planning Process, Springer Berlin Heidelberg, Berlin, Heidelberg, 2018, pp. 89–96.

114. Abhishek Gupta, Environmental and pest analysis : An approach to external business envi- ronment, International Journal of Modern Social Sciences 1 (2013), no. 2, 34–43.

115. Florencia Heredia and Agostina L Martinez, Argentina Mining Getting The Deal Through GTDT, 2019.

116. Amy J Hillman, Michael C Withers, and Brian J Collins, Resource Dependence Theory: A Review, Journal of Management 35 (2009), no. 6, 1404–1427.

117. Amy J. Hillman, Asghar Zardkoohi, and Leonard Bierman, Corporate political strategies and firm performance: indications of firm-specific benefits from personal service in the U.S.

government, Strategic Management Journal 20 (1999), no. 1, 67–81.

118. Gerard P. Hodgkinson, Peter Herriot, and Neil Anderson, Realigning the Stakeholders in Management Research: Lessons from Industrial, Work and Organizational Psychology, British Journal of Management 12 (2001), no. s1, S41–S48.

119. Anna Hopper, Recharging Bolivia: Evo Morales' Lithium Dilemma, (2009).

120. David Humphreys, A business perspective on community relations in mining, Resources Policy 26 (2000), no. 3, 127–131.

121. ICLG, Mining Law 2019 — Laws and Regulations — Australia — ICLG, ICLG (2019).

122. Mining Law 2019 — Laws and Regulations — Chile — ICLG, 2019.

123. Mining Law 2019 — Laws and Regulations — China — ICLG, ICLG (2019).

124. IEA, Global EV Outlook 2019, 2019.

125. Mordor Intelligence, Lithium Market — Growth, Trends, and Forecast (2019 - 2024), 2019.

126. International Electrotechnical Commission, IEC 62196-1:2014 — IEC Webstore — LVDC, 2014.

127. IEC 62196-3:2014 — IEC Webstore — LVDC, 2014.

128. IEC 62196-2:2016 — IEC Webstore, 2016.

129. International Mining, Progress at lithium clay projects looks to open up new source in Nevada

- International Mining, 2018.

130. Investopedia, Competitive Advantage Definition, 2019.

131. Irene Preisinger, China's CATL to build its first European EV battery factory in Germany

- Reuters, 2018.

132. Felip Iturrieta, Chile open to increasing SQM lithium quota to satisfy Tesla: Corfo - Reuters, 2018.

133. Jacqueline Lynch, Residents fear jobs at WA lithium refinery are going to city workers, (2019).

134. Cecilia Jamasmie, SQM just made it very difficult for Tianqi to access company secrets MINING.COM, 2019.

135. Tianqi Lithium to name three directors to SQM board next month MINING.COM, 2019.

136. Tianqi Lithium to name three directors to SQM board next month Page 3208 MINING.COM, 2019.

137. Cecilia Jasmie, Tianqi puts world's biggest lithium plant expansion on hold, 2019.

138. Daniel Jimenez, Lithium Market Outlook, (2018).

139. John C. Roper, U.S. becomes world's largest oil producer - ExpressNews.com, 2018.

140. R. Burke Johnson and Anthony J. Onwuegbuzie, Mixed Methods Research: A Research Paradigm Whose Time Has Come, Educational Researcher 33 (2004), no. 7, 14–26.

141. JPMorgan Chase, Driving into 2025: The Future of Electric Vehicles — J.P. Morgan, 2018.

142. Michael Kanellos, Is There Money To Be Made In Lithium Mining?, 2016.

143. AMIT KATWALA, The spiralling environmental cost of our lithium battery addiction — WIRED UK, 2018.

144. Patrick Keneally, Should I buy an electric car? All you need to know about prices, technology and range — Environment — The Guardian, 2019.

145. SOBHON KHAIRY, Eyes Set on Lithium Strange Markets, 2018.

146. Katherine Koleski, The 13th Five-Year Plan, Tech. report, 2017.

147. Kirsten Korosec, Tesla plans to launch a robotaxi network in 2020, 2019.

148. Felix Kuhnert, Christoph Stu¨rmer, and Alex Koster, Five trends transforming the Automo- tive Industry, PWC (2018), 36.

149. Kajal. Lahiri and Geoffrey Hoyt. Moore, Leading economic indicators : new approaches and forecasting records, Cambridge University Press, 1991.

150. Ben Lane and Stephen Potter, The adoption of cleaner vehicles in the UK: exploring the consumer attitudeaction gap, Journal of Cleaner Production 15 (2007), no. 11-12, 1085–1092.

151. Paul D. Larson, Jairo Vi´afara, Robert V. Parsons, and Arne Elias, Consumer attitudes about electric cars: Pricing analysis and policy implications, Transportation Research Part A: Policy and Practice 69 (2014), 299–314.

152. Laura Millan Lombrana, Lithium Industry Buildup Is Outracing the Electric-Car Boom - Bloomberg, 2019.

153. Kenneth Lebeau, Joeri Van Mierlo, Philippe Lebeau, Olivier Mairesse, and Cathy Macharis, Consumer attitudes towards battery electric vehicles: A large-scale survey, International Journal of Electric and Hybrid Vehicles 5 (2013), no. 1, 28–41.

154. Lithium Americas, Lithium Americas Announces Closing of Transaction with Ganfeng Lithium and SQM Toronto Stock Exchange:LAC, 2018.

155. Lithiummine.com, Lithium Mining in USA - Lithium Mining - The Worldwide Website, 2018.

156. Yajie Liu, Zhixin Tai, Jian Zhang, Wei Kong Pang, Qing Zhang, Haifeng Feng, Konstantin Konstantinov, Zaiping Guo, and Hua Kun Liu, Boosting potassium-ion batteries by few- layered composite anodes prepared via solution-triggered one-step shear exfoliation, Nature Communications 9 (2018), no. 1.

157. Andy Lockett and Steve Thompson, The resource-based view and economics, Journal of Management 27 (2001), no. 6, 723–754.

158. Logan Goldie-Scot, A Behind the Scenes Take on Lithium-ion Battery Prices — BloombergNEF, 2019.

159. Laura Millan Lombrana, Bolivia's Almost Impossible Lithium Dream - Bloomberg, 2018.

160. Lithium industry buildup is outracing the EV boom, 2019.

161. Laura Millan Lombrana and Joe Deaux, U.S. Has Battery Problem in Race for Electric Car Supremacy - Bloomberg, 2019.

162. Laura Millan Lombrana and Jonathan Gilbert, High Risk/High Reward Lithium Bet Drives Argentina Surge - Bloomberg, 2018.

163. Ludvigson and Sydney, The Channel of Monetary Transmission to Demand: Evidence from the Market for Automobile Credit, Journal of Money, Credit and Banking 30 (1998), no. 3, 365–383.

164. Marija Maisch, Lithium oversupply hurts Australian miners pv magazine Australia, 2019.

165. Marcos Martinez, CASE mobility: connected, autonomous, shared, electric vehicles, 2018.

166. & Gary Gereffi Marcy Lowe, Saori Tokuoka, Tali Trigg, Lithium-ion Batteries for Elec- tric Vehicles, Duke Center on Globalization, Governance & Competitiveness (Duke CGGC) (2010).

167. Cees J. Gelderman Marjolein Cani¨els, Purchasing Strategies in the Kraljic Matrix A Power and Dependence Perspective, 2005.

168. Mark Kane, US Plug-In Electric Car Sales Charted: December 2018, 2018.

169. Market Insider, Carsharing Market to witness a massive 34%+ growth over 2016-2024 — Markets Insider, 2017.

170. Market Line, Metals & Mining in Argentina, (2019).

171. MarketLine, Global Mining Equipment, MarketLine Industry Profile (2014).

172. Tesla brand image basis of strength: Brand perception lies behind recent success and high prospects for 2019 - Marketline, 2019.

173. Gunther Martin, Lars Rentsch, Michael H¨ock, and Martin Bertau, Lithium market research global supply, future demand and price development, Energy Storage Materials 6 (2017), 171–179.

174. Richard Martin, Quest to Mine Seawater for Lithium Advances - MIT Technology Review, 2015.

175. Cristina Martinez-Fernandez, Knowledge-intensive service activities in the success of the Australian mining industry, Service Industries Journal 30 (2010), no. 1, 55–70.

176. Federico Mascolo, The Rise of Lithium Batteries: A New Form of Energy Dependence? — IAI Istituto Affari Internazionali, 2018.

177. Lucien Mathieu, Roll-out of public EV charging infrastructure in the EU Is the chicken and egg dilemma resolved?, Tech. report, 2018.

178. Philip Maxwell, Transparent and opaque pricing: The interesting case of lithium, Resources Policy 45 (2015), 92–97.

179. David McHugh, After years of promise, battery cars about to go mainstream, 2019.

180. McKinsey, Mobility of the future opportunities for automotive OEMs, Advanced Industries (2012), 20.

181. 2 Global energy demand Electricity demand/supply Gas demand Oil demand Carbon emissions, Tech. report, 2019.

182. Global Energy Perspective 2019 — McKinsey, 2019.

183. Global Oil Supply and Demand Outlook - Summary — 2019 H1, Tech. report, McKinsey Energy Insights, 2019.

184. Improving electric vehicle economics — McKinsey, 2019.

185. Martin B Meznar, BUFFER OR BRIDGE? ENVIRONMENTAL AND ORGANIZA- TIONAL DETERMINANTS OF PUBLIC AFFAIRS ACTIVITIES IN AMERICAN FIRMS, Tech. Report 4, 1995.

186. Mica, H2020 MICA PROJECT Mineral Resources and Reserves Estimation, Tech. report, 2019.

187. Andy Miles, The Secret Life Of An EV Battery — CleanTechnica, 2019.

188. Usgs Minerals Information Team, LITHIUM (Data in metric tons of lithium content unless otherwise noted), Tech. report, 2009.

189. Mining.com, Focus on Latin American mining industry - MINING.COM, 2015.

190. Ronald K. Mitchell, Bradley R. Agle, and Donna J. Wood, Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts, The Academy of Management Review 22 (1997), no. 4, 853.

191. Jung Youn Mo and Wooyoung Jeon, The impact of electric vehicle demand and battery recy-

cling on price dynamics of lithium-ion battery cathode materials: A Vector Error Correction Model (VECM) analysis, Sustainability (Switzerland) 10 (2018), no. 8.

192. Mokgaotsa Jonas Mochane, Teboho Clement Mokhena, Thabang Hendrica Mokhothu, Asanda Mtibe, Emmanuel Rotimi Sadiku, and Suprakas Sinha Ray, The Importance of Nanostructured Materials for Energy Storage/Conversion, Handbook of Nanomaterials for Industrial Applications, Elsevier, 2018, pp. 768–792.

193. Joss Luis Moraga Gonzalez, Zsolt Sandor, and Matthijs R. Wildenbeest, Consumer Search and Prices in the Automobile Market, SSRN Electronic Journal (2015).

194. Manuel Moritz, Tobias Redlich, Pascal Krenz, Sonja Buxbaum-Conradi, and Jens P. Wulfs- berg, Tesla Motors, Inc.: Pioneer towards a new strategic approach in the

automobile in- dustry along the open source movement?, 2015 Portland International Conference on Man- agement of Engineering and Technology (PICMET), IEEE, aug 2015, pp. 85–92.

195. Mike Morrison, History of PEST analysis, 2012.

196. Jonathon Wayne Moses and Trobjorn L. Knutsen, Ways of Knowing: Competing method- ologies in social and political research, 2007.

197. Colleen B. Mullery, Steven N. Brenner, and Nancy A. Perrin, A Structural Analysis of Corporate Political Activity, Business & Society 34 (1995), no. 2, 147–170.

198. NASDAQ, Albemarle Corporation (ALB) Balance Sheet - NASDAQ.com, 2019.

199. Sociedad Quimica y Minera S.A. Common Stock (SQM) Financials — Nasdaq, 2019.

200. Nathaniel Bullard, Electric Vehicle Battery Shrinks and So Does the Total Cost - Bloomberg, 2019.

201. National Bureau of Statistics of China, National Bureau of Statistics of China, 2019.

202. Usgs National Minerals Information Center, LITHIUM (Data in metric tons of lithium content unless otherwise noted), Tech. report, 2011.

203. NetworkNewsWire, Trump's Recent Executive Order Could Boost Lithium Supply in the U.S., 2018.

204. Investing news, Low Cost, High Margins: Lithium Brine Extraction — INN, 2018.

205. Joseph White Nick Carey, Ford plans $11 billion investment, 40 electrified vehicles by 2022 - Reuters, 2019.

206. Nick Routley, Visualizing Electric Vehicle Sales Around the World, 2019.

207. Michael Nienaber, Germany secures access to vast lithium deposit in Bolivia — Reuters, 2018.

208. Alaric Nightangale, Forget Tesla, It's China's E-Buses That Are Denting Oil Demand - Bloomberg, 2019.

209. OEC, OEC: The Observatory of Economic Complexity, 2019.

210. OECD, Shared Mobility: Innovation for Liveable Cities — ITF, 2016.

211. Office for National Statistics, Consumer price inflation basket of goods and services - Office for National Statistics, 2019.

212. Office of Energy Efficiency & Renewable Energy, Batteries, Charging, and Electric Vehicles — Department of Energy, 2019.

213. Anne Olhoff and John (Hrsg.) Christensen, Emissions gap report 2017, 2017, pp. 13–13.

214. Christine Oliver, Strategic Responses to Institutional Processes, Tech. Report 1, 1991.

215. OPEC, World Oil Outlook 2018, 2019.

216. Orsted, Green energy is now cheaper than black, 2019.

217. Saada Oussama, Strategic Analysis of EV's electrical energy storage using PEST analysis and Analytical Network Process for Technology Adoption, Tech. report, 2018.

218. John A. Parnell, The External Environment: Social and Technological Forces, Strategic Management: Theory and Practice, SAGE Publications, Ltd, 1 Oliver's Yard, 55 City Road London EC1Y 1SP, 2017, pp. 78–115.

219. Nathaniel S. Pearre, Willett Kempton, Randall L. Guensler, and Vetri V. Elango, Electric vehicles: How much range is required for a day's driving?, Transportation Research Part C: Emerging Technologies 19 (2011), no. 6, 1171–1184.

220. M. W. Peng and Y. Luo, MANAGERIAL TIES AND FIRM PERFORMANCE IN A TRANSITION ECONOMY: THE NATURE OF A MICRO-MACRO LINK., Academy of Management Journal 43 (2000), no. 3, 486–501.

221. Jeffrey. Pfeffer, Power in organizations, Pitman Pub, 1981.

222. Jeffrey Pfeffer and Gerald R. Salancik, The External Control of Organizations: A Resource Dependence Perspective, 1978.

223. Michael Porter, How Competitive Forces Shape Strategy, 1979.

224. Theo J.B.M. Postma and Franz Liebl, How to improve scenario analysis as a strategic management tool?, Technological Forecasting and Social Change 72 (2005), no. 2, 161–173.

225. Qnovo, 82. THE COST COMPONENTS OF A LITHIUM ION BATTERY - Qnovo, 2016.

226. Daniel Ramos, Bolivia picks Chinese partner for $2.3 billion lithium projects - Reuters, 2019.

227. Ayn Rand, The metaphysical versus the man-made, Philosophy: Who needs it. New York: New American Library (1982).

228. Robert Rapier, The Holy Grail Of Lithium Batteries, 2019.

229. Grand View Research, Lithium Market Share, Size, Growth — Global Industry Trend Report, 2025, 2019.

230. Reuters, China NEV public charging points increased 51 pct in 2017 - Xinhua - Reuters, 2018.

231. Albermarle declina insistir en pedido de alza de cuota de litio en chileno Salar de Atacama — Am´ericaEconom´ıa — Am´ericaEconom´ıa, 2019.

232. China's General Lithium to launch 60,000 T spodumene converter by end of 2020

- MINING.COM, 2019.

233. SQM receives Chile's approval for lithium plant expansion - Reuters, 2019.

234. Sabrina Roth, Communities challenge lithium production in Argentina, 2019.

235. Sabrina Roth, Communities challenge lithium production in Argentina, 2019.

236. Samco, Cost to Extract Lithium from Geothermal Brine and Crushed Ore?, 2018.

237. What is Lithium Extraction and How Does It Work?, 2018.

238. R. Samson, Problems with the Five Forces Model — Profolus, 2017.

239. Samsung, Samsung Electronics Completes Acquisition of HARMAN Samsung Global News- room, 2017.

240. M. N. K. Saunders, Philip Lewis, and Adrian Thornhill, Research methods for business students, 2016.

241. Danile Saxton, LITHIUM: Emerging Lithium Extraction Technologies — Nemaska Lithium leads the charge — Nexant, 2018.

242. Ernst Scheyder, Tianqi says happy 'for now' with stake in SQM: present, 2019.

243. Carla Selman, Chilean lithium policy — IHS Markit, 2019.

244. Dave Sgerwood and Ernest Scheyder, Albemarle shares drop after Chile rejects hike in lithium quota - Reuters, 2018.

245. Dave Sherwood, In Chilean desert, global thirst for lithium is fueling a 'water war' - Reuters, 2018.

246. Chilean lithium producer SQM's profits fall on lower prices, higher royalties - Reuters, 2019.

247. Dave Sherwood and Ernest Scheyder, Albemarle pushes Chile to reverse lithium quota deci- sion, 2018.

248. Ira Sohn, Long-term projections of non-fuel minerals: We were wrong, but why?, Resources Policy 30 (2005), no. 4, 259–284.

249. Jian Feng Song, Long D. Nghiem, Xue Mei Li, and Tao He, Lithium extraction from Chinese salt-lake brines: Opportunities, challenges, and future outlook, jul 2017, pp. 593–597.

250. Julian Spector, Study: We're Still Underestimating Battery Cost Improvements — Green- tech Media, 2017.

251. SQM, Investor Day 2018, Tech. report, 2018.

252. Ken Starkey and Paula Madan, Bridging the Relevance Gap: Aligning Stakeholders in the Future of Management Research, British Journal of Management 12 (2001), no. s1, S3–S26.

253. State Administration of Markets and China National Standardization Administration, En- ergy consumption limits for electric vehicles—GB/T 36980-2018, 2018.

254. Statista, Projection total lithium demand globally 2025 — Statista, 2019.

255. Stratfor, Why Cashing in on Lithium Won't Be Easy In South America, 2018.

256. David Stringer and Laura Millan Lombrana, Lithium Miners Australia, Chile See Riches as EV Battery Makers - Bloomberg, 2019.

257. Rob Stumpf, Battery Breakthrough Could Lead to Lighter Batteries with Longer Range for EVs - The Drive, 2018.

258. Xin Sun, Han Hao, Fuquan Zhao, and Zongwei Liu, Tracing global lithium flow: A trade- linked material flow analysis, Resources, Conservation and Recycling 124 (2017), 50–61.

259. Jessica Szarek, Bolivia's Massive Supply of Lithium, and the Implications for the Local Community of Potosi, Upstream Journal (2018).

260. TAM HUNT, Is There Enough Lithium to Maintain the Growth of the Lithium-Ion Battery Market? — Greentech Media, 2015.

261. Naoto Tanibata, Yuki Kondo, Shohei Yamada, Masaki Maeda, Hayami Takeda, Masanobu Nakayama, Toru Asaka, Ayuko Kitajou, and Shigeto Okada, Nanotube-structured Na 2 V

3 O 7 as a Cathode Material for Sodium-Ion Batteries with High-rate and Stable Cycle Performances, Scientific Reports 8 (2018), no. 1.

262. TechNexus, How technology is transforming the mining industry MINING.COM, 2017.

263. Tesla, Panasonic and Tesla Sign Agreement for the Gigafactory — Tesla, 2014.

264. The Department of Finance, Climate Change Budget, Tech. report, The Department of Finance, 2018.

265. The European Parliament, EUR-Lex - 32014L0094 - EN - EUR-Lex, 2014.

266. The World Bank, Doing Business in Bolivia - World Bank Group, 2019.

267. Ease of Doing Business in Argentina — 2019 — Data — Chart — Calendar, 2019.

268. Ease of Doing Business in Australia, 2019.

269. Ease of Doing Business in Chile — 2019 — Data — Chart — Calendar — Forecast, 2019.

270. Tiba, Sea freight to and from Chile, 2019.

271. Toyota, Annual Report — Investors Library — Shareholders & Investors News — Toyota Motor Corporation Official Global Website, 2018.

272. Transparency International, Transparency International - Chile, 2018.

273. Transparency International: Argentina, Corruption Perceptions Index 2018 (2018).

274. Transparency International - Australia, 2019.

275. Transparency International - Bolivia, 2019.

276. Tim Treadgold, China And The U.S. Heading For A Showdown In An Australian Lithium Mine, 2019.

277. UNFCCC, Paris Agreement, Conference of the Parties on its twenty-first session (2015).

278. Osvaldo Urzu´a, Emergence and Development of Knowledge-Intensive Mining Services (KIMS), 2012.

279. U.S. Bureau of Economic Analysis, Auto and Truck Seasonal Adjustment — U.S. Bureau of Economic Analysis (BEA), 2019.

280. Detailed Data for Fixed Assets and Consumer Durable Goods, 2019.

281. U.S. Department of Energy, Alternative Fuels Data Center: All Laws and Incentives Sorted by Type, 2019.

282. OAR US EPA, Sources of Greenhouse Gas Emissions, (2019).

283. OMR US EPA, OA,OPA, U.S. EPA and DOT Propose Fuel Economy Standards for MY 2021-2026 Vehicles, (2018).

284. USGS, USGS - Lithium, (2019).

285. Stephanie Van der Berg and Aislinn Laing, World Court: Chile not forced to negotiate over Bolivia sea access - Reuters, 2018.

286. John Vidal, As water scarcity deepens across Latin America, political instability grows — Global Development Professionals Network — The Guardian, 2017.

287. Volkswagen, Summary - Volkswagen Group Annual Report 2018, 2019.

288. Volkswagen plans 36,000 charging points for electric cars throughout Europe — Volkswagen Newsroom, 2019.

289. Nicholas. Walliman, Your research project : designing and planning your work, Sage Publi- cations, 2011.

290. Gordon A Walter and Jay B Barney, Management Objectives in Mergers, Tech. Report 1, 1990.

291. Fred Weiller, Compelling Evolutions In Electric Vehicle Technologies, 2019.

292. Westlaw, Mining in Bolivia: overview — Westlaw UK, 2019.

293. Yahoo! Finance, SQM Income Statement 2018, 2018.

294. Richard Yamarone, The Trader's Guide to Key Economic Indicators, John Wiley & Sons, Inc., Hoboken, NJ, USA, jul 2012.

295. Sixie Yang, Fan Zhang, Huaiping Ding, Ping He, and Haoshen Zhou, Lithium Metal Extrac- tion from Seawater, sep 2018, pp. 1648–1651.

296. Jia Ying Yong, Vigna K. Ramachandaramurthy, Kang Miao Tan, and N. Mithulananthan, A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects, may 2015, pp. 365–385.

297. Dimitri Zenghelis, Policy brief A strategy for restoring confidence and economic growth through green investment and innovation — 1, Tech. report, 2012.

298. Wenchao Zhang, Yajie Liu, and Zaiping Guo, Approaching high-performance potassium-ion batteries via advanced design strategies and engineering, Science Advances 5 (2019), no. 5.

# Appendixes

## Appendix 1 – Interview with Mr. Rajiv Maher

Students:

So, first thing we want to know something about you. What is your background?

Mr. Rajiv Maher:

Okay. So I should say from the beginning, I have a little to do with work or research on lithium as, as it is. It is quite new to Chile compared to a copper and gold, other minerals. I know there's a lot of interest being raised on it because of all electrics, that is the way the economy is changing and stuff. So Chile has a big proportion of that demand together with, Bolivia, Argentina and maybe Mexico. I've started in Chile at about ten and a half years ago. I've been working on these subjects (mining) from a social responsibility perspective and the affected communities, indigenous and non-indigenous communities. So one thing I've always taken an interest in is to, is to understand what does CSR look like from those impacted by mining or those recipients of CSR. Because from the company's perspective, it's all smiling communities and happy children and a good one, big happy family if you look at the sustainability report. But it's a different story often when you go to speak with the people in the community and also within communities. It's a lot different, lot of impacts from the mining. So, my interest is particularly at the effects of mining in cities in Latin America. Uh, so it's not just restricted to Chile either. I've done a few years research in Brazil on this subject and more recently in Peru. So I went to Cajamarca couple of years ago.

Students:

Which are the linkages between the mining business and the governments in Latin America?

Mr. Rajiv Maher:

And that's your question on Latin America. That's the way they see to grow. They just have not been capable of finding another way out like Asia, has done, you know, if you think of Korea or well, China 50 years ago, they were different economies, but they chose education. And with that they could innovate. They found different ways out. Of course, there's some mining in China, but nothing compared to Latin America. I mean, Latin America is a continent that is so dependent on extracting its natural resources. In particular in the Andean and countries and the Pacific side, it's just mining is a lot of mining. And you know, in Brazil there's the mix of agriculture and mining, but it's again, it's just, uh, it's the same concept. Let's take out the land and, and sell it to the rest of the world.

Mr. Rajiv Maher:

And so that's how governments understand is the way for them to grow, it is a way for them to develop and get progress for their people. And those have been influenced in the 1990s and especially by, the World Bank who was giving them loans saying "look, this is the best way you guys can grow". Chile has been controversial or questionable, you know, Chile is absolutely dependent on mining, and arguably it's developed or almost developed now as a nation. It's been an OECD country for many years now if you look at all the stats, which I'm not a big fan of, but today the GDP per capita looks, you know, it's around the same levels as Portugal or Greece. But it's a very, very unequal society. Because of that, and also because they've also been pretty good with dealing with corruption compared to their neighbors.

Mr. Rajiv Maher:

I mean, still not European levels of transparency. Moreover, countries like Peru or Bolivia have looked, you know, look to their side and thought "hmm, we can do the same, we've got this copper, we've got lithium, we've got a similar, geography and natural resources to Chile. We can follow the Chilean model. So there's another reason. You can say unfortunately or fortunately, you know, previous governments have also looked towards Chile. And thought, “well, let's do the same”. It's the only way they understand, the only way they believe they can realistically achieve growth. I mean, I know that these countries are investing a lot into startup hubs and innovation and move away from mining. But no, it's just proved to be very difficult for them for many, many different reasons.

Students:

Talking about companies and government participation in Latin America, is mining exploration for new sites state-driven or company driven?

Mr. Rajiv Maher:

Cool. So that's a good question. Lithium is a strategic resource, and the government in Chile is just, it's selling it all off because it's such a neoliberal government. It is becoming more company driven. And there's been a lot of corruption involved with the SQM case with one of Pinochet's relatives.

Students:

Are mining resources primarily seen as a resource to grow or as resources to be sold?

Mr. Rajiv Maher:

I think it's both. They sell them to growth. They sell them to get money. Um, and then I think one of the projects I'm working on at the moment is about Chinese mining and Peru. And you've got the Chinese state involved in these companies, and they are causing a lot of issues, labor issues and community issues in different communities. We are working as activists on a publication for the governments: the Chinese government should be paying more attention to what these companies are doing in Peru because it signed agreements internationally. And also the Peruvian government should ensure that their laws are enforced. Because when I've spoken to people from the Chinese government about it, their first response is always, "well, it's the local government that needs to be regulating us and regulating everything properly". And they don't do that. We know there's not much we can do.

Students:

Is it convenient doing business in Latin America? Is it a matter of price? Why should companies source from there?

Mr. Rajiv Maher:

I think it's the ease of doing business, definitely. So first of all, they have to go where the minerals are. Latin America has a lot of deposits that they need. So lithium is not just anywhere. If you think about that, it's in various specific strategic places. And that is that the Andean salaries. And so you've got Argentina it seems to have it. Um, and thus, you know, that's one crucial reason. While perhaps you could also find a lot of minerals in Africa, what Latin America has is a lot of infrastructures already put in place, um, a lot of it. So there they have the roads, they have the personnel, they have people trained, a lot of people trained and you know, they have a history of mining.

Mr. Rajiv Maher:

Um, so they have the infrastructure and capacity to do this. They have laws; the whole institutional arrangement is made to be mining-friendly in Latin America. Africa or parts of Asia... they would probably like that, but they still, they just don't have the capacity at the moment. And, I mean a lot of mining does take place in the US, Canada, and Australia. China's still, um, but yeah, Latin America has been very blessed with all these minerals, which is why the Spanish and Portuguese originally went there in the beginning, you know, to get out gold.

Students:

What are the bottlenecks in the business?

Mr. Rajiv Maher:

Well, my main research topic is resistance, conflicts, and communities on mining. So, in the last 10, 15 years, bottlenecks as you call it, as you call it, have really risen a lot for companies in trying to do mining. And it's very complex and confusing scenario for them. I'll explain two examples. One from Chile and one from Peru. So, Barrick gold, which is the largest mining company in the world and Newmont which is the second-largest mining gold miner in the world, they signed their mining deals, in the 1990s I think.

Mr. Rajiv Maher:

It was easy to do, so there wasn't so much legislation then governments put in place environmental impact assessments and procedures where there had to be some community participation. They were making a bit more democratic. We have the rise of civil society and across all of Latin America, civil society movements, you know, sometimes it's led by the church, sometimes by western NGOs, more ecological perspectives saying mining is bad, which I'm sure it is in many aspects of environmental ecologist. Main problems have been associated with water. So if you think about these societies in Peru and, and Chile before, if they don't have a history of mining, I can almost guarantee that they will be doing a lot of agriculture. And for agriculture and farming, they require water, and without water they're finished. And so the NGOs and the protesters very cleverly linked mining towards an impact on water. One of the main slogans in Perù was "Agua sì, oro no", we can't live without water, but we can definitely live without coal.

Mr Rajiv Maher:

So this created a lot of the concern at the beginning of the century. In a lot of sites all over Latin American community started to stand up and say "hang on a second, we don't want this massive mine. We're not sure if we want this. And we've been told it's not good". And that created some resistance in some cases. For example, in Conga in Peru, you had five deaths because of protests where the regional governments, the protest and they were against the mind. And in fact the, the candidate for president Ollanta Humala, he went to Casapalca county project and he said the famous slogan "Agua sì, oro no" and then, he got to become president and Peru on that.

Mr Rajiv Maher:

And then as soon as you became president, he then said, I didn't say that. I said, I "Agua sì, oro sì". It created a lot of protests. Regional government was against it, four, five deaths of protestors and the company, eventually Newmont said "okay, we need to just stop this". And they they put it on hold and it's still on hold since 2011 in the case of Chile, slightly different and no deaths with protesters, but definitely some sort of violence and a lot of um, resistance from a small group in a community and a lot of ecologists from Santiago coming up there. Uh, and then eventually in the Chile case over the years, the government put in so much more legislation, especially when they had a more left leaning government, the social kind of socialist government with Michelle Bachelet.

Mr Rajiv Maher:

She really started to incorporate a lot more of the advice coming from international organizations, including OECD that they need to have independent environmental regulators. And so the activists very strategic, you know, they're, they're very ideological, but they can also be very practical, practical and use these, these systems within the states. And so they started to go to the courts a lot more instead of just having street protests in handcuff, you know, chaining themselves to things, they will actually be doing more judicial resistance. And they managed to suspend the Pascua Lama because regulations went to make some checks and found they were some irregularities and Barrick itself admitted it. So in 2013, the mine was suspended. And then five years later, or four and a half years later in January of last year, the regulators went up there again and found more irregularities in how they were storing, you know, dealing with the water and cause golden mining needs a lot of cyanide. And you know, if that touches the water in the water system, then the whole valley os destroyed forever. And so they then this, they then told Barrick gold, which was Chile's largest gold mining projects. "Ooh, sorry, we're closing you forever. And that's it". So that was a victory again for the activists. Barrack has since been trying to go against that and everything. And it's just those two examples show the interaction between civil society, community states and mining company, and two cases of failure for the companies and successfully activists.

Students:

So what you are saying is that communities have that much power sometimes...

Mr Rajiv Maher:

It's not everywhere either. Because, you know, when I go to Brazil, I've been to communities where they just, you know, the impact is worse than in what you would than what I've seen elsewhere, but they just don't have nowhere near as much power because the company is way more powerful and, and so too is the state behind it. Um, and it's also been there for over 30 years. So I mean, there might be a lot of people in the community who don't like it, but there's also even more people in the community who benefit from it and are willing to defend it. So it is case by case, but, legislation definitely helps.

Students:

Are we on the verge of a white gold rush?

Mr Rajiv Maher:

I think there is going to be one because of the way our economy is moving towards doing everything electric and electric cars. They haven't massified yet. So I think once they do and we need these a lithium, we need lithium batteries, then of course it's definitely going to mean a lithium rush.

Students:

Which are the benefits for communities?

Mr Rajiv Maher:

uh, it depends who you speak to in the community of course, because if the person, the community is going to be impacted by the mine, if their water will be impacted and it doesn't matter what the economic benefits are, um, they, they will outweigh. They're gonna look at cost benefit. The main benefit they tend to want from my conversations with them is a job at the mine for their son or their daughter or themselves. Um, it's, it's, and when they don't get the job or the son or daughter does not get the job, then they get really annoyed. Then they say, I kind of, I don't, you know, why did I support this is mine. And there were also some people who want to defend the land, the territory, depending on, on the community or on the spiritual beliefs.

Mr Rajiv Maher:

Some people, for them, some communities, water is sacred. Uh, and they don't want mega mining going on there and they don't want to change. They don't even want extra, they don't want more money if it means destroying their terrotory. Others benefit more if they have a hairdresser or a small restaurant, you know, it means a lot more people coming for their services or they have a hotel. You normally you talk about the boomtown scenario as well. If there's a town there and [inaudible] and you can have hyperinflation where things go up by 1000%, uh, because you get, normally when a mine opens, thousands of men come and they need services.

## Appendix 2 – Interview with Mr. Alonso Barros

Students:

What is your experience in the lithium business?

Mr. Alonso Barros

Well, I have been working in the Atacama Desert, for the Atacama people for decades. I had been working with the Atacamenian council for many years and we had the idea to create a perpetual movement machine so that, you know, where the brine, it's part of the equation to generate energy. The solar energy powers pumps the water to the brines. So, I worked closely with local communities living in the area where the plant was built and I assisted them to strike a deal with the company operating the project, the Albemarle. The communities received 3% of the royalties on the mining activities for the deal.

Okay. So that's when I started, getting involved as a lawyer for the indigenous community. But at one point in 2000 and I don't remember the exact dates. It must been 2012, I suggested, I told the community that I wouldn't work with them anymore because I had seen some things, hints of corruption in the operations and the way that Atacamenos were receiving the money. And I thought that, you know, it would lead to corruption and the governmentality things and governance. And it's true, they have been in trouble with payments, et Cetera, like many other organizations in Chile. But I wouldn't have any of it and didn't want to take parts of that sort of corruption schemes. I walked away now after a while. Yeah, about two years ago, I was contacted by one community called Camar and they asked me to be their lawyer and to have them in a series of negotiations like, with the other players in the southbound and also with SQM of with all three with pending sort of agreements that they should have had and they haven't had yet, especially SQM, which is starting its environmental approval process for a few of its mitigation measures, but it adopted recently and then that will need to be submitted to consultation.

I've been pushing for consultation with all the companies involved except Albemarle because of that, they already have an agreement with the communities that I've been participating in these, uh, due diligence processes between indigenous communities and the mining companies with the relative success set that corruption and the ghost of corruption is always present. So then I saw recently one of the community I was working for was also involved in dubious sort of money laundering schemes. And I decided to quit those and pick the defense of the treasury of the community. So you see there's a lot of complexity and there are a lot of problems with the communities granting their social license to the mining companies, and I do my best with communities to ensure those minimum standards that I've always try to set in order to defend them.

Students:

Speaking of corruption, in which cases companies recurr to it? Where and why do they need to corrupt locals in order to operate?

Mr. Alonso Barros

Well, in order to operate companies need to obtain 2 licenses. They need an environmental license for which there is a procedure, called the environmental impact assessment system and they will try to get that license. Environemntal regulators will evaluate the projects that the companies have. And from there on, see if it's found, if it's sustainable, if it works, if the project is not harmful. There's another license that they need, which is the social license to operate, which is a more political process. It's based on a state consultation in case of indigenous communities and agreements being reached by the, the local communities with the companies.

If companies reaches agreements with local community regarding the exploitation or whatever, then they have a social license to operate, which is not just a legal burden, it's also as a social, you know, so that's a, it's about reputation. it's about corporate governance, et Cetera. So companies need to reach agreements with local populations no matter what because they should try not to have any conflict with local communities because that takes away the possibilities for long term development of sound mining projects. In the long term, the success of the operation may be undermined, right?

So they have two sorts of licenses that they should get and that's when the corruption comes in. If for, to obtain the environmental license, we would have to bribe some public servants, that's complicate sometimes. For the social license to operate need just to bribe a few people from the community, their leadership. This is something that happened at the country level. It is not a problem for local communities only, but it may happen at every level. People sometimes feel they are not getting proper services from the state, so they recurr to corruption.

Students:

Can you tell us something about the environemntal aspect of the extraction?

Mr. Alonso Barros:

Well. Yeah, that's, that's, that's perhaps the most interesting aspect is that usually like 10 years ago nobody really put a focus on how lithium was extracted and what impact lithium extraction industry had on the salt plan. The conditions of the salt plan were deteriorating and nobody really linked this to the over exploitation of brine. Everybody thought that bride exploitation was innocuous, yet it wasn't. The communities started to observe it is that the lagoons on the side of the salt plan, on the edge of the salt plan, were starting to dry out. Now what are these lagoons? These lagoons that have brackish water. They're no property. The brines are on the edge of the salt plan.

By pumping water from the underground, mines change the biochemical properties of the lagoon. The lagoons are filled by sweet water coming from the Andes. These waters float on deeper salty water. So if you take out too much brine out of the system, then the lagoon system collapses because there is no salt water to keep the sweet water floating anymore.

So, these salt lagoon need to be protected by different laws. In the past, companies like SQM used to take out whatever they wanted. Now we forced the company SQM to submit environmental impact assessment studies. The measure will be used to change the rates of exploitation. But that is an ongoing process and there are not many more things that we can do. The chances to make things better are small and the work is difficult because SQM has all the information, so it basically does what it wants.

And also SQM has corrupted the government for a long time.It paid bribes to most political parties in the country and they haven't had anything against them. They, they've just gotten off the hook and all of the politicians that receive money spent unless you do them as well. SQM got cornered into one small issue relating to how they will replenish the saltwater that keeps this freshwater floating. It worked only because we pressured them to do it. But that's basically the situation that you have here. It (SQM) gets away with anything.

We have seen that the business environment in Chile in particular is changing because, Tianqi invested in SQM. We want your opinion about the future of the business environment because the administration of SQM has changed after the involvement of China. Samsung, and the LG Chemical are investing in the battery business. So also the customers are changing now. Wanted to know, if there is something ongoing now or if pretty similar to the past, what is your opinion about?

There was supposed to be an incentive in the contract with Albemarle and in the contract with SQM that 25% of their productions should be destined to internal development, so to speak. So they would need to be pre, add add value to these products in should be.

Albemarle had reached an agreement with three companies, one of them being Samsung. The other being local companies. The company and the government, all the money in the government couldn't to reach an agreement on the transfer prices, which were, you know, what price was Albemarle going to sell this 25% of lithium to these companies that were going to produce cathods with. There was a negotiation with the government and they didn't reach an agreement on what sort of price. I mean the government wanted the price to be that which Albemarle used to sell to it's own affiliates or its own companies.

That's why they were trying to reach that sort of agreement. So one of the things that looked promising was that the Chilean market would add value to, the battery market, not to produce batteries, but to produce cathodes which is a good enough, which is fair step ahead. Now, this didn't work because at the end of the day, because like I said, they didn't reach proper agreements and the government didn't produce incentives to support local investments for the production of cathodes. The good thing about Tianqi being part of the SQM business is that you could do whatever you would want in Chile and Tianqi would agree to it.

You know, if you said, let's have a battery department and Tianqi he would agree to that. I mean they don't mind that Cjile develops itself on the back of lithium exploitation or the lithium derivatives or whatever. But it's the Chilean government that hasn't been able to corner the issue and create the appropriate environment for these other companies to develop. You require a, a strong will and decision making to develop this sort of an industry or a cathode industry in Chile. You had all the elements, but you need some powerful decision making. There's a lack of mentality of how it, how to do mixed business public/private even though we are very legalistic and very market pro-market oriented.

There's lack of interest actually from private sector to get help from the states at this level. The state hasn't been proactive enough in distributing these resources and setting the controls and getting what it wants. What it needs, you know, the real point is that there's a lithium Oligopoly. Right. And also a Monopsony. You have a perfect sort of cartels here, right? Yes. You have the limited number of buyers and the limited number of producers. So the price thing is, being fixed by the five or four companies, the big players, right? There's Albemarle, it's American, the other is SQM.

Then Albemarle, IBM, the chemical group. And in China there are two big companies. One is Ganfeng and the other Tianqi. So you have effectively that these five, four or five companies, you have FMC eventually you can count in. But the four big players control the whole production levels and they control pricing. Playing with these two things, price and the supply, keeps your control. You keep the competition out either because you reduce or increase and production to always keep the market tight. That's the way I see it. That this is the way it's operating. You know? The world needs infinite amount of lithium and this is how these companies can keep this energy development under control. These four companies control price and levels of production, that's what cartels do. Then with that, they can control the whole industry, which it was what I think was happening. New countries are trying to come on such as Portugal, Argentina, Brazil, Peru... but these 4 companies are still trying to keep the market tight and increase their margins, just enough to keep smaller players outside.

Students:

Even though the world is abundant of lithium, some raise concerns about production capacity. When electric vehicles will become mainstream, lithium demand will eventually go up. Do you think there's going to be lithium shortage in the future due to that? Do you see bottlenecks in the supply chain?

Mr. Alonso Barros:

Also, the JP Morgan is saying there will be, there'll be too much lithium when prices will go down or not enough. It's under control and Tianqi, it has a greater part of this control. And China has, you know, the sort of lead. The two Chiense companies, Tianqi and Ganfeng control the lithium market, but also eventually the battery market. Because they a supply chain directly linked into the automotive industry in China. Right. So, they've secured their supply chain for the energy transition and they're going to lead it. Well, we'll see hundreds of new Chinese brands coming into the market very soon because they've managed to the whole supply chain from salt plans to the cars.

Students:

We have one last question. We are informed that Evo Morales is running to become president for the third time in Bolivia. If elected, he promised he will keep up with his socialist policies in the country. What would eventually be the impact of this on the lithium mining sector in the country?

Mr. Alonso Barros:

Well, I think they're are only behind Chile and Argentina. So, the government owns the resources and foreign companies must come deal with them to operate. In Argentina Ganfeng announced the commencing of a deal there but so far nothing has happend. They promise they create battery, but that is nowhere near happening. I see it. And in Bolivia, even even worse, Bolivia is well known for making fabulous declarations about what it's going to do and how it's going to develop its associates.

But the market is a stubborn monster and, and it has some kind of sense, not that I am totally pro market or that . That's what I was saying earlier, that I thought in Chile the state needed to have a more longterm stand from the management of the reserves. Right. It seemed that's an appropriate route. And the other extreme of a state intervention is Bolivia.I think they had a deal with a German company nobody's ever reallyheard about it. It's all about good intentions and it's not all about things that seem very much, and I'm not even with a pilot to extract the lithium. So I don't know when these projects will be effectively running. Okay. I don't know when Bolivia will be site exploiting its brines appropriately and doing it through the same models that you have in Chile. I don't see it in the near future.

And the oversupply issue is something that's plenty, that's pretty much in control of this cartel and this cartel is nothing new. It's been going on for decades. Okay. There's all, there was also a cartel for potash as can also extract potash from the outbound so so, and there's a world's cartel of potash and as you have as part of it and so you have here the salt plan is a key asset not only because it produces the most of world's lithium, but also because it produces different kinds of resources. One of them being potash and alsowater.

Okay. You have the two biggest copper mines in the world operating nearby and they're extracting some Sweetwater and also depleting to something which is going to be then mined by Ba from BHP that it didn't and the other is the letter it was put off to empty. I've got the minerals and they're all tapping into the freshwater that deploys into the cellphone mark his pocket. JP Morgan at some point tried to sell that the whole lithium thing was this is scam and there's plenty of lithium and there's going to be an oversupply in, you know. And that made the prices fall and they'd bought their own positions. And the market does what JP Morgan does, right? So it's trying to bargain, in a, in an arena where the players, the two main players are Chinese, you know, and JP Morgan has tried to make some kind of leverage and buy into this. It was an opportunity to buy into oligopoly, But it hasn't been very successful.

## Appendix 3 – Questionnaire to Mr. Joe Lowry

1) What are, from your experience, the drivers that push a Battery Manufacturer to source from a specific supplier?

2) What are the main bottlenecks and risks in the supply chain of a lithium battery producer?

3) To what extent the top 4 lithium producing companies (Tianqi, Gangfeng, SQM and Albemarle) can influence the market?

4) Is access to lithium a source of concern for governments? If so, to what extent governments (such as the USA or China) are influencing the lithium industry?

5) While the majority of reports indicate lithium as the primary material for the batteries of the Electric Vehicles of today, which are the potential substitutes of this metal in the nearest future for the production of batteries?

1) In most cases battery makers don't buy lithium directly, cathode maker does. Battery makers want quality and consistency from their cathode makers. Financial position & sustainability are also important

2) To date, the main bottleneck doesn't concern availability of raw material: producers of battery components are more concerned with the consistency in terms of quality of lithium compounds.

3) Given their cumulative 75% market share they consistently control the market.

4) Yes look at what Japan did to support Toyota Tsusho's investment in ORE & look at China / Korea

5) Alternative technologies are currently being tested but most of them will remain confined into small niches. We will probably have no alternatives to lithium batteries for the next 15 years.