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Impact of Lithium Carbonate Spot Price Fluctuations on Electric Vehicle Sales

Comparing Emerging & Developed Markets

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ABSTRACT:
With increased sustainability goals, the demand for electric vehicles has increased, as they are considered to be the more sustainable option compared to internal combustion engine vehicles. No prior studies were identified that examined the relationship between the price of lithium carbonate and electric vehicle sales in different markets. The purpose of this research is to analyze lithium carbonate spot price fluctuations impact on electric vehicle sales. As there are differences in consumer behavior and purchase power between different markets, the results are compared between emerging and developed markets to investigate differences between them and to see if lithium carbonate spot price can forecast electric vehicle sales in different markets.

Three countries from each market are chosen and their electric vehicle sales, GDP per capita and different incentives are used to examine their differences during 2021–2024. This study uses a quantitative method to investigate secondary accessible public data through different statistical analysis methods. Theories, such as law of supply and demand, cost pass-through, as well income elasticity of demand, are used to help in analyzing the findings. In this study, descriptive analysis provides a simple understanding of the data gathered and its trends, which aids in providing a foundation for the next analyses methods that test the hypotheses and ultimately give answers to the research question. While comparative analysis is used to compare the differences of electric vehicle sales in emerging and developed markets, a correlation analysis investigates the relationship between lithium carbonate spot price and electric vehicle sales. The core analysis of this research is regression analysis, and it is used to study the dependency of GDP per capita and incentives, along with lithium carbonate price to electric vehicle sales.

The comparison between markets in their electric vehicle sales leads to an observation that even though emerging markets had some higher electric vehicle sales, their mean per month is lower than in developed markets. From the findings, it can be observed that there are differences in consumer patterns between the markets, emerging and developed, in terms of electric vehicles sales. This is in line with what the theory of income elasticity of demand suggests. It is also found that there is a weak but negative correlation between lithium carbonate spot price and EV sales, which aligns with the law of supply and demand theory. However, the findings indicate a delayed cost pass-through between them. Overall, the results suggests that higher income market, developed market, is related to higher electric vehicle sales, but it does not change the strength how lithium carbonate price impacts electric vehicle sales.

KEYWORDS: Electric Vehicle Sales, Lithium Market, Law of Supply and Demand, Market Structure

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TIIVISTELMÄ:

Kasvavien kestävyystavoitteiden myötä sähköautojen suosio on kasvanut, koska niitä pidetään polttomoottoreita ekologisempana vaihtoehtona. Kuitenkaan aiempia tutkimuksia litiumkarbonaatin hinnan ja sähköautojen myynnin välisestä suhteesta eri markkinoilla ei ole havaittu. Tämän tutkimuksen tarkoituksena on siis analysoida litiumkarbonaatin hinnan vaihteluiden vaikutusta sähköautojen myyntiin. Koska eri markkinoiden välillä on eroja kuluttajakäyttäytymisessä ja ostovoimassa, tuloksia verrataan nousevan talouden markkinoiden ja kehittyneiden markkinoiden välisiin eroihin. Tämän lisäksi tutkitaan litiumkarbonaatin hinnan mahdollisuutta ennustaa sähköautojen myyntiä eri markkinoilla.

Tutkimuksessa valitaan kolme eri maata markkinaa kohden, joiden sähköautojen myyntitilastoja analysoidaan vuosilta 2021–2024. Tämän lisäksi otetaan huomioon bruttokansantuotetta henkeä kohden, sekä erilaisia kannustimia sähköautojen ostoon. Kvantitatiivisen tutkimus menetelmän avulla julkisista lähteistä saatavaa tietoa analysoidaan useiden tilastollisten analyysimenetelmien, sekä erilaisten teorioiden, kuten kysynnän ja tarjonnan, hinnan välittymisen, ja kysynnän tulojouston avulla. Tutkimuksessa käytetyt kuvailevat tunnusluvut antavat yleisen kuvan tutkimuksessa käytettävästä tiedosta ja niiden kehityssuunnasta, mitkä auttavat luomaan pohjan seuraaville analyyseille hypoteesin testausta varten. Vertaileva analyysi puolestaan vertaa eri markkinoiden välisistä suhteista litiumkarbonaatin ja sähköautojen välillä. Korrelaatioanalyysin avulla tutkitaan yleisesti litiumkarbonaatin hinnan ja sähköautojen myynnin välistä suhdetta. Tutkimuksen pää analyysimenetelmänä toimii regressioanalyysi, jonka avulla tarkastellaan bruttokansantuotetta henkeä kohden, litiumkarbonaatin hinnan ja erilaisten kannustimien riippuvuutta sähköautojen myyntiin.

Vertailu sähköautojen myynnin ja markkinoiden välillä johti päätelmään, että vaikka nousevan talouden markkinoilla oli tilanteita, missä eri maiden kuukausitasoinen myyntinsä oli korkeampi, oli heidän sähköautojen kokonaismyynninkeskiarvo kehittyneitä markkinoita pienempi. Tästä voidaan päätellä, että markkinoiden välillä on eroavaisuuksia kuluttajakäyttäytymisessä sähköautojen myynnin osalta. Tämä on linjassa kysynnän tulojousto teorian kanssa. Tämän lisäksi tutkimus osoittaa, että litiumkarbonaatin ja sähköautojen myynnin välillä on heikko, mutta negatiivinen korrelaatio, mikä puolestaan vastaa kysynnän ja tarjonnan lakia. Tutkimuksessa on kuitenkin löydetty viitteitä, että litiumkarbonaatin ja sähköautojen myynnin välillä on viivästynyt kustannusten siirtyminen. Yleisesti voidaan todeta, että tulokset esittävät kehittyneiden markkinoiden liittyvän korkeampiin sähköajoneuvomyynteihin, mutta sillä ei kuitenkaan ole vaikutusta litiumkarbonaatin hinnan ja sähköautojen välisessä suhteessa.

AVAINSANAT: Electric Vehicle Sales, Lithium Market, Law of Supply and Demand, Market Structure

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Abbreviations

BEV	Battery Electric Vehicle
EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
PHEV	Plugin Electric Vehicle
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
LIB	Lithium-ion batteries
GDP	Gross Domestic Product

1 Introduction

This research will analyze the impact lithium carbonate spot price has on electric vehicle sales and compare the results with between emerging and developed markets. As these markets differ in consumer behavior and purchase power, as well as their regulations (Meszaros et al., 2021), their reaction to lithium carbonate price fluctuations is studied. This introduction chapter will introduce the research background, research gap, and the questions the research will provide answers to. On top of this the research objectives will be told, with keywords relevant to the research. Scope of study will be gone through to explain what is included in the study and the possible limitations encountered. Finally, the chapter will conclude with an explanation of the structure of the research.

1.1 Research Background

The transportation sector is growing due to increase in vehicle demand (Mohammadi & Saif, 2023). This growth has made them one of the most pollutant sectors, responsible of over a quarter of all global carbon dioxide emissions, and the rise in demand will further grow the number of emissions emitted to the atmosphere (Mohammadi & Saif, 2023; Schvartz et al., 2024). Because of the increase in pollution, governments, organizations and even individuals are putting pressure on each other to increase sustainability, adds Schvartz et al. (2024). Electric vehicles are a more sustainable option as they release fewer harmful pollutants, like carbon dioxide, into the atmosphere compared to internal combustion engine vehicles, and thus aid governments to reach their carbon dioxide targets (Mohammadi & Saif, 2023; Schvartz et al., 2024).

Electric vehicles are becoming more popular and will increase their popularity due to governments setting targets to decrease emissions and banning internal combustion engines in the near future (Schvartz et al., 2024; Agency for Natural Resources and Energy, 2024). Electric vehicles have an electric motor that either is the sole motor in the vehicle or works together with an internal combustion engine (Mohammadi & Saif, 2023).

Both types of electric vehicles have a battery inside them, which typically is a lithium-ion battery, explains Kavanagh et al. (2018). These batteries use lithium carbonate, together with other raw materials to operate (Kavanagh et al., 2018). Lithium carbonate is, however, considered to be the most important component of the battery, according to the article. It is told that currently, lithium offers a better lifecycle, rechargeability, and increased range compared to other raw materials. This increase in electric vehicles has increased the demand for lithium, especially since the main target for lithium mining is to fulfill the demand of rechargeable batteries (Kavanagh et al., 2018). The recycling of lithium-ion batteries is in early stages, which further increases the impact of lithium availability to electric vehicle manufacturing (IEA, 2025 p. 136–145; Kavanagh et al., 2018).

There are three different markets, developing, emerging and developed (Bekaert et al., 2023). The focus of this research is on the two latter. Emerging and developed markets are typically separated by GDP (gross domestic product) per capita and regulations, especially the ones concerning how accessible the market is to foreign companies (Bekaert et al., 2023). They also differ in consumer behavior and purchase power (Meszaros et al., 2021), and purchasing an electric vehicle is told to come with cost related challenges, due to them being more expensive compared to internal combustion engine vehicles (IEA, 2025, p.51–53).

1.2 Research gap, questions and objectives

The focus with several other research has been the overall impact of price fluctuations on the end-product, and how the major electric vehicle consuming countries or continents electric vehicle demand changes (Sullivan et al., 2025; Sun et al., 2022). The correlation of lithium carbonate price impact with electric vehicle demand has also been debatable in different research. Some say that they have correlation with each other (Sullivan et al., 2025), while others argue that their relationship is mainly short term (Sun et al., 2022). No studies were identified that examined the difference behavior between markets concerning how they react to selling electric vehicles when their demand is impacted by lithium carbonate fluctuations. It is known that emerging and developed markets have differences in their consumer behavior (Meszaros et al., 2021). This study aims to investigate the following research question:

> *What affect does lithium carbonate spot price fluctuations have on electric vehicles sales in emerging markets compared to developed markets?*

The following objectives will help answer the research question:

1. To measure the relationship between lithium stock prices and electric vehicle sales in different markets, emerging and developed markets. Three countries from each market group will be compared to one another.
2. Research on whether lithium stock price can forecast electric vehicle sales in different markets.

1.3 Definitions and Scope of Study

As the main focus of this research is analyze the relationship between lithium carbonate price and electric vehicle sales, and their difference between the two markets. The keywords are electric vehicle sales, lithium market, market structure and derived demand. The definition and scope of the keywords are stated below.

Electric vehicles sales can be defined as the sales of vehicles that operate on electric motors (Mohammadi & Saif, 2023). Electric vehicles in this thesis includes hybrids, plugin hybrids, as well as battery electric vehicles. The electric vehicles described in this research are passenger vehicles, and thus will exclude heavy and light vehicles, which essentially are trucks and scooters. Electric vehicle sales drive the demand for lithium-ion batteries, and simultaneously the lithium demand, and vice versa, because most extracted lithium is used in electric vehicles (Sullivan et al., 2025; Kavanagh et al., 2018).

Also, the electric vehicle sales data is gathered from six different countries over a specific time period of four years.

Lithium market is the market of a critical raw material that is used in electric vehicle batteries, for example (Kavanagh et al., 2018). More specifically, electric vehicles use lithium carbonate in their lithium-ion batteries (Kavanagh et al., 2018). In this thesis, lithium carbonate price is considered the primary demand for electric vehicles, as it is told that their market is influenced by the electric vehicle market (Sullivan et al., 2025). The study focuses on lithium carbonate spot price fluctuations over a four-year period. The limitations on downloading the data for lithium carbonate spot price is, that it is behind a paywall.

Law of supply and demand aids in explaining the relationship between lithium carbonate and electric vehicle sales. The theory provides an explanation how price changes in lithium carbonate impact production cost, leading to changes in electric vehicle costs, which then leads to changes in demand (Buechner, 2018). Since the data is focused on the raw material price and electric vehicle demand of different markets, it will not focus on either the upstream or downstream segments of the supply chain. The emphasis remains on the relationship between EV demand and a component price of the battery, lithium carbonate.

Market structure includes emerging and developed markets that are used to compare the difference in consumer behavior of electric vehicle sales. Emerging markets are countries that show potential in global markets but have more risk factors than developed markets (Kutaula et al., 2024). Emerging markets are considered to be in the process of becoming a developed economy, adds the article. Alternatively, developed markets are described as countries that have advanced economies (Bekaert et al., 2023). The market structure includes GDP per capita data, and any possible incentives provided by the government for purchasing an electric vehicle. The focus is on incentives that increase demand and will exclude the incentives concerning innovation and other business transactions. As one of the main differentiating factors between the two markets is GDP per capita (Bekaert et al., 2023), the research will provide one value per country per year. Emerging and developed countries were based on based on an annually updated list provided by MSCI (MSCI, 2025). Limitations in this study are that the focus is on three countries per market, emerging and developed market. There are limited number of monthly electric vehicle sales data available, which impacted the country selection process. These limitations are the number of countries selected by each market and their geographical location. Also, as most countries have started collecting monthly data just a few years prior, the timeframe for this study is limited to four years, from 2021 to 2024. For the six countries, most of the monthly electric vehicle sales data is in their native language, which resulted in trusting the translator application, Google translate, to correctly translate the needed information. For some countries, there were other sources that had gathered the data, so cross-checking information from their trusted website was an option to ensure the accuracy of the translation and therefore the accuracy of the data.

1.4 Structure

This research consists of five main chapters and is constructed in the following way: introduction, literature review, empirical study, results, as well as discussion and conclusion. The introduction has outlined the research background and defined the main research question to provide an overview of the research. The remaining chapters review relevant literature and theories, explain the empirical study, present results of the statistical analysis, and discuss how the findings relate to the research objectives.

After this introduction chapter, a dive through literature of electric vehicles, their batteries and lithium are provided. Also, theory on supply and demand, and how to draw the relationship between the change of a component price, lithium carbonate, and the end-product, electric vehicles, it will be used in. On top of this, the markets, emerging and developed, are introduced and key differences between them explained. This is there to provide a general foundation and understanding of the study and the relationships. A summary of the conceptual framework of this research is presented in this part of the research, that also includes hypotheses that are used to analyze the obtained data.

The research will continue with an empirical study to deepen the understating of what is studied, how the data is obtained and how this research will analyze the data to either reject or approve the hypothesis made in the earlier chapter. This chapter starts with explaining the research design and the reasoning behind the choice of quantitative methods used. As this study relies on secondary data, the chapter describes the sources where the data are obtained from. On top of this, the variables used to perform the statistical analysis to answer the hypotheses are introduced. This is followed by with a brief overview on the chosen analysis methods and finally concluding in a discussion of reliability and validity of the data and thus the research.

The results chapter gives information on the analyzed data, and also provides charts and figures to further illustrate the data and their relationships. The chapter starts by demonstrating the basic data, such as mean, frequency and skewness of the variables. For the continuous variables, their distribution is analyzed to see if they fit normality. This is followed by comparing the monthly sales of electric vehicles between emerging and developed markets. It discusses the findings of the comparative analysis and gives statistical reasoning whether or not there is a difference. The results of correlation and regression analysis are presented next to provide information on the relationships between the variables in the study.

Finally, a discussion and conclusions chapter will conclude the research. This chapter will summarize the findings made in the previous chapters, as well as discuss the results. This is followed by analyzing the limitations of the research, such as data availability and timeframe. The study concludes with giving ideas for future research, like replicating the study in the future when more data is available to possibly further improve the research results.

2 Literature Review

On this chapter, the insight on the lithium, electric vehicles (EVs) and the reason why these two are linked together, as well as the importance of it are provided. This section also includes a theoretical portion of the research, providing further context on the relationship between lithium carbonate and electric vehicle sales. After this, the market structure is introduced and explained how emerging and developed markets differ from each other. In this section, three countries per market and their relationship with electric vehicle adoption are presented, and summaries of consumer related subsidies. This chapter concludes in the conceptual framework, that draws together the relationship with all variables in the research and while providing the hypotheses that are used to analyze the data.

2.1 Overview of Electric Vehicles

Becoming more sustainable has been an ongoing challenge in today's world, and with a rising number of vehicles on the road leading to more carbon dioxide emitted to the atmosphere, the transportation sector is becoming one of the most pollutant industries (Schvartz et al., 2024). Currently, the whole transportation sector makes up around one fourth of all of the global carbon dioxide emissions, which is why many countries are making attempts on reducing their carbon dioxide emissions, adds the article. This is where EVs come into place, because using them instead of internal combustion engine vehicles (ICEV), creates a reduced number of carbon dioxide emissions into the atmosphere (Schvartz et al., 2024). Today, it is estimated that EVs create around 20–30% less emissions compared to ICEV (European Environment Agency, 2024).

One of the main reasons for the current relevance of electric cars is that oil reserves are expected to last only for the next 45–100 years and that electric cars will reduce the need for fossil fuels (Mohammadi & Saif (2023). The electric car revolution began in 2015 (Sun et al., 2022), and by 2024 the share of electric vehicles sold worldwide had already reached 20% (IEA, 2025, p. 10). This increase in demand for electric cars is due to the environmental awareness of consumers, as well as various incentives offered by governments to increase the affordability of vehicles (Schvartz et al., 2024; Meszaros et al., 2021). This makes the demand for electric cars country-specific (Meszaros et al., 2021). The increase in demand for electric vehicles has also increased the demand for vehicle components, such batteries where lithium is one of its most important components (Mohammadi & Saif, 2023).

All EVs use electricity to operate, but some more than others (Mohammadi & Saif, 2023). Currently, there are hybrid electric vehicles (HEVs), plugin electric vehicles (PHEV) and battery electric vehicles (BEVs), informs the article. HEVs and PHEVs utilize an electric motor and an internal combustion engine (ICE) to operate, and the advantage of these is that they emit less carbon dioxide and consume less fuel compared to internal combustion engine vehicles (Schvartz et al., 2024; Mohammadi & Saif, 2023). In HEVs they are battery assisted, while PHEVs rely on both ICE and electric motors, where the battery of the electric motor needs to be charged (Mohammadi & Saif, 2023; IEA, 2025, p. 45–46). Even HEVs use less fuel when travelling the same distance compared to ICEV (Mohammadi & Saif, 2023). BEVs on the other hand only operates on its electrical motor that stores energy in their rechargeable batteries (Schvartz et al., 2024; Mohammadi & Saif, 2023). These three different EVs require varied amounts of lithium in their batteries, depending on their battery size and vehicle type (Kavanagh et al., 2018). PHEV require the least lithium per power with 0.176 kg/kWh, HEVs require 0.375 kg/kWh, and for BEVs, for example a Tesla with an 85kWh battery needs over 50kg of lithium in their battery, which means that the lithium usage is around 0.590kg/kWh (Kavanagh et al., 2018). These vehicle and engine type separation, as well as their lithium usage are found in Table 1.

Table 1 Types of Electric Vehicles

Vehicle Type	**Engine Type**	**Lithium Usage**
Hybrid electric vehicle: HEV	Battery assisted ICEV	0.375 kg/kWh
Plugin Electric Vehicle: PHEV	Both ICE and electric motors	0.176 kg/kWh
Battery Electric Vehicle: BEV	Only electrical motor	0.590kg/kWh

Note. Table data found in an article by Kavanagh et al. (2018). BEV lithium usage calculated based on a Tesla performance in kWh and the weight in kg of lithium carbonate in its battery.

The reason lithium-ion batteries are in EV batteries, is that they do better in lower temperatures, have longer life cycles, are lighter and have faster charging compared to other batteries (Mohammadi & Saif, 2023; Kavanagh et al., 2018). Even though EVs operate better in different temperatures, the battery requires travel restrictions and circuit protectors to stop it from overheating and causing fires (Kavanagh et al., 2018; IEA, 2025, p. 105). As the initial cost of EVs is still more expensive than ICEV, but many not be aware that their maintenance is cheaper (IEA, 2025, p.51–53; Mohammadi & Saif, 2023). Since lithium-ion batteries are rechargeable, the cost of electricity is most often cheaper than fuel, which makes them cheaper to operate (Mohammadi & Saif, 2023). Another way of getting the price of EVs down, is having material prices, like lithium, drop which makes the battery packs cheaper and ultimately leads to more affordable EVs (IEA, 2025, p. 12–17). Other challenges that come with EV adoption are their availability of charging infrastructure and long charging times, on top with their range (Schvartz et al., 2024). In 2024, the average range an EV had was around 340 kilometers, and the preferred range according to consumers would be over 500 kilometers (IEA, 2025, p. 44). The problem with increasing the range of an EV, is that it would require a bigger battery that would ultimately increase the vehicles energy consumption and the need for more critical minerals, such as lithium (IEA, 2025, p. 44). The materials used in EV batteries also limit EV availability in poorer countries, due to the fact that the batteries are expensive and require resources, which makes low- and middle-income countries struggle to widely adopt them (Meszaros et al., 2021). On top of this, charging of EVs can put stress on local electricity grids, especially the super-fast chargers, which could lead to increased charging prices (IEA, 2025, p. 106–123). However, in many developed countries, they have started adding renewable energy sources to their power grids to avoid this problem (Mohammadi & Saif, 2023).

The increase in demand of EVs leads to increased innovation speed, which drives better technology and increases EV production (Meszaros et al., 2021). Because the battery is such an important part in EVs and their performance, the future challenges EVs are facing is to make these vehicles more reliable, energy efficient, cheaper and increase the lifecycle of batteries (Mohammadi & Saif, 2023). Currently, EV batteries cannot be serviced and need to be replaced when a problem occurs or their lifecycle, which is around a decade, is up (Deng et al., 2020). In other words, around every ten years the battery of an electric vehicle needs to be replaced, which increases the need for lithium. Also, since the recycling of old batteries is not current, the lithium from the batteries is not repurposed to new vehicle batteries up, which could lead to shortages in raw materials (Deng et al., 2020). In the long run, recycling could help bring the cost of EV down by reusing battery materials, but according to IEA (2025, p. 137–145) it will take at least a decade to have enough recyclable material for recycling to be profitable.

There are arguments that the electric vehicle demand impacts lithium carbonate demand (Sullivan et al., 2025), this thesis, however, focuses on the opposite view, the law of supply and demand. The suggestion on this research is that lithium carbonate price fluctuations influence, production decisions in car manufacturing, which then impacts the end-product, electric vehicle demand. The study also considers why consumers may hesitate to purchase electric vehicles, the incentives offered to consumers to increase demand, and the impact of the market structure of countries on demand. Understanding this is essential in explaining how lithium carbonate price fluctuation has an impact on electric vehicle sales in different markets, emerging and developed markets.

2.2 The Role of Lithium Carbonate in Electric Vehicle Batteries

Most electric vehicles contain a lithium-ion battery (Mohammadi & Saif, 2023). These batteries contain lithium carbonate, that is a type of lithium, that is mainly extracted to meet the electric vehicle demand (Kavanagh et al., 2018). The upcoming sections start by introducing the lithium market and its properties, followed by drawing the relationship between lithium carbonate and electric vehicles, while also deepening the understanding with theories concerning law of supply and demand, as well as cost pass-through.

2.2.1 Current Status of Lithium Market and Its Properties

Lithium can be found in salts or minerals, because it is not available in nature as a pure metal (Kavanagh et al., 2018). Though there are various types of lithium minerals, only a few lithium is of commercial value (Goa et al., 2023). The salts and minerals that contain lithium are found in waters, soil, brines and in different mineral resources (Kavanagh et al., 2018). It is also told in the article that most lithium resources are in the US, Chile and Bolivia. Today, lithium can be extracted mainly from two different sources, hard rock and brines (Sun et al., 2022). From these, hard rock extraction is more popular and for example in China almost 70% of the lithium extracted came from there (Goa et al., 2023). When a lithium extraction project starts, it typically takes seven years for brines and three years for hard rock mines to have production at full capacity, explains Sun et al. (2022). Lithium carbonate can be extracted from both brines and hard rocks (Kavanagh et al., 2018).

As extracting lithium from places of low concentration is not feasible, existing projects focus on areas with high concentration of lithium (Goa et al., 2023). This is because an extraction project emits a lot of pollution and requires energy as well as resources to run successfully, explains the article. Just these two latter usually account to most of the production costs (Goa et al., 2023). Extracting from hard rocks is not only more unsustainable, but it is told to be more expensive than brines, adds the article. There is also uncertainty to plan new lithium extraction projects due to insecurities of car manufacturers strategies on electric vehicle production, which then cause fluctuations in lithium price (Sullivan et al., 2025). In addition to this, there is concern that the environmental impact of hard rock extracting can be damaging if no regulations and monitoring is put into place (Kavanagh et al., 2018).

Lithium has many uses, it can be used in making glasses and ceramics, as well as it can be found in medicine, cleaning supplies and batteries (Kavanagh et al., 2018). Lithium batteries, were first used in smartphones and currently they are used in most portable electronic devices, explains the article. It could be stated that today most lithium extraction goes to lithium-ion batteries that are used in EVs (Kavanagh et al., 2018). Thus, lithium plays on important role in EVs, and its shortage could pose as a challenge for the whole industry (Mohammadi & Saif, 2023). Only a small percentage of lithium is being recycled, because currently there is not enough lithium waste for recycling to be economically reasonable (Kavanagh et al., 2018). However, lithium is described in the article to be easy to recycle due to its chemical properties. The article adds that there is a risk of lithium production being smaller than demand, which increases the need for majority of lithium to be recycled in the future. The importance of recycling becomes current especially when the cost of mining rises or when the quality of mineral drops, because the increased recycling would improve the elasticity of lithium supply (Sun et al., 2022). According to the article, around half of the lithium used is estimated to come from recycling in 2050. However, Bajolle et al. (2022), argues that even though recycling is important, the recycled material would not alone be able to meet the increasing demand, especially since there is a risk of availability of lithium. These availability concerns could also lead to decrease of quality of lithium (Bajolle et al., 2022).

The European Union is one of the top two consumers of lithium resources, while China is told to be in control of over half of the lithium production (Kavanagh et al., 2018). The reason for Chinese being in control, is that they are heavily invested in many lithium projects, they import lithium and even have their own lithium resources (Kavanagh et al., 2018). Due to many advantages of lithium, is it considered to an important metal economically, and is even considered to show such economic significance in the European Union to be considered a critical raw material there (Kavanagh et al., 2018; European Commission, 2025).

Before, lithium was not traded publicly, and long-term contracts were made between producers and buyers (Sun et al., 2022). However, today lithium price is more transparent and dynamic with spot pricing (Sun et al., 2022; Trading Economics, 2025a). However, Bajolle et al. (2022) argues that even though lithium is in spot markets, it is also traded privately, which according to them makes the price of lithium volatile and decreases its transparency. They believe that this makes lithium prices sensitive to different kinds of disruptions. The lithium market indeed has recently become more volatile, as can be seen from Figure 1, especially during the COVID-19 due to disruptions in supply chains especially because lithium supply is concentrated in just few regions (Sun et al., 2022). Sun et al. (2022) argue that long-term price of lithium is mostly determined by the availability of lithium, while the short-term price can be impacted, for example, by demand, supply and fossil fuel prices. During the last five years, lithium prices have been fluctuating tremendously, as can be seen from Figure 1 (Trading Economics, 2025a). According to the spot prices, there was a high peak during 2022 and a smaller one in the beginning of 2023, and since then the price has dropped down to almost what it was before the 2022 peaked happened (Trading Economics, 2025a).

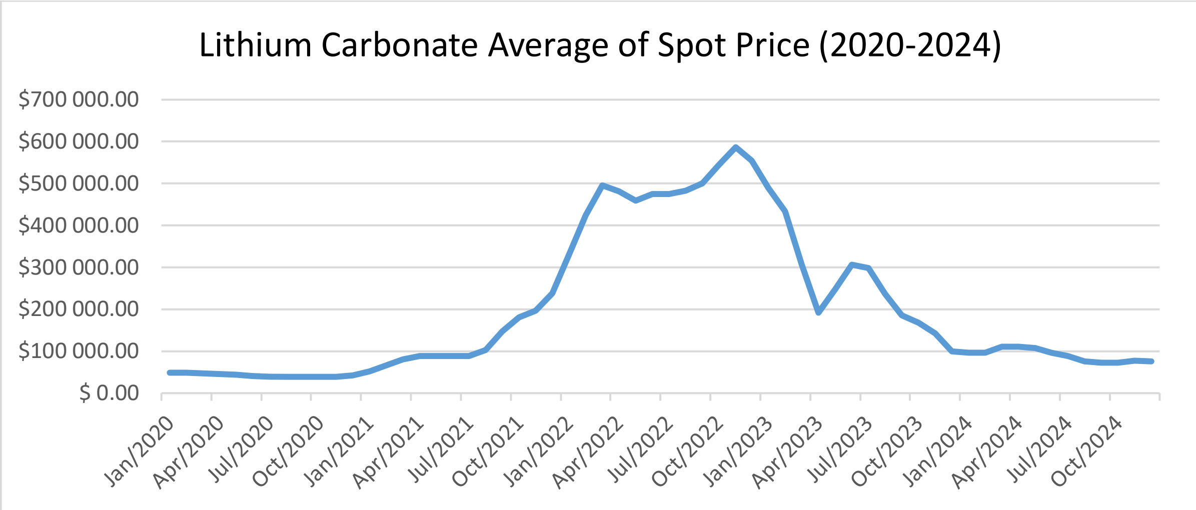

Figure 1 Lithium Carbonate Spot Price

Note. Data obtained from Trading Economics (2025a)

During the lithium carbonate price peak in 2022, the increased cost of lithium carbonate was passed along from suppliers all the way to consumers (Sun et al., 2022). The article elaborates that in that time, the price of EVs rose around 5% and some models were even discontinued. When product manufacturing becomes more efficient, it will together with raw material costs likely determine the price of EVs in the future (Bajolle et al., 2022). In the meantime, the strategies to reduce the impact of lithium price fluctuations on car manufacturers is that they could make changes to the battery, shift production to vehicles that require smaller batteries or delay the manufacturing processes (Sullivan et al., 2025).

2.2.2 Lithium-ion Batteries in Electric Vehicles

According to Mohammadi & Saif (2023), the EV battery market is a several billion-dollar market annually and the market size is expected to further increase. Lithium-ion batteries (LIBs) are one of the commonly used batteries in EVs and are considered to be one of the most important parts of the vehicle, explains the article. They’re popularity comes from their lower costs and high durability compared to other battery types

(Mohammadi & Saif, 2023). Also, it is good to mention that there currently is not a competitive alternative to lithium-ion batteries on the market (Sullivan et al., 2025). They way lithium-ion batteries work is that ions move from the negative to the positive electrode when used and move back when the battery is charging (Mohammadi & Saif, 2023). These batteries are the largest consumers of lithium, and the market is further increased by different emission targets, which EV can help happen (Kavanagh et al., 2018).

A recent study examined what kind of a dependency does electric vehicle prices have on the price of electric vehicles batteries (Sheldon & Dua, 2024). The results of the study concluded that the decrease of price in batteries does not decrease the price of vehicles at the same rate. It is implied in the article that vehicle manufacturers are keeping the vehicle prices higher even though the price of batteries is less than before. In other words, the difference between the battery cost and electric vehicle cost has increased, they are making more profit. It is said that this could lead to slower EV adoption (Sheldon & Dua, 2024). Currently the capacity increase of a battery per 1kWh is more than double the battery cost (Sheldon & Dua, 2024). As seen in the previous chapter, lithium carbonate had a price spike during 2022 (Trading Economics, 2025a), which then impacted the whole battery industry (Sheldon & Dua, 2024). This demonstrates the raw material prices, and their availability do impact lithium-ion battery prices, clarifies Sheldon & Dua (2024).

The high prices of EVs can partially be explained through manufacturers keeping higher prices to cover risks of unstable supply chains and cost volatility challenges of batteries and raw materials (Sheldon & Dua, 2024). The share of raw materials used in LIBs is subject to grow after improved technological innovations and thus would make the battery price more sensitive to raw material fluctuations (Sun et al., 2022). There is also a possibility in the future that the demand for lithium will overtake production, if recycling batteries does not increase (Kavanagh et al., 2018). The amount, for example, to manufacture a billion cars with a lower end battery size would take over a fourth of lithium reserves available (Kavanagh et al., 2018).

LIB has optimal temperatures it works in and anything higher can result to energy loss, and lower temperatures, on the other hand, lead to reduced battery life, which is something to consider when living in areas with either long periods of heat or cold (Lebrouhi et al., 2021; Kavanagh et al., 2018). LIB can also degrade due to overusing it and charging mainly on fast charging stations (IEA, 2025, p. 130). However, the degradation of the battery is carefully monitored to ensure its safe use, especially since in BEVs the battery is the sole source in how the vehicle can be operated (Lebrouhi et al., 2021).

The current state of the price of LIB is that their price has decreased due to increased competition, which has led to decrease in lithium prices (IEA, 2025, p. 136–139). According to the article, the price of lithium came down due to oversupply, which leads to bigger companies controlling lithium mining as smaller companies are pushed out. As the oversupply is expected to continue, lower prices could scare away investors, ultimately leading to lithium shortages (IEA, 2025, p. 136–139). Due to these lithium price fluctuations vehicle manufacturers need better strategies to reduce lithium price fluctuations, especially since over half of the world's lithium demand went to LIBs (Sullivan et al., 2025). It is told that smaller vehicles are more subject to battery costs changes than for example SUVs or luxury vehicles, because they have higher profit margins. On top of this, lithium mining is considered unstable due to only having a small number of companies dominating the supply chain in just a few locations geographically (IEA, 2025, p. 146; Sun et al., 2022). If an undersupply were to take place, only miners would benefit and the other sector of EVs would see raised prices (IEA, 2025, p. 137–146). Technological innovation on lithium extraction could prevent lithium undersupply and help in avoiding price spikes, informs the article. The typical life cycle of a LIB has been tested be around a decade, but it has the possibility to be increased up to two decades in the future (Sun et al., 2022; Lebrouhi et al., 2021). This improvement could decrease the need of lithium. However, in order to further grow the EV industry, the battery should be even lighter, cheaper and increase its capacity informs Mohammadi & Saif (2023). Because the battery is such a big part of EVs and their performance, car manufacturers are constantly trying to improve cost effectives, reliability and technology in batteries explains the article.

2.2.3 Law of Supply and Demand Between Lithium Carbonate and Electric Vehicles

Previously in the literature, it was established that there is a relationship between lithium demand and electric vehicle demand (Kavanagh et al., 2018). The relationship works both ways as increased adoption of EVs increases LIB demand, which then increases lithium demand, and vice versa (Sullivan et al, 2025). However, the focus of this research is on the impact of lithium carbonate price on electric vehicle sales. The law of supply and demand, as well as cost pass-through theory are provided to explain how lithium carbonate price fluctuations have an impact on electric vehicle sales.

In supply and demand theories, supply is explained to be represented by in this case vehicle manufacturers, while demand is the consumers (Buechner, 2018). When the cost of producing vehicles rise, the price of vehicles is also raised, while the demand of the vehicles tends to drop, which then leads to reduced sales, explains the article. Also, the theory explains that when a change in the price of the product, it changes demand, which then impacts production (Buechner, 2018). When applying the supply and demand theory to the study, it explains how increases in lithium carbonate prices would increase the production costs, which then leads to higher prices in electric vehicles. This increase in electric vehicle price, according to the theory, would decrease the demand of the vehicles, as shown in Figure 2.

Figure 2 Law of Supply and Demand

Note. Figure based on theory found in article written by Buechner (2018) and modified to fit this research

RBB Economics (2014), defines cost pass-through as how much the change in price is passed on to the final product. There are different kinds of cost pass-throughs, according to the article, such as full, partial and over. A full cost pass-through is when the production and product prices change the same amount, a partial cost pass-through when the raised production costs are only partially passed down to consumers, while over cost pass-through is when the cost of the product is more than the raised production costs (RBB Economics, 2014). It is told that the amount of cost pass-through is dependent on things such as the structure of the supply chain, competition, elasticity of demand and even between organizations there can be differences. The cost pass-through in some instances can be delayed, meaning that the increase in price would not show up instantly in the final product, it would take some time to see the impact (RBB Economics, 2014). To relate this theory to the research, the impact of lithium carbonate price fluctuations is dependent on how much manufacturers absorb the price. For example, Sun et al., (2022) discusses how during the span of two years, lithium carbonate spot price increased over 800%, but the average price of a lithium-ion battery increased only around 50% and the electric vehicle price increase was even less in percentage. On top of this, some types of EVs are overrepresented in their vehicle categories, meaning that they have no competition, and thus they have the availability to keep the prices the same even though production cost decrease (Sheldon & Dua, 2024). Also, when governments offer subsidies, the price of an EV is often kept higher on purpose, because subsidies create the illusion of vehicle affordability, explains the article. When these subsidies are taken away, or when the competition increases, the price of vehicles comes down to be able to keep on selling the vehicles (Sheldon & Dua, 2024). When material prices increase, some vehicle manufacturers have different strategies in place to absorb the price changes, such as producing vehicles with smaller batteries, thus needing less lithium carbonate (Sullivan et al., 2025).

2.3 Market Structure

Markets are divided into developing, emerging and developed (Bekaert et al., 2023). This chapter will focus on emerging and developed markets. Further along in the chapter, each market will introduce three countries to further explain the country's subsidies, GDP per capita, as well as taxing and different policies concerning EVs. The countries selected were from Europe, Asia and the Americas, as most EV users come from either China, the United States or Europe (IEA, 2025, p. 15–19). On top of this, geographical similarities between the markets were wanted.

Emerging countries are often described as low-income countries whose economy is growing rapidly, while also becoming more open to global markets than before (Kutaula et al., 2024). On top of this, it is a country that is making a transition from developing to developed markets (Kutaula et al., 2024). To differentiate markets from each other, many benchmark providers list GDP per capita as their main indicator (Bekaert et al., 2023). The article states that the average GDP per capita for developed markets is around $36,000, while the GDP per capita is much lower on average in emerging countries. On top of this, regulations, environmental factors and political risks are something that are looked at when making the classifications (Bekaert et al., 2023). Another difference mentioned in the article is that, developed markets tend to be more integrated, while emerging markets are more volatile to changes. For companies to enter emerging markets, there needs to be a suitable business environment, because on top of their weaker purchasing power, they have more technical and regulatory hurdles to get through to thrive in these types of markets (Meszaros et al., 2021). When comparing to developed markets, foreign companies only have few legal restrictions when operating in financial markets, whereas emerging countries have more restrictions (Bekaert et al., 2023). This lack of market integration also can be caused by different political risks or bad corporate governance, adds the article.

EV adoption often comes with cost related challenges and other practical matters, which is why governments need to help consumers and businesses with their adoption by, for example, providing subsidies, tax breaks, policies and different regulations favoring EVs (Meszaros et al., 2021). These practical matters, on the other hand, are EVs long charging times, lack of charging infrastructure, and shorter range compared to ICEV, clarifies the article. The lack of sufficient charging infrastructure can be due to poor supply and reliability of electricity (Meszaros et al., 2021). To minimize the impact of unreliable electricity, developed countries have been using sustainable energy options in their energy grid, like solar and wind power, to meet their increased electricity demands (Mohammadi & Saif, 2023). In short, EV adoption is influenced by several factors and can become costly, which could pose as a risk in countries with less purchasing power and financial resources (Meszaros et al., 2021).

In consumer behavior, ethics is considered important in both developed and emerging markets, however developed markets often look for it in luxury items, while in emerging countries, they look for it in in more affordable items (Kutaula et al., 2024). As price of products is one of the most important factor in emerging countries (Meszaros et al., 2021), EVs are often considered a luxury items (IEA, 2025, p. 10–14), which is why their social acceptance in these countries is important for market growth, explains Meszaros et al. (2021). However, as of 2024, emerging markets have increased their EV sales significantly (IEA, 2025, p. 10). The sales of EV have been growing in emerging countries, mostly due to Chinese EV imports, adds the article. On top of this, emerging countries have made improvements on affordability and policy incentives, which have also been a part of the growing market, tells IEA (2025, p. 10–20). These policy incentives, according to the article, have been things like, tax breaks, increasing fossil fuel prices, and other benefits for EV drivers.

2.3.1 Emerging Markets

As the main criteria to divide countries is GDP per capita, including criteria on regulations and market infrastructure (Bekaert et al., 2023; MSCI, 2025). The MSCI conducts market research and divides countries into to market groups, and according to them Hungary, China and Brazil are all considered emerging markets (MSCI, 2025), which are presented below. Each country's most important benefits for consumers EV adoption, such as subsidies, also GDP per capita, charging infrastructure, as well as taxing and other incentives concerning EVs are presented. These special exemptions given to EVs are believed to have longer lasting impact on EV purchase, and thus influence demand (Zhao et al., 2024). It is told that they are more tempting than any monetary benefit. On top of, the overall outlook of the country's EV status and other incentives are briefly introduced.

Brazil is the largest car market in Latin America (IEA, 2025, p. 10), and their main mode of transportation is with private vehicles, which increases the need to change vehicles to something more sustainable (Schvartz et al., 2024). Currently, there are incentives for businesses and people to purchase EVs, however, according to the article, fewer than in many countries. The cost of purchasing an EV in Brazil is still high, and purchasing one is considered a luxury, adds the article. During 2021, less than 2% of car sales were EVs (Schvartz et al., 2024) and in 2024 the percentage increased to 6% (IEA, 2025, p. 10), which shows slight improvement. The increase in vehicle sales was told to be due to car imports from China, as the cost of EVs dropped significantly after import started (IEA, 2025, p. 10). As the Brazilian government doesn't offer many incentives on purchasing an EV, it has believed to have slowed down their adoption (Schvartz et al., 2024). The potential for a bigger EV market is there, however, Brazil needs to increase their incentives, further lower the cost of EVs and create better infrastructure for them, argues the article.

China is one of the biggest EV manufacturers in the world, and around half of global electric vehicle sales happened there in 2024 (IEA, 2025, p. 10–17). Additionally, their EV industry is strong since every tenth car on the road there is an EV, enlightens the article. Zhao et al. (2024), explains that the reason China is a global leader in EV sales is because of their different government incentives and policies on EVs, as well as their willingness to reduce carbon dioxide emissions. Different incentives in China were put into place to increase market demand of EVs by decreasing the financial burden of purchasing an EV (Zhao et al., 2024). According to the article, some subsidies already stared in 2011. Even though there are restrictions on the number of vehicles a person can purchase in China, it is told that buying an EV is easier and cheaper (Zhao et al., 2024; IEA, 2025, p. 47–51). Most EVs in China are cheaper than their corresponding ICEV even before incentives, which is unlike in many other countries (IEA, 2025, p. 51).

Hungary is a part of the European Union, which provides different laws and legislations to its member states (European Council, 2025a). The European Union has a legislative called Fit for 55, which means that the target for all members is to make a 55% decrease on their greenhouse gas emissions by 2030, as well as to be climate-neutral by 2050 (European Council, 2025a). These kinds of legislations concern the transportation sector, adds the article. On top of this, EU started a project called Green eMotion to encourage its members to use more sustainable transportation options, like EVs, as wells as making plans on increasing charging infrastructure and in general creating common standards for all members that they can aim at to grow sustainable transportation in their countries (European Council, 2025b). For example, a regulation in 2023 stated that there needs to be a charging station available every 60km along main roads running in EU (European Council, 2025c). The European Union also supports car manufacturers operating in their member states by funding the development of environmentally friendly cars with the Green Car Initiative (European Council, 2025b). In addition to all this, a ban set to start in 2035, will prohibit EU member states in selling cars that emit carbon dioxide (European Council, 2025c).

A huge part of the Hungarian economy relies on their automotive industry and many manufacturers located there are making a transition to produce more EVs (Šebeňa et al., 2025). Hungary produces EV batteries, making them the fourth largest EV battery manufacturer (Šebeňa et al., 2025). It is also mentioned that they are one of EUs largest car producers, and around 90% of the vehicles manufactured in the country are exported to other countries. Many incentives and subsidies in Hungary concern company issued BEVs, for example they offer the company is exempt from paying corporate taxes when buying the vehicle and when installing charging stations to the workplace (European

Alternative Fuels Observatory, 2025a). Additionally, local companies are allowed to deduct half of value added tax on operating costs, like maintenance, related to BEVs, while foreign companies need to go through refund processes to see if they are eligible for value added tax benefits (European Alternative Fuels Observatory, 2025a).

Table 2 Emerging Countries

Country	GDP per capita	Incentive Type	Charging Infrastructure
Brazil	$13,301	• No Import tax (Until 2023) • Reduced import tax (2024) • Tax exemption/reduction on vehicle ownership tax (Current) • Tax exemption/reduction on state sales tax (Current) • Free parking (Current) • EV specific lanes (Current)	12,000 Charging public charging stations
China	$10,280	• Subsidy of $2,500 (2021) • Subsidy of $1,750 (2022) • No purchase tax (Current) • Free parking (Current) • Dedicated parking spaces (Current) • EV Specific lanes (Current)	12 million public charging stations
Hungary	$23,310	• No registration tax (Current) • No annual vehicle tax (Current) • Free parking (Current)	Charging station available every 60km along main roads

Note. Data adapted from IEA (2025, p. 23, 100–113), Rosa et al. (2023), Zhao et al. (2024), World Bank (2025a), European Council (2025c) and European Alternative Fuels Observatory (2025a). Currency conversions used 2024 average rates: BRL–USD, CNY–USD and EUR–USD (World Bank, 2025b)

The three countries presented earlier in this chapter, provide many incentives, either through companies, free parking, tax breaks or even subsidies. In Table 2 the most important benefits for consumers EV adoption are listed above. The focus is what a consumer benefits from purchasing and owning an EV in these countries, through subsidies, home charging incentives and tax incentives. As this research analyzes electric vehicle sales until 2024, the incentives on this chapter only list incentives that happened before 2024, or during. It has excluded subsidies or tax breaks that were applied after this time period as it is not relevant for this study. As noticed from Table 2, the most common incentives given are different kinds of tax reliefs. Just one country, China, provided subsidies to consumers at one point. All the emerging countries offer parking benefits, and Brazil and China even have specific lanes for EVs. It can be observed that Brazil has the weakest charging infrastructure of the three, just 10,000 public charging stations throughout the country. It can also be noticed that most incentives in the three countries are price-based incentives.

2.3.2 Developed Markets

Like emerging markets, MCSI also provides a list of developed markets (MSCI, 2025). According to them, Finland, Japan and the United States are all considered to have developed markets. They have higher GDP per capita and better purchasing power compared to emerging markets (Bekaert et al., 2023; Meszaros et al., 2021). Each of the three countries are presented, and this chapter will provide information on that country's GDP per capita, charging infrastructure, incentives as, as well as other benefits and challenges that comes to EV adoption in their country.

The use of EVs has risen in Finland, especially in the recent years (Autoalan Tiedotuskeskus, 2025). According to the statistics, at the end of last year over around 50% of the passenger cars were EVs. Like Hungary, Finland is also a member state of the European Union. The same laws, regulations and legislations coming from EU concern Finland as much as they do Hungary. However, as the target for carbon neutrality for EU is 2050, Finland is planning on achieving this goal by 2035 (State Treasury of Finland, 2021). This may have an impact on the adoption of electric cars. It is also told that Finland has made improvements on increasing sustainable electricity production recently. The contribution and innovation on improving EV in Finland is, for example, that a Finnish company called Virta is developing electric car charging stations that are connected to the power grid in order to help keep it balanced (Business Finland, 2024). On top of this, they hope to be able to bring EV battery manufacturing to Finland in the near future.

What it comes to cars in Japan, their objective is to have all new cars sold there to be electric vehicles by 2035 (Agency for Natural Resources and Energy, 2024). This, however, does not mean that they are fully electric, also hybrids are a part of this goal. In 2023, the combined amount of EVs sold, including HEVs, was 50%, which means that they are halfway in their target (Agency for Natural Resources and Energy, 2024). Their ultimate goal is having zero emissions by 2050 and currently automobile sector accounts for about 16% of the countries emissions (Agency for Natural Resources and Energy, 2024). Unlike other countries, Japan wants to focus on all kinds of EVs, because each one of them has their advantage and purpose (Agency for Natural Resources and Energy, 2024). The increased number of charging infrastructure built to meet the charging needs of EVS has raised the electricity demand in Japan, and to tackle this they are developing their energy grid and to invest in smart electric systems (Ministry of Economy, Trade and Industry, 2021). Compared to other developed markets, Japan is falling behind on EV adoption (IEA, 2024, p. 18). These challenges are most likely to be that Japanese prefer smaller and affordable cars, which is the reason why the EVs sold there are mostly smaller cars (IEA, 2024, p. 47). However, the article adds that these smaller vehicles are more expensive than ICEV, which could be a reason why ICEV are still more preferred.

The United States of America is considered to be one of the biggest EV manufacturers in the world (IEA, 2025, p. 87–96). The USA has a lot of incentives, regulations and laws surrounding EVs (U.S. Department of Energy, 2025, p. 1–10). However, EVs are more expensive than ICEV, which can could be the reason they are not widely adopted (IEA, 2025, p. 12). Also, as most charge their EVs at home, the US is encouraging consumers to build home chargers through different incentives (IEA, 2025, p. 86; U.S. Department of Energy, 2025, p. 1–10). The government offers subsidies to aid with research, manufacturing and development of EV related technologies, such as chargers, hardware or batteries (U.S. Department of Energy, 2025, p. 1–10). The government is committed to the transition to electric cars, as it has programs and funding for states to reduce traffic emissions (U.S. Department of Energy, 2025, p. 1–10). These include on giving out incentives to make school busses and public transportation switch to EVs. Even some airports are committed to change their ground vehicles to electric or hybrid vehicles with the help of different government programs (U.S. Department of Energy, 2025, p. 1–10). There are also state related benefits and regulations on top of what the government has issued (U.S. Department of Energy, 2025, p. 1–24). For example, California presented a regulation where all new cars, like passenger cars, SUVs and trucks, sold after 2035 must be zero-emission vehicles (U.S. Department of Energy, p. 10–23). This California regulation is like what the European Union and Japan have presented (Agency for Natural Resources and Energy, 2024; European Council, 2025c).

Table 3 lists below the most important benefits for consumers EV adoption. The focus in the table is what a consumer benefits from purchasing and owning an EV in these countries, through subsidies, home charging incentives and tax incentives. The incentives on this chapter only list incentives that happened before 2024, or during. Though many of the above countries are improving their charging infrastructure, USA has realized that most people charge their cars at home, and they want to encourage so it would not be an obstacle when deciding to purchase an EV (U.S. Department of Energy, 2025, p. 1–10; IEA, 2025, p. 86). It can be seen from Table 3, that they only have 200,000 publicly available charging stations, so it is important for them to provide incentives on building charging infrastructure to homes (IEA, 2025, p. 100).

Table 3 Developed Countries

Country	GDP per capita	Incentive Type	Charging Infrastructure
Finland	$53,188	• Subsidy of $1,850 (Until 2022) • No annual tax (Current) • Reduction in registration tax (Current) • Reduced parking fees (Current) • Incentive on home charging (Current)	12,000 charging stations, distance between them max 50km
Japan	$32,475	• Subsidy of $5,300 (Until 2023) • Subsidy of $5,600 (Current)	Goal is to install over 300,000 charging port by the end of 2030
USA	$85,809	• Tax reliefs (Current) • Incentive on home charging (Current) • EV Specific lanes (Current) • Exemption on road tolls (Current)	200 000 public charging points

Note. Data adapted from U.S. Department of Energy (2025, p. 1–24), Ministry of Economy, Trade and Industry (2023), World Bank (2025a), Agency for Natural Resources and Energy (2024), Traficom (2024) and European Alternative Fuels Observatory (2025b), IEA (2025, p. 100). Currency conversions used 2024 rates: EUR–USD and JPY–USD (World Bank, 2025b).

All developed countries mention above, provide many incentives to either company's or consumers. These incentives include things such as free parking, tax breaks or even subsidies. Also, it can be noticed that developed countries have more government regulatory and plans when it comes to EV adoption. The three countries in one shape or form, have carbon targets they want to achieve in the near future, and EVs are included in these plans to reduce carbon emissions.

2.3.3 Income Elasticity of Demand Between Emerging and Developed Markets

The law of supply and demand theory explains the relationship between raw material, lithium carbonate and its end-product, electric vehicles (Buechner, 2018). Cost pass-through, on the other hand provides an explanation on how the change of the raw material price passes onto the end-product (RBB Economics, 2014). Income elasticity of demand theory, i.e. Engel's Law, on the other hand, provides a theoretical base for explaining the differences between consumer purchase pattern, between the two markets, emerging and developed (Matsuyama, 2019; AlKathiri et al., 2024). Together these three theories help on understanding the impact of lithium carbonate prices fluctuations on electric vehicle sales, and how these markets, emerging and developed react to the price changes.

The theory provides an explanation on the differences in consumers spending pattern based on income and how sensitive they are to prices (Matsuyama, 2019). According to AlKathiri et al. (2024)., higher income countries, in this case developed countries, have a higher demand in luxury goods compared to lower income countries, emerging markets. Since emerging markets are going through a transition from developing to developed, their consumer patterns are changing (Kutaula et al., 2024), because when the consumer income grows, the demand for basic goods also increases (AlKathiri et al., 2024). When it comes to business and policy strategies, higher income countries focus more on innovation, efficiency and sustainability, while lower income countries strive for affordability and accessibility (AlKathiri et al., 2024). Developed countries attract more investment and innovation because their economies are focused in sectors where demand rises with income, innovation pays off more, as well as returns in technology and skills are higher compared to emerging countries (Matsuyama, 2019).

2.4 Summary of Theoretical Framework

The purpose of this research is to find out if the spot price of lithium carbonate has an impact on electric vehicle sales in different markets, emerging and developed, using statistical data analysis methods. With the three theories provided earlier in this chapter, law of supply and demand, cost pass-through theory and income elasticity of demand theory, the relationship between lithium carbonate price and electric vehicle sales can be explained, as well as the differences in consumer purchase patter and price sensitivity between emerging and developed markets. The hypotheses provided below are based on previous literature and theories, and the assumptions gathered from it. It will be used to perform the statistical analysis later in the study.

Figure 3 provides a visual overview on the conceptual framework of the study. It illustrates the relationship between lithium carbonate and electric vehicle sales through law of supply and demand. According to that theory, increases in lithium carbonate prices would increase the production costs, which then leads to higher prices in electric vehicles, ultimately leading to decrease in electric vehicle demand (Buechner, 2018). The distinction between emerging and developed markets, is there to illustrate the income elasticity of demand theory. This theory explains the differences of consumer purchases pattern between emerging and developed markets and draws a difference between how they react to price changes. (Matsuyama, 2019; AlKathiri et al., 2024). Also, incentives, such as taxes and subsidies impact the number of cost pass-through passed through in the supply chain, which is why the outcome of incentives is taken into consideration (RBB Economics, 2014; Sheldon & Dua, 2024).

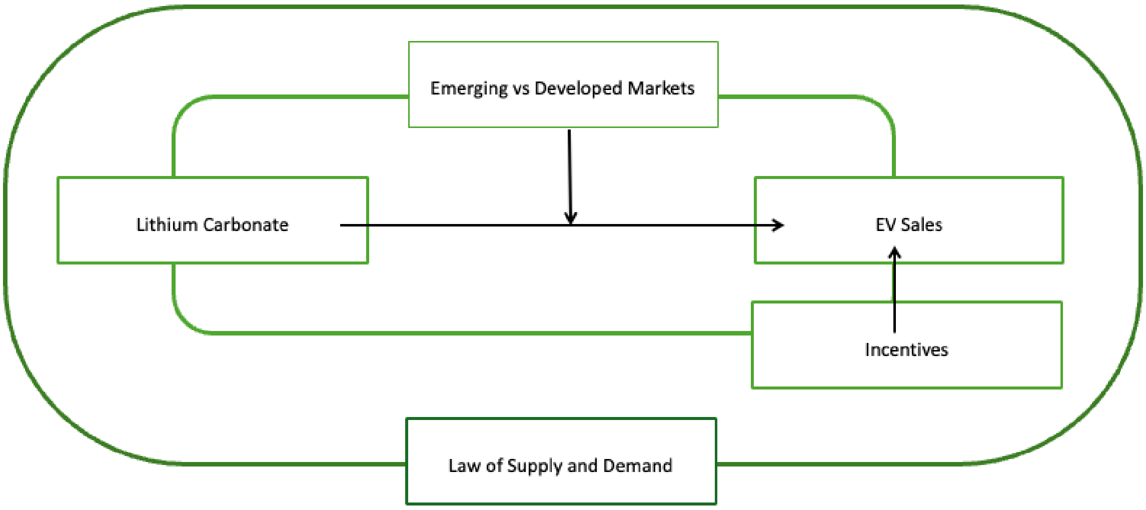

Figure 3 Conceptual Framework

Firstly, to test the significance of the differences in market groups in EV sales a comparative analysis is performed (Wall Emerson, 2023). As learned from the literature, it is known that lithium price impacts EV sales (Kavanagh et al., 2018). However, some literature argue that their correlation is only short term (Sun et al., 2022), which is why the relationship between EV sales and lithium carbonate price will be examined using a correlation analysis (Gogtay & Thatte, 2017). To test this, a hypothesis in made and illustrated in Table 4. For the regression analysis, a hypothesis is set to test the relationship between lithium carbonate prices and electric vehicle sales using incentives as a control variable and GDP per capita as the moderator variable (Aguinis & Gottfredson, 2010). The hypotheses for comparative, correlation and regression analysis are presented below in Table 4.

Table 4 Hypotheses

Hypothesis	**Description**
H0a: There is no difference between the market groups, emerging and developed markets **H1a:** There is a difference between the market groups, emerging and developed markets	A comparative analysis to test out whether there is a difference between the market groups, emerging and developed markets in EV sales
H0b: There is no relationship between lithium carbonate price and EV sales **H1b:** There is a relationship between lithium carbonate price and EV sales.	A correlation analysis will be performed, it will include all EV sales and lithium price during the study period to establish their relationship
H0c: Lithium carbonate price has no relationship with EV sales, controlling for incentives, and this relationship is moderated by GDP per capita. **H1c:** Lithium carbonate price has a relationship with EV sales, controlling for incentives, and this relationship is moderated by GDP per capita.	Moderated multiple regression analysis to test the impact of variables, such as GDP per capita and incentives, on EV sales and lithium carbonate price. The GDP per capita act as the moderator, incentives are control variables.

All above mentioned hypotheses will aid in answering the research question and reaching the objectives. In later chapters, the data analysis methods will be explained more in depth and provide reasoning for why they were chosen. All hypotheses will be tested, and their p-value will be compared against the chosen significance level to see the strength of the relationship between the variables (Aguinis & Gottfredson, 2010). If the null hypothesis can be rejected, this indicates a relationship, explains the article.

3 Empirical Study

Data and methodology are discussed in this part of the research and idea of this chapter is to provide insight on what data is processed and the methods used to analyze the data. Firstly, the research design of the thesis is introduced and the reasoning behind the approaches used in the research, such a quantitative method. This is followed by providing data sources and variables. This section talks about the source of data, timeframe, variables and challenges during data collection. After, all data analysis methods used are presented, and given reason to their use. Finally, this chapter concludes with considering of the reliability and validity of the data and study.

3.1 Research Design

The research Onion Model (Gamage, 2025) is used to explain the research design that is used to guide the thesis. The objective of this chapter is to justify the different strategies and approaches used, such as the choice of quantitative method, as well as the strategy of data collection and analysis methods.

The designing of a research starts with determining the research philosophy (Gamage, 2025). To choose the correct philosophy or paradigm as the article says, depends on the goals of the research. The decision is based on whether the goal is to be objective or subjective, and what kind of understanding is wanted to gain from the research (Gamage, 2025). The next decision is to choose if the study is based on a theory or whether the goal is to create a theory. After, the appropriate methodology for the research is chosen, and the options are qualitative, quantitative or a mix of these research (Gamage, 2025). A qualitative method uses non-numerical data and centers around experiences, while a quantitative data is focused on numerical data in order to generalize results (Lim, 2024). A mixed method, on the other hand, is the combination of these two (Gamage, 2025). This decision determines the strategy of the research, adds the article.

As the purpose of this study is to find out how the price of lithium carbonate has an impact on EV sales in different markets, emerging and developed markets, by comparing three countries per market, while also taking into consideration the GDP per capita and EV related incentives of each country. In other words, the overall objective of this study is to find patters in social phenomena to be able to generalize results, as well as to discover relationships between the measurable variables (Lim, 2024), guiding the philosophy of the research towards positivism (Gamage, 2025). To reach this goal, a deductive approach is used, which starts with an observation and data collection, while utilizing different theories, in this case law of supply and demand, cost pass-through and income elasticity of demand, to form hypotheses around them (Gamage, 2025). Then these hypotheses are tested to either verify or deny them, explains the article.

When deciding between quantitative and qualitative approaches, this study opted for the quantitative method, since it helps to understand different social trends through numerical data (Lim, 2024). The data is naturally occurring data, meaning that the different variables in the study are not controlled, making this also a non-experimental study (Gamage, 2025). This makes the data collection of the research observational, explains the article. According to Lim (2024), data collected for this research is done using a cross-sectional design, as it is collected at once. However, as data is historical, tracked for a longer period in time, 2021–2024, the data represents a longitudinal design (Lim, 2024). The data in this research is collected from publicly available secondary data, which means that existing data will be obtained and measured using different statistical analysis methods to answer find answers for the hypothesis and thus answer the research question (Lim, 2024).

This research uses descriptive and diagnostic analysis, because they investigate trends, compare the markets and investigate how fluctuations in raw material prices are related to sales of the final product. A descriptive analysis summarizes trends and uses descriptive statistics to highlight differences in the data (Lim, 2024). A diagnostic analysis, according to the article, is used because it uses correlation analyses to explain relationships between the variables (Lim, 2024). A computer software, SPSS, and Microsoft Excel will aid to analyze the data and investigate how fluctuations in raw material prices are associated with sales of the final product in different markets, as well as provide results in a format that makes them easier to be compared to one another.

3.2 Data Sources and Variables

This thesis uses monthly EV sales data from six different countries, Hungary, China, Brazil, Finland, Japan and the US, from 2021 to 2024. For Hungary the sales data is obtained from ACEA (2025) (see Appendix 1.) and cross-checked with the yearly sales provided by the European Union (Eurostat, 2025). The same is done for the Chinese data, so it is gathered from Trading Economics (2025b), and cross-checked with the Chinese National Association of Autombiles (CAAM, 2023). This was done to minimize the language barrier, as the CAAM data is in Chinese. For Brazil, all data obtained is through the National Association of Brazilian Automotive Distributors (Fenabrave, 2025). This data is also in their native language and Google Translate will be used to translate it to English. The information of monthly sales in Finland is obtained also from a website run by the national automotive association (Autoalan Tiedotuskeskus, 2025). Additionally, the Japanese EV sales data is gathered from a national automotive association website (JADA, 2025). The reports are in Japanese and Google Translate is used to translate them to English. However, the data of EV sales in the US is gathered from a government website (Argonne National Laboratory, 2025). All data, excluding Finnish and Chinese EV monthly sales data, were not downloadable as an Excel format, thus the numbers need to be written cell by cell to Excel, where it is later transferred to SPSS. This can lead to typos and impact the data. To minimize errors, the numbers were cross-checked by another individual.

The EV sales consist of passenger BEVs, HEVs and PHEVs, and excludes light- and heavyweight vehicles (IEA, 2025, p. 57–81), which are essentially scooters and trucks from two different markets, with three different countries selected from each market group. The data includes monthly sales of each vehicle type. However, for Hungary during 2021, the original dataset provided quarterly observations of EV sales, and to ensure consistency with monthly indicators, the quarterly data was converted into monthly data. To do this, monthly data of all fuel types was imported from ACEA (2025) (see Appendix 1.), from here the to fit the data into monthly data, the monthly data of all new registered vehicles (not categorized by fuel type) is obtained and the monthly share of quarterly passenger vehicle sales is calculated. This approach assumes that monthly variation in EV sales follows approximately a similar pattern with new registered vehicle sales. For example, in Q1 of 2021 EV Sales were 14,392 and total sales of vehicles proportion in January was 27.5%, 33.8% in February and 38.6% in March of total Q1 sales. EV sales per month would then be calculated as follows:

$$January\ EV\ Sales = 14{,}392 \cdot 27.5\%$$
$$February\ EV\ Sales = 14{,}392 \cdot 33.8\%$$
$$March\ EV\ Sales = 14{,}392 \cdot 38.6\%$$

Equation 1 EV Sales per Month Example Calculation

The countries were chosen due to their geographical locations, as wanted one emerging and one developed country from the same region. To which market group a country belongs to is based on the list provided by MSCI (2025). Both Hungary and Finland are in Europe, Japan and China in Asia, while USA and Brazil are from the Americas, though one is from North and the other from South. Emerging and developed countries differ in consumer behavior and purchase power, and thus capture difference in EV sales between lower- and higher income economies (Meszaros et al., 2021). All countries selected have consistent EV Sales data, which ensures statistical comparability across different months. Also, only few emerging countries had monthly data available of the EV sale volumes, so the options to choose from where somewhat limited. To statistically justify the reason emerging and developed markets are used in the study statistical testing will take place. Either an independent t-test or Mann-Whitney U test is conducted to confirm that there is a significant difference between the markets in EV sales. The choice of test depends on distribution of data (Wall Emerson, 2023). These statistical tests are introduced under chapter 3.3.2 Comparative Analysis.

Using the same timeframe lithium carbonate monthly prices are obtained from Trading Economics (2025a). Here, the closing prices are used to calculate the average monthly price of lithium carbonate. This is done using Microsoft Excel Version 16.95.4 (25040241). The information is provided in dollars and does not need to be modified to another currency, because US dollars is used as the currency in this study. The reason it is lithium carbonate and not lithium is because the former material is used in EV batteries (Kavanagh et al., 2018). It is one of the main components of the battery, as previously mentioned, and thus is better to compare to EV sale volumes to see their correlation. On top of this, each of the selected country's GDP per capita data will be collected from the World Bank (2025a). World bank provides the GDP per capita data in dollars and the values do not need to be modified to another currency. The source (World Bank 2025a) provides GDP per capita data annually and thus the assumption is made that throughout the year the GDP per capita stayed consistent in that country. The corresponding year will be used for all countries, so for example, 2021 data for all EVs sold during that year, and so on. Since GPD per capita is used to differentiate markets from each other, it is a valid variable (Bekaert et al., 2023). Another variable that will be focused on is the incentives each country provides, and the focus will be on the demand side of the incentives, like tax incentives, subsidies and home charging, as these have the most direct impact on EV sales (Meszaros et al., 2021). These three different incentives are all dummy variables, either the country has the incentive, or it does not (0=No and 1 = Yes). The incentives are based on the data provided previously in Table 2 and Table 3. All data used in this thesis are publicly accessible secondary data. To note, lithium carbonate price (Trading Economics, 2025a) can be viewed publicly, but the data can be downloaded for a small fee.

As the objective is of this research is to see what kind of an impact lithium carbonate price has an EV sales in different markets, the primary variables are EV sales of country and lithium carbonate price. In this scenario, EV sales are the dependent variable, while lithium carbonate price is the independent variable. On top of this, GPD per capita, and incentives are something that are taken into consideration. GDP per capita will be a moderator variable, and subsidy, tax incentives, as well as home charging will all be control variables. The variable used are presented in Table 5.

Table 5 Variables

Variable	**Type**
EV Sales	Dependent variable
Lithium Carbonate Price	Independent variable
Tax Incentives	Control variable
Subsidy	Control Variable
Home Charging Incentives	Control Variable
GDP per capita	Moderator variable

The data period, 2021–2024, was chosen due to the fact that lithium carbonate had variability in its price during this time (Trading Economics, 2025a). The year 2020 is left out due to the COVID-19 pandemic, as it disrupted many supply chains, like the EV, and thus could impact the data (Sun et al., 2022). Something that also impacted the selection of the timeframe was the availability of data. Especially the monthly data from emerging countries was challenging to obtain. It is noteworthy to mention that many developed countries do not have a long history of collecting monthly sales data of EVs either, for example Japan started collecting monthly data from 2021 onward (JADA, 2025).

3.3 Data Analysis Methods

Several statistical data analysis methods will be used in this research. The raw data will be brought from Microsoft Excel Version 16.95.4 (25040241) and imported to IBM SPSS Statistics version 31.0.1.0 (49), where the analyzation of data will take place. Also, some graphs can be performed using Microsoft Excel. First, a descriptive analysis will be done to provide a simple understanding of the data, then a correlation analysis will take place to give raw association of variables, followed by a comparative analysis to compare the markets with each other. Finally, a regression analysis, which is the core analysis of this research. This analysis studies the dependency of GDP per capita and incentives, along with lithium carbonate price, to EV sales.

3.3.1 Descriptive Analysis

Descriptive analysis provides simple summaries of observations in the data given (Mishra et al., 2019). It will include summary statistics, different visualizations of the data, and comparison of the market groups. These summary statistics are, for example, mean and median, and give information on the distribution in data (Mishra et al., 2019). With these values, the distribution of the market groups can be evaluated, which will also help with other statistical analysis (Mishra et al., 2019). On top of this, how much variation is in the data is calculated, so how spread out the values are compared to mean (Mishra et al., 2019). Descriptive analysis examines the normal distribution of the variables, because correlation, comparison, and regression tests make assumptions of normality, according to the article. The distribution impacts on what analysis method is used or if the data needs to be transformed to fit normality (Gogtay & Thatte, 2017; Wall Emerson, 2023). These are further clarified under each analysis method. Also, a table of incentive frequencies is presented to demonstrate the occurrences of them. All this will provide information on what the data looks like, how these markets differ, and the possible relationships.

To test normality, either numerical or visual methods can be used (Mishra et al., 2019). According to the article, if a sample size is larger than 100, violating normality is not a raise for concern, which just means that the mean does not truly represent the data set. The summary of descriptive analysis provides a table listing the skewness and kurtosis of the data (Mishra et al., 2019). With skewness, it can measure the symmetry of data, and thus indicate if the distribution of the data is normal or not, and a result of zero would illustrate perfect symmetry (Mishra et al, 2019). Kurtosis, on the other hand, is used to measure the distribution of the data, explains the article. The result of zero in kurtosis indicates that the data is symmetrical on both sides from the center (Mishra et al., 2019). However, if either the kurtosis or skewness, is between -1 and +1, the data is approximately normal, according to the article. For a sample size smaller than 300, a histogram has the ability to illustrate the normality of data (Mishra et al., 2019). It is told that if the shape of the histogram resembles a bell, meaning that it is symmetrical on both sides from the center point, the data can be assumed to be normally distributed. The descriptive statistics is done using SPSS on the continuous variables, EV sales, lithium carbonate price and GDP per capita. If with either skewness or kurtosis the normality of data is unable to be interpreted, a histogram will be used to illustrate the data. This is sufficient as the sample size as less than 300 (Mishra et al., 2019). The incentives, subsidies, taxes and home charging, are presented in a frequency table, as well as a dual axis scatter plot, both using SPS. The frequencies in SPSS are located in the analyze section under descriptive statistics and all three incentives were placed under variable(s). To further get an understanding of three incentives and their relation to GDP per capita and EV sales, a dual axis with scale x axis is chosen in SPSS. In chart builder, both EV sales and GDP per capita are placed on the y-axis, while the incentive, subsidy, tax or home charging, is placed on the x-axis.

3.3.2 Comparative Analysis

The comparative analysis is used to compare the general differences in the markets without GPD per capita and incentives. The analysis method is based on a normality test, and if it were to fail, a Mann-Whitney U test will be done (Wall Emerson, 2023). This is due to the fact that those test are calculated based on means, and if the means do not represent the typical value of the dataset a nonparametric tests (Mann-Whitney U test) are conducted, because they are not depended on the means (Wall Emerson, 2023). However, if the data is normally distributed an independent t-test is done (Wall Emerson, 2023). The results of either test are compared to the hypothesis made in Table 4. Based on the literature (Wall Emerson, 2023) the equation for the independent t-test is:

$$t = \frac{\overline{x_1 - x_2}}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Equation 2 Independent t-test

where: $\overline{x_1, x_2}$= sample means, n_1 = sample size of emerging markets, n_2 = sample size of developed markets, s_p = pooled standard deviation

Whereas the equation for Mann-Whitney U test according to Wall Emerson (2023) is:

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} R_2$$

Equation 3 Mann-Whitney U test

where: n_1 = sample size of emerging markets, n_2 = sample size of developed markets, R_1 = Sum of ranks for emerging markets, R_2 = Sum of ranks for developed markets

The results in descriptive statistics will provide an answer to the normality of the data (Mishra et al., 2019). Both independent t-test and Mann-Whitney U test can be found in SPSS. Independent t-test is located in "Compare Means and Proportions". Place EV Sales on the Test variable(s) and grouping variable should be market groups. The confidence interval is not changed, thus stays at 95%. For the Mann-Whitney U test, in SPSS locate non-parametric test in analysis section and select independent samples. From here customize analysis is selected in the objectives, in fields EV Sales is the test field and market belongs in groups. The setting should be put to Mann-Whitney U (2 samples). The results provide the significance of the test, as well as frequency of the mean rank in markets compared to EV Sales in a graph format.

The independent t-test compares these market groups using means and standard deviations, and Mann-Whitney U test calculates the differences using ranks of scores

(Wall Emerson, 2023). Either results provide results that are compared to the significance level and thus decided if they are statistically significant or not, adds the article. If the chosen p-value is <0.05, the null (H0a) hypothesis can be rejected, which indicates a difference between emerging and developed markets, and if it is >0.05, the null hypothesis is accepted, which means that there is no difference between emerging and developed markets in their EV sales.

3.3.3 Correlation Analysis

Before applying the correlation analysis in SPSS, a scatter plot graph is used to evaluate the correlation between the variables, lithium carbonate price and electric vehicle sales. When applying the scatter plot graph to the variables in Microsoft Excel, a least square line can be added to the graph. The graph is analyzed by looking at the data points if they are close to the line. If they are, there is a strong linear relationship between them, and the further the data points are from the line, the less the variables have a linear relationship between them (Gogtay & Thatte, 2017). Also, the direction of least square line indicates either a positive, if pointing up, or negative if pointing down, relationship between the variables, adds the article. The R^2 on the scatter plot graph explains the variability of the variables (Gogtay & Thatte, 2017).

With the help of a correlation analysis, the strength of the relationship between the variables can be determined (Gogtay & Thatte, 2017). The analysis provides numbers from -1 to 1, indicating the correlation of the variables, adds the article. Negative number means a negative correlation, zero means that there is no correlation, while the positive number indicates a positive correlation (Gogtay & Thatte, 2017). The closer the correlation number is to either -1 or 1, there is a strong correlation, and if the number is closer to zero, the correlation is weak (Gogtay & Thatte, 2017). Depending on if the variables, lithium carbonate price and EV sales, if they are variables are normally distributed a Pearson correlation analysis is done, and if not, Spearman's rank correlation analysis will be performed (Gogtay & Thatte, 2017). As mentioned previously, the results in descriptive statistics will provide an answer to the normality of the data. These test can be done using SPSS. In SPSS, bivariate correlation analysis method is chosen, and depending on the normality, either Pearson correlation or Spearman's rank analysis is performed. Variables EV sales and lithium carbonate price are selected as the variables and two-tailed is selected as the test of significance. The assumption of 95% confidence interval is not changed. From the table, the p-value is test against the significance level of 0.05. If the p-value <0.05, the null (H0b) hypothesis can be rejected, indicating a relationship, and if it is >0.05, the null (H0b) hypothesis is accepted. The Pearson Correlation equation is the following (Mukaka, 2012):

$$r = \frac{\sum_{i=1}^{n}(x_i - x) \cdot (y_i - y)}{\sqrt{(\sum_{i=1}^{n}(x_i - \bar{x})^2) \cdot (\sum_{i=1}^{n}(y_i - \bar{y})^2)}}$$

Equation 4 Pearson Correlation Analysis

Where: x = EV sales and y = lithium carbonate price

Whereas the equation for a Spearman's Rank Correlation Analysis is the following (Mukaka, 2012):

$$r_s = 1 - \frac{6\ \sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}$$

Equation 5 Spearman's Rank Correlation Analysis

Where: d = difference in ranks between EV sales and lithium carbonate price, n = number of pairs

The correlation analysis is done to see the strength of the relationships between the variables in the study, but it does not provide causality (Gogtay & Thatte, 2017). This means that it does not provide information on if lithium carbonate price does in fact cause a change in EV sales volumes, it provides their association with one another. Finally, the results of the correlation analysis are compared to the hypothesis made in the previous chapter, Table 4. To further visualize the data, in SPSS using chart builder and selecting dual axes with categorical X axis. In this graph, the means of EV sales and lithium carbonate price are placed on the y-axis, and x-axis includes the monthly dates from 2021–2024. The price of lithium carbonate is illustrated as bars, and EV sales, on the other hand, is a line graph.

3.3.4 Regression Analysis

Regression analysis is the core statistical analysis method used in this study. The analysis method is used to describe the relationship between variables (Gogtay et al., 2017). The independent variable in the analysis method is something that is not impacted by other variables, while the dependent variable is the one that changes in response to the independent variable, adds the article. In this study the independent variable is lithium carbonate price, while the dependent variable is EV sales. The reason lithium carbonate price is an independent variable, is that it is expected to stay unchanged when other variables change (Gogtay et al., 2017).

A multiple regression analysis is performed when the dependent variable is continuous, and the research has more than one independent variable (Gogtay et al., 2017). As this analysis methods requires for the independent and dependent variables to have a linear relationship and if during earlier analysis methods it has been found that they are not, the data will be transformed to fit normal distribution (Gogtay et al., 2017; Lee, 2020). To transform the data, a box-cox method will be used. This method spreads the residuals to make them more constant and the results can be used to evaluate the linear regression model of the data (Lee, 2020). To calculate the box-cox, the following equation found in Lee (2020) is used:

$$y_i^\lambda = \frac{\left(y_i^\lambda - 1\right)}{\lambda}, when\ \lambda \neq 0 \qquad y_i^\lambda = \log y_i, when\ \lambda = 0$$

Equation 6 Box-Cox

Where: y_i = data points, λ = used to perform non-linear transformation of data

In SPSS, the perform a box-cox on a value, firstly find the mean and standard deviation from descriptive statistics, then transform the variables by rank cases. Finally compute the variables by selecting inverse DF as the function group and the Idf.Normal as the functions and specials variables. This provides an equation were the previously made rank cases are placed, along with the mean and standard deviation of the original value. To present that the variable is normally distributed after the box-cox transformation, descriptive statistics, from frequencies select Histogram with normal curve on Charts selection.

Because the dependency of GDP per capita is used as a moderator variable, a moderated regression model needs to be used. A moderator variable can strengthen or weaken, or even change the direction of the relationship with variables, and thus tells if the independent and dependent variable are reliant on the moderator (Aguinis & Gottfredson, 2010). The control variables, subsidy, tax incentives and home charging incentives, are added to the analysis, because they are told to be impact the purchase of EVs, and it is argued that non-monetary incentives are stronger than for example, subsidies in the long run (Zhao et al., 2024). The moderated multiple regression analysis equation found in the article (Aguinis & Gottfredson, 2010) is modified to this research as follows:

$$\begin{aligned} EV\ Sales = \beta_0 + \beta_1 \cdot Lithium\ Carbonate\ Price + \beta_2 \cdot GDP\ per\ capita \\ + \beta_3 (GDP\ per\ capita \cdot Lithium\ Carbonate\ Price) + \beta_4 \cdot Subsidy \\ + \beta_5 \cdot Tax\ Incentives + \beta_6 \cdot Home\ Charging + \in \end{aligned}$$

Equation 7 Moderated Multiple Regression Analysis

Where: β_0= Least square of intercept, β_1 = Least square of lithium carbonate, β_2 = Least square of GDP per capita, β_3 = Least square of lithium carbonate and GDP per capita, β_4 = Least square of subsidies, β_5 = Least square of tax incentives, β_6 = Least square of home charging, $\in$ = estimated residual

A moderated multiple linear regression analysis will be performed, with the above equation (Equation 7), because on top of EV sales and lithium carbonate price, the dependency of GDP per capita and incentives are also compared to EV sales. In SPSS, this correlation analysis can be performed using linear regression analysis. Before this, a moderated variable is created, multiplying lithium carbonate and GDP per capita together. For the linear regression in SPSS, place EV Sales on dependent, and lithium carbonate price, GDP per capita, subsidy, tax incentives and home charging incentives on where it says block. From here go to block 2 and add the moderated variable. The confidence interval is not changed, thus stays at 95%, and estimates are added in statistics. Model summary table and coefficients table are the outputs that will be focused on (Laerd Statistics, 2018).

In the model summary, there are two models and the looking at Model 2 and their R^2 change value, it tells how the moderated variable increases the variation compared to the Model 1 (Laerd Statistics, 2018). The first model will be the one without the moderated variable, while the second one includes it, adds the article. The Sig.F Change in the model summary table from the latter model suggest the significance of the moderated variable (Laerd Statistics, 2018). The p-value of the results of the regression analysis are compared to the significance level of 0.05. If the p-value is <0.05, the null (H0c) hypothesis can be rejected, indicating a moderated relationship with EV sales and lithium carbonate price, and if it is >0.05, the null (H0c) hypothesis is accepted, which means that GDP per capita is not a moderator variable in the relationship between lithium carbonate price and EV sales. The hypothesis for the regression analysis can be found in Table 4. In the coefficients table, all the variables in the second model can be compared to the dependent variable, EV Sales (Laerd Statistics, 2018). It is told that the unstandardized beta suggests what happens when the dependent variable raises to that specific variable, a negative sign would indicate that the variable decreases when EV sales go up by one unit (van den Berg, 2025). This table also includes the significance of each variable (Laerd Statistics, 2018). Here again, the p-value of the results is compared to the significance level of 0.05.

3.4 Reliability and Validity

Quantitative research focuses on measuring numerical data, and studies social trends without bias (Lim, 2024). It stays objective and impartial by testing ideas in a structured manner and producing data that can be generalized (Lim, 2024). Also, the results of a mathematical model are not flexible in interpreting them, which then increases the likelihood that another researcher can reproduce and validate the results (Lim, 2024). This itself increases the reliability and validity of the thesis. Thoughtful decision making throughout the research increases its rigorous, however this research made slight changes after the initial thesis proposal (Lim, 2024). Several statistical methods are used to test the correlation and relationships of the variables, which has a positive impact on the reliability and validity of this research. With hypotheses testing, theories can either be confirmed or rejected, proving a rigorous framework for the research (Lim, 2024).

Having limited understanding of the results can lead to missing of details and less in-depth analysis and explanation when making conclusions (Lim, 2024). This decreases the validity of the research (Lim, 2024). As using peer reviewed articles, this research has assumed the validity of their findings, which can decrease the reliability of conclusions made. Also, having a good sample size, collecting data accurately and analyzing it carefully are all important aspects when evaluating the reliability of a research (Lim, 2024). In this research, there was limitations on the availability of emerging EV sales monthly data, and due to the fact, the sample was restricted to those countries where reliable data could be obtained. Thes selection of developed countries was based of the emerging country data by selecting countries with close geographical proximity. This created selection bias on the data as the country choices were driven by data availability rather than on research design (Lim, 2024). Also, Finland was chosen due to its geographical locations, but also for personal reasons, which could be stated as convenient sampling of data (Lim, 2024). Also, the number of countries selected per market could expose the research to quota sampling and thus increase bias (Lim, 2024). Data collection, however, has been done from reliable sources, such as national automotive associations. Although, data is obtained from reliable sources, most of the data was in the country’s native language. This means that a translator, Google Translate, needed to be used to understand and find correct data from reports. The lack of monthly data in Hungary during 2021 decreases the reliability and validity of the data and an assumption that monthly variation in EV sales follows approximately a similar pattern as do all new registered vehicle sales was made. Also, since the use of AI is encouraged in the University of Vaasa (University of Vaasa, 2023), this study applied ChatGPT (OpenAI, 2025) to assist with brainstorming ideas, finding relevant literature to the research, and clarifying more complex ideas. All content provided by AI are reviewed and verified in this research.

4 Results

Results are gathered in this chapter. First, to get a basic understanding of the variables, the result of a descriptive analysis is presented. After, the result of a comparative analysis is illustrated to understand the if lithium carbonate prices are able to predict EV sales. This is followed by a correlation analysis that is performed between lithium carbonate prices and electric vehicles sales to establish the relationship between them. Finally, the main analysis of this research, the multiple regression analysis is done to test the hypotheses.

4.1 Descriptive Analysis

This chapter provides a summary of basic statistics of the data used in this study, as well as frequencies of key variables. There are 288 observations, and in descriptive statistics, EV sales, lithium carbonate price, GDP per capita and subsidies are looked at more closely. Their normality is also analyzed based on skewness and kurtosis, excluding subsidy variable, which can be explained by the high frequency of countries not providing them (Mishra et al., 2019), this is shown in Table 6. If neither skewness nor kurtosis can fully determine the normality, a histogram is used to interpret normality.

Shown in Table 6, the monthly electric vehicle sales ranged from 1,308 units to 1,596,000 units and the mean number of passenger vehicles sold is 148,832 per month in the six countries analyzed. Some of the countries, such as USA and China, are one of the biggest EV manufacturers, which makes their sales substantially larger than compared to Brazil or Finland, for example (IEA, 2025, p. 15–19). The price of lithium carbonate had a range of \$52,310–\$587,773. This suggests that the price has been fluctuating in the past years. The mean for lithium carbonate price is \$237,858. Since this research consists of emerging and developed markets, the GDP per capita varied from \$7,973 to \$85,810. Brazil had the lowest GDP per capita recorded in this research, while the United States had the highest (World Bank, 2025a). The mean for GDP per capita is \$35,008. The standard deviation (Std. Deviation) in Table 6, shows how spread out the values are from the mean (Mishra et al., 2019). For all, electric vehicle sales, lithium carbonate price, and GDP per capita, the standard deviation shows that all these values have a lot of variation.

Table 6 Summary of Descriptive Statistics

Descriptive Statistics									
	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
EV Sales	288	1 308,00	1 596 000,00	148 832,33	254 673,93	3,09	0,14	11,41	0,29
Lithium Carbonate	288	52 310,00	586 773,00	237 858,67	171 175,72	0,68	0,14	-1,11	0,29
GDP per capita	288	7 973,00	85 810,00	35 008,17	24 708,58	0,73	0,14	-0,74	0,29

For data to be considered normal, skewness or kurtosis should be between -1 and +1 (Mishra et al., 2019). For EV Sales, according to Table 6 neither skewness nor kurtosis falls between these values, meaning that it is not normally distributed. For the price of Lithium Carbonate, skewness of 0.68 would indicate normality, however, kurtosis is -1.11 which would suggest that it is not normally distributed. The normal distribution is checked with a histogram, shown in Figure 4, which indicates that lithium carbonate price is not normally distributed, since the data values do not form a bell-shaped curve (Mishra et al., 2019).

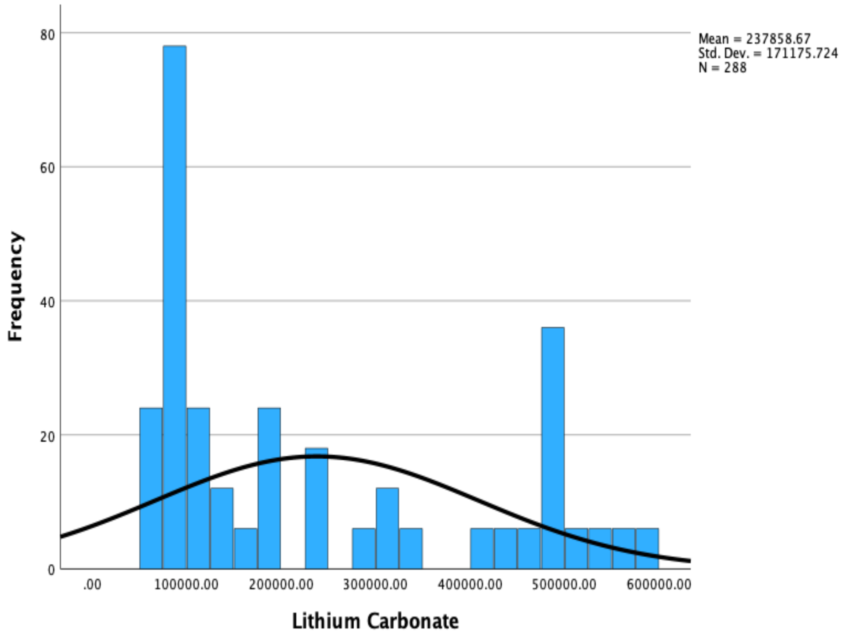

Figure 4 Histogram of Lithium Carbonate Price

However, GDP per capita is normally distributed according to both skewness and kurtosis, but their standard deviation is large. Their normal distribution is checked with a histogram that can be seen in Figure 5. From the figure it can be observed that it does not resemble a bell-shape, it can be stated that GDP per capita data is also not normally distributed (Mishra et al., 2019).

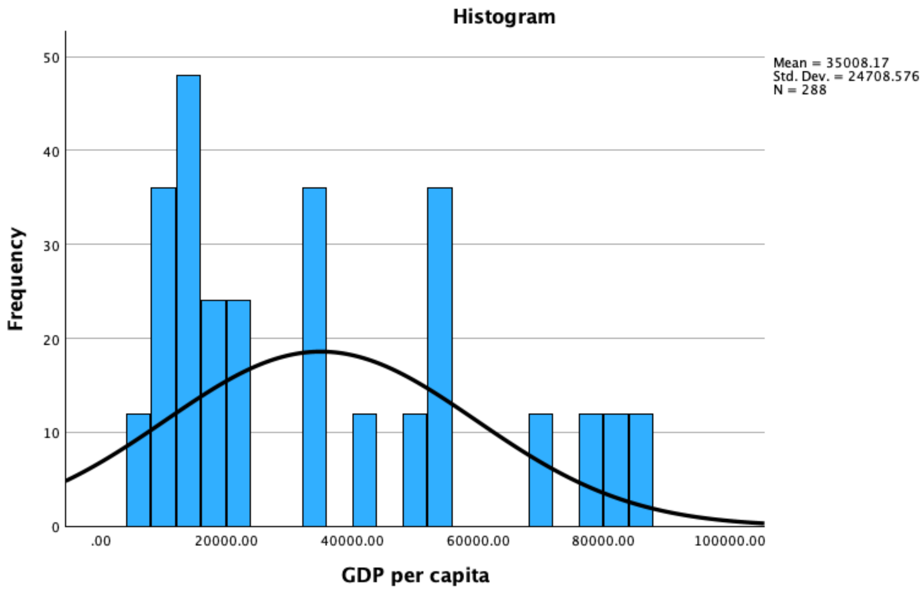

Figure 5 Histogram of GDP per capita

In Table 7, the frequency of different incentives is listed. It illustrates that most of the time (almost 70%), there were no subsidies given for consumer when purchasing an electric vehicle. For the tax incentives, it can be seen that most consumers receive a tax break or relief, when purchasing an electric vehicle. As 17% of the time no tax incentives were provided, indicating that most of the time a consumer would receive some kind of tax incentive. For home charging incentives, which is considered an important incentives, as most consumer charge their vehicles at home (IEA, 2025, p. 86), only a third of the consumers receive it. In fact, only two countries, Finland and USA, provide this benefit (U.S. Department of Energy, 2025, p. 1–10; European Alternative Fuels Observatory, 2025b). From Table 7, it can be observed that tax incentives are more popular than subsidies or home charging, while the two ladder are tied in least frequent.

Table 7 Frequency of Incentives

	Tax Incentives	
	Frequency	Percent
No	48	16,7
Yes	240	83,3
Total	288	100
	Subsidies	
	Frequency	Percent
No	192	66,7
Yes	96	33,3
Total	288	100
	Home Charging	
	Frequency	Percent
No	192	66,7
Yes	96	33,3
Total	288	100

To further describe patters in the data, scatter plots are presented. In Figure 6, GDP per capita and values of EV sales is grouped by tax incentives, yes or no. It can be observed that the higher the GDP per capita, the more tax incentives there are. Also, the more EV sales are happening in a month, the more tax incentives were.

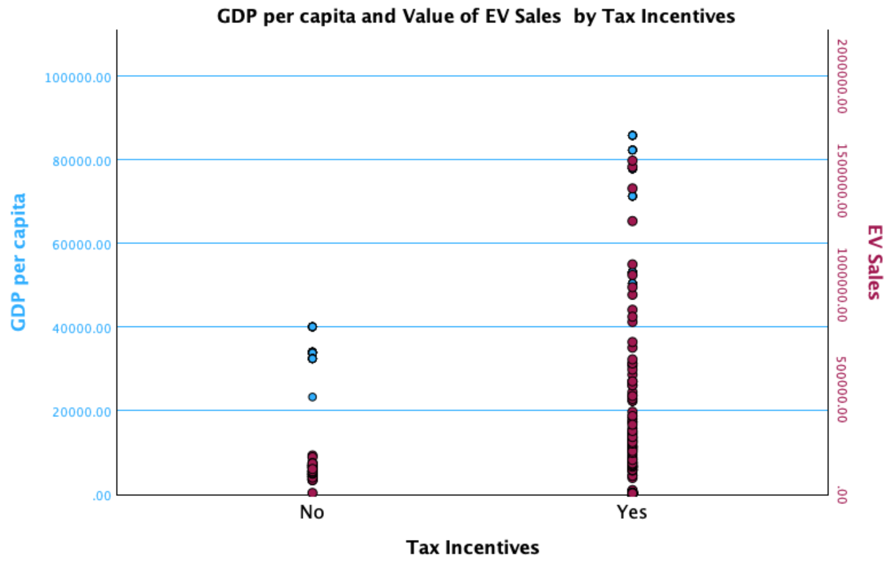

Figure 6 GDP per Capita and Value of EV Sales by Tax Incentives

In Figure 7, it can be observed that more EV sales were made per month even though there were no home charging incentives. The figure also illustrates that the higher the GDP per capita, the more home charging incentives there were.

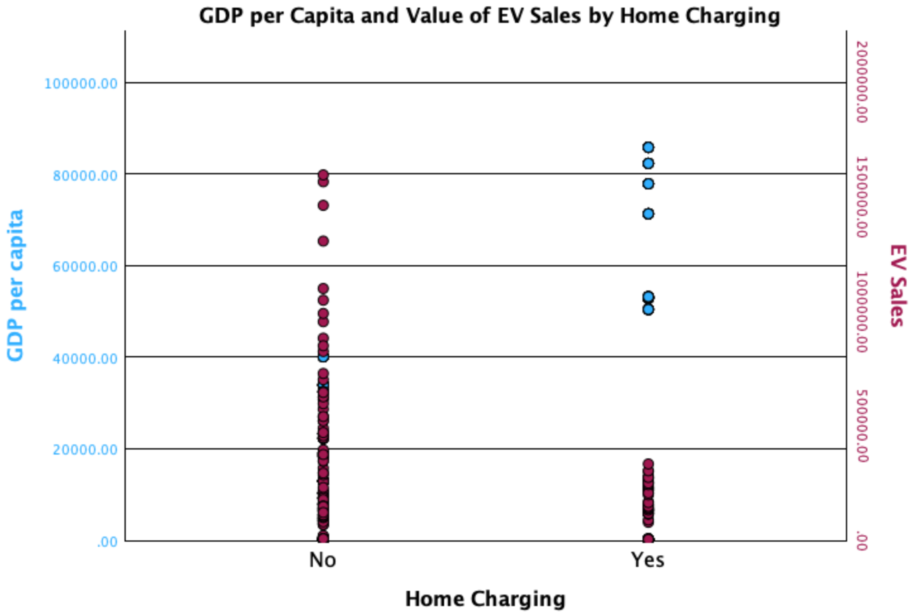

Figure 7 GDP per Capita and Value of EV Sales by Home Charging Incentive

In Figure 8, it can be seen that the more countries that did not have subsidies sold more EVs per month. From the same figure, on both yes and no column, the GDP per capita is above $40,000, indicating that mostly developed markets have subsides (Bekaert et al., 2023). However, the figure suggests that the higher the GDP per capita, there were no subsidies present. The significance of all these relationships is further tested with a regression analysis.

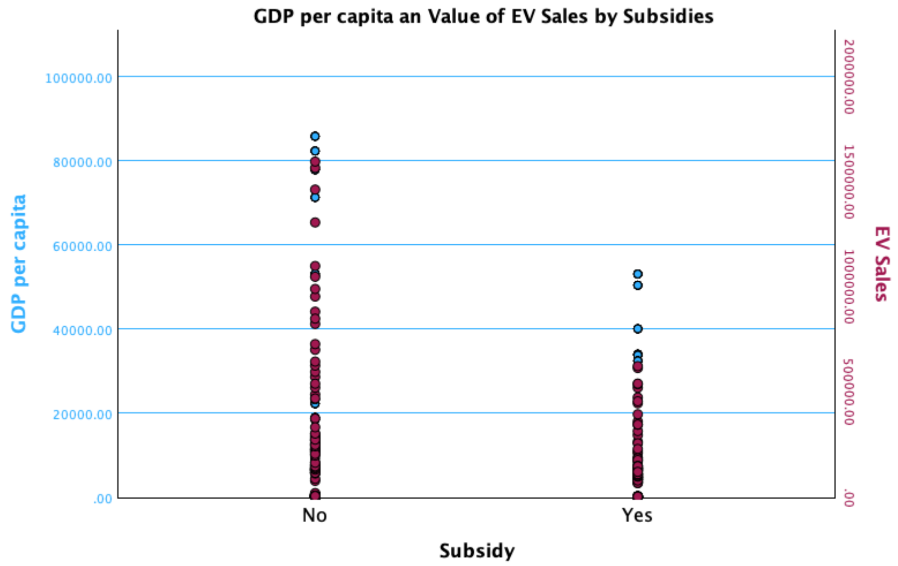

Figure 8 GDP per Capita and Value of EV Sales by Subsidy

Overall, the descriptive analysis suggests patterns that are consistent with the hypothesis of this research. The findings indicate that there are differences in consumer patterns depending on the market, which are mainly differentiated by GDP per capita (Bekaert et al., 2023). These initial trends found provide potential connection between key variables of this research and help on providing a foundation for the next analyses methods that test the hypotheses.

4.2 Comparative Analysis Between Markets

Based on the skewness in Table 6 and the conclusions made in chapter 4.1, EV sales are not normally distributed, and thus a Mann-Whitney U test is conducted to compare the sales in different markets, emerging and developed market (Wall Emerson, 2023). The test is performed in SPSS, and the results can be found in Table 8. The results are compared to the hypothesis made in the earlier chapter, chapter 2.4 Summary of Theoretical Framework.

From Table 8, it can be observed that when testing the difference between EV sales in emerging and developed markets the p-value is 0.022. Thus, we can reject the H0a hypothesis at a significance level of 0.050. This means that there is a difference between EV sales in different markets and it is statistically significant.

Table 8 Mann-Whitney Hypothesis Results

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.a,b	Decision
a. The significance level is 0.05 b. Asymptotic significance is displayed.	The distribution of EV Sales is the same across categories of Market.	Independent-Samples Mann-Whitney U Test	0.022	Reject the null hypothesis.

From the Figure 9, it can be observed that mean number of electric vehicle sales is higher in developed markets compared to emerging markets. Also, to point, the graph shows that even though emerging markets have a higher scores on the table, their mean ranks is lower, 133.29. This could be, because China is one of the biggest EV manufacturers and sells a significant number of EVs per month compared not only other emerging countries, but also developed markets (IEA, 2025, p. 15). The average EVs sold by other emerging countries, Brazil and Hungary drop the mean rank below developed countries.

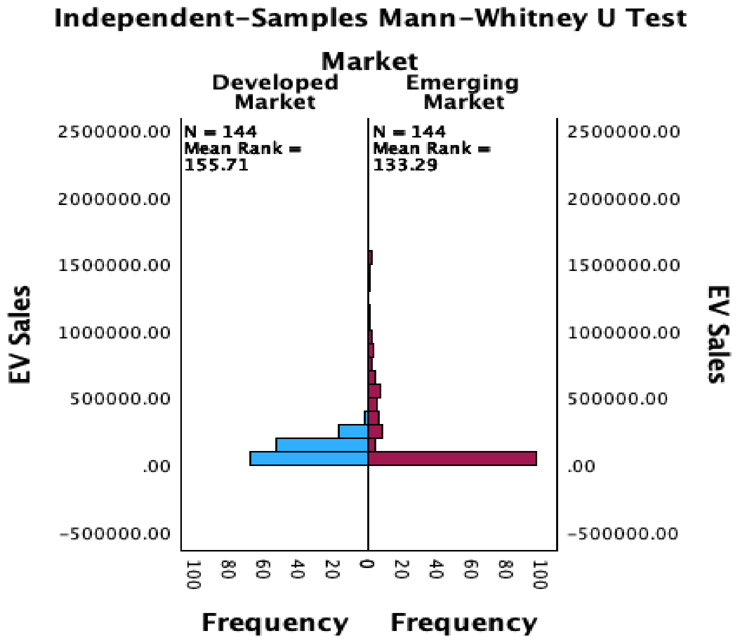

Figure 9 Mann-Whitney U Test Results

These results in comparative analysis suggest that there is a statistically significant difference between EV sales in emerging and developed markets. The mean rank of developed markets in EV sales is higher which is consistent with income elasticity of demand theory (Matsuyama, 2019; AlKathiri et al., 2024). Hence it can be said that the observed differences across the groups are aligned with the theoretical perspective that developed countries have a higher demand on luxury goods and therefore focus more on sustainability (Kutala et al., 2024; AlKathiri et al., 2024). In this scenario, EVs are classified as luxury goods according to (IEA, 2025, p. 10–14).

4.3 Correlation Analysis Between Lithium Carbonate Price and Electric Vehicle Sales

In this chapter a correlation analysis between lithium carbonate price and electric vehicle sales is performed. As in the previous chapter, it is stated that neither the monthly price of lithium carbonate nor electric vehicle sales are normally distributed, a Spearman's rank correlation analysis is done (Gogtay & Thatte, 2017). Before this, a scatter plot of both variables is done to provide an overview of their relationship.

A scatter plot between variables Lithium Carbonate Price and EV Sales is performed in Figure 10 using Microsoft Excel. From here it can be observed that the least square line is pointing slightly down, indicating that their relationship is negative (Gogtay & Thatte, 2017). However, it can be noticed that most data points do not fit into the straight line, indicating that their relationship is not strongly linear. The R^2 is 0,008 according to Figure 3, which means that there only 0,8% of the variance can be explained (Gogtay & Thatte, 2017). To further investigate their relationship, a Spearman's rank correlation is performed.

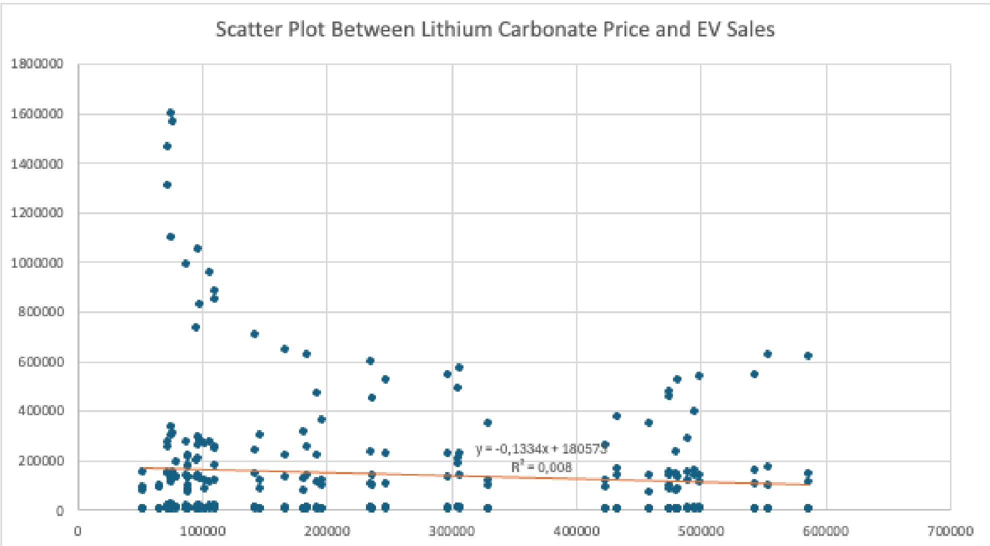

Figure 10 Scatter Plot Between Lithium Carbonate Price and EV Sales

A two-tailed Spearman's rank correlation analysis was performed to calculate if lithium carbonate prices and electric vehicle sales have a relationship between them. According to the correlation coefficient of -0.06, the two variables have negative, but weak correlation with one another (Gogtay & Thatte, 2017). The p-value according to Table 9 is 0.29, which is more than 0.05. This means that correlation between the variables is not statistically significant, and the H0b hypothesis can be accepted at a significance level of 0.05. These results are found in below in Table 9.

Table 9 Spearman's Rank Correlation

Correlations				
			Lithium Carbonate	EV Sales
Spearman's rho	Lithium Carbonate Price	Correlation Coefficient	1	-0,063
		Sig. (2-tailed)		0,287
		N	288	288
	EV Sales	Correlation Coefficient	-0,063	1
		Sig. (2-tailed)	0,29	
		N	288	288

From Figure 11 it can be observed that the mean of lithium carbonate price per month does seem to have a negative correlation with EV sales per month. It can be seen that the price and sales volume move together, however when looking at the chart, the lines and bars are not perfectly moving together. Them not moving at the same time would suggest that there is a delay in after the price changes, to how the sales change.

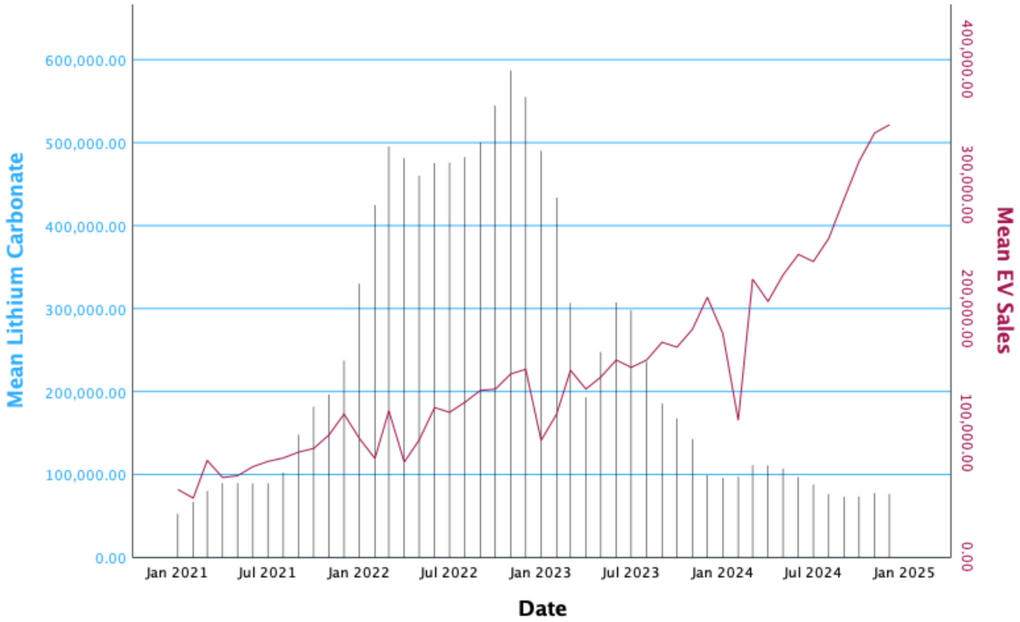

Figure 11 Monthly Trends of Mean Lithium Carbonate Price and Mean Electric Vehicle Sales

This correlation analysis suggested a weak but negative correlation between EV sales and lithium carbonate price is in accordance with the law of supply and demand. The theory states that when lithium carbonate prices would increase the demand of the vehicles decreases, indicating a negative relationship (Buechner, 2018). As previously mentioned, the bars and lines in Figure 11 are not moving in sync, which suggest a delayed cost pass-through (RBB Economics, 2014). This means that for the price increase or decrease in lithium carbonate, it takes time for this to impact EV price, and thus their demand, enlightens the article.

4.4 Regression Analysis

The regression analysis is the core analysis method in this study and the results describes the relationship between the variables, lithium carbonate price, electric vehicle sales, GDP per capita, subsidy, tax incentives, as well as home charging incentives. Because lithium carbonate price, EV sales and GDP per capita are not normally distributed, a box-cox method will be done to transform the data to fit normal distribution (Lee, 2020). The reason for doing this is, because data used in a regression analysis needs to be normally distributed (Gogtay et al., 2017).

Figure 12 illustrates how after Box-Cox transformation, the data of EV sales is now normally distributed, and thus can be used in a regression analysis (Gogtay et al., 2017).

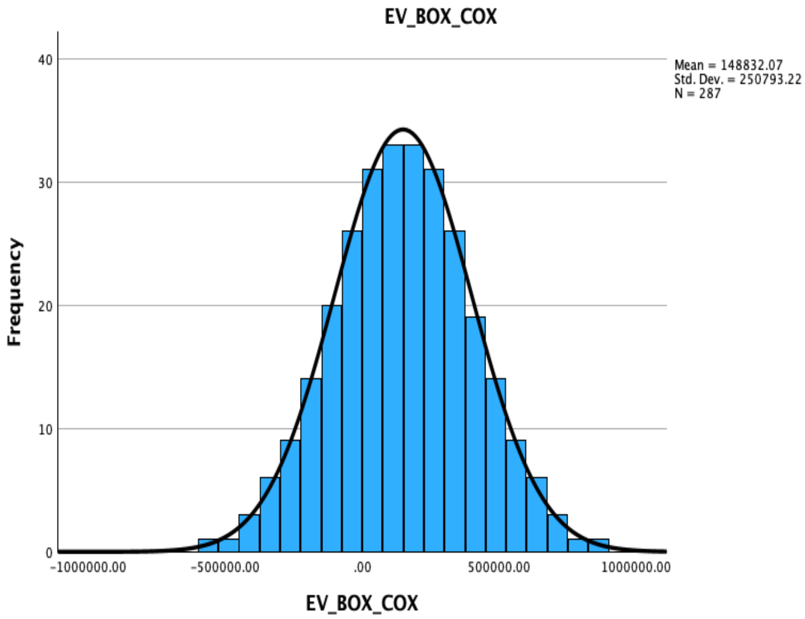

Figure 12 EV Sales After Box-Cox Transformation

In Figure 13, it can be seen that lithium carbonate price after performing a Box-Cox transformation, is normally distributed, which is a prerequisite before using the data in a regression analysis (Gogtay et al., 2017).

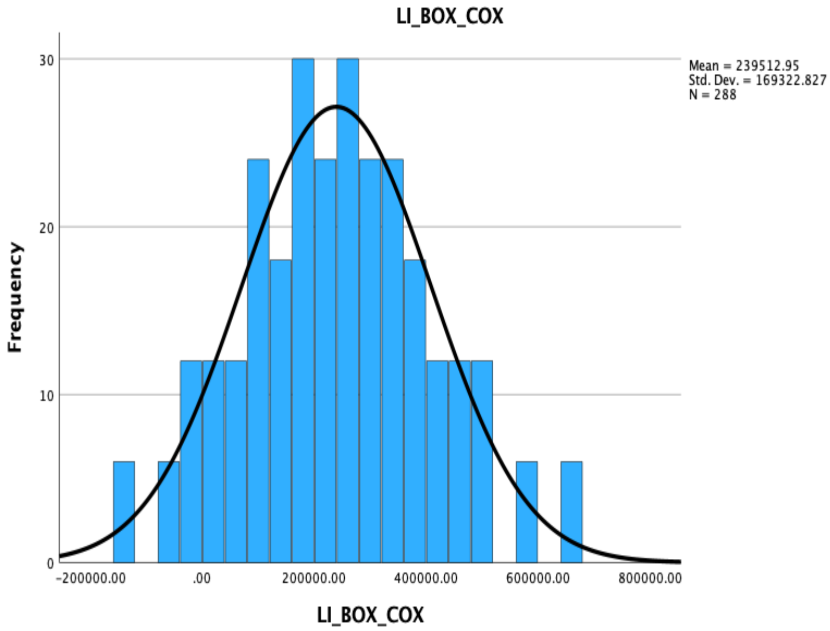

Figure 13 Lithium Carbonate Price After Box-Cox Transformation

After, the box-cox data transformation it can be seen in Figure 14 that GDP per capita data is now normally distributed. Since the needed data is transformed to fit into normal distribution, a moderated regression analysis can be performed.

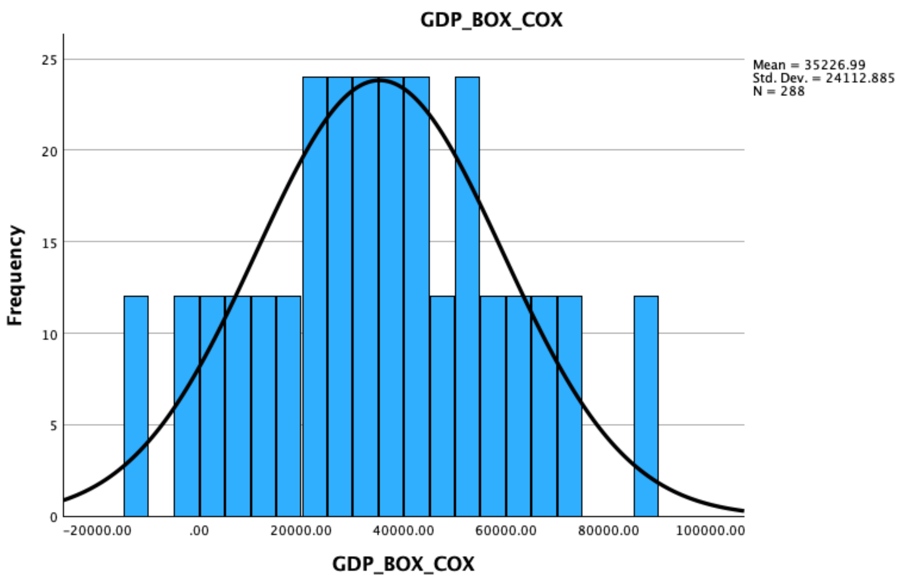

Figure 14 GDP per Capita After Box-Cox Transformation

It can be seen in Table 10 that the R^2 change, according to Laerd Statistics (2018), is the change the increase in variation with the moderated variable. The R^2 change in model 2 is 0.0021, suggesting that the moderated variable increases the variation by 0.21%. This increase, according to Table 10 is not statistically significant. The Sig. F change in model 2 determines how the moderated variable changes the significance. In this case it is 0.38, suggesting that the H0c can be accepted at a 0.05 significance level. Therefore, the GDP per capita is not a moderator variable between EV sales and lithium carbonate price, which would suggest the relationship it does not impact strength of the relationship between lithium carbonate and EV sales.

Table 10 Model Summary of Regression Analysis

Model Summary[c]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.489a	0,24	0,23	220647,41	0,24	17,70	5,00	281,00	0,00
2	.491b	0,24	0,23	220739,55	0,0021	0,77	1,00	280,00	0,38

Note: a. Predictors: (Constant), Home Charging, Lithium Carbonate box-cox, Tax Incentives, Subsidy, GDP per capita box-cox. b. Predictors: (Constant), Subsidy, GDP per capita BOX_COX, Lithium Carbonate BOX_COX, Tax Incentives, Home Charging, Lithium x GDPBOX_COX. c. Dependent Variable: EV Sales.

Looking at the unstandardized coefficients B in Table 11, and with the help of van den Berg (2025) and Laerd Statistics (2018), interpreting the table, it can be observed from model 2 that when the price of lithium carbonate goes up by a unit, EV sales drop by 0.15. When GDP per capita goes up by a unit, EV sales increase by 9.09. The moderator variable, if that increases by a unit, EV sales go up only slightly (2,85E-6). However, when home charging incentives, the increase in EV sales when there is a home charging incentive is -433 878,54 lower compared to when there is not a home charging incentive. This indicates a negative relationship of having a home charging incentive to EV sales.

The increase in EV sales when there are tax incentives is 247 316,46 higher compared to when there is not a tax incentive. Additionally, EV sales increase by 128 708,46 when there are subsidies, compared to the absence of subsidies.

The Sig. column in Table 11 is the p-value for each coefficient, as told by van den Berg (2025). From this, it can be seen that GDP per capita, home charging incentives, subsidies and tax incentives are statistically significant, and thus have a relationship with EV sales. The moderator (Lithium x GDP) and Lithium Carbonate price do not have a relationship with EV sales. The significance or p-value for the moderated variable (Lithium x GDP GDP_BOX_COX) is 0.38, and for Lithium Carbonate price 0.28. Even though, GDP per capita is not a moderator in the relationship between EV sales and lithium carbonate price, it however, has a relationship with the variables own its own.

Table 11 Coefficients in Regression Analysis, GDP per capita

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-278 262,20	70700,13		-3,94	0,00
	Lithium Carbonate BOX_COX	-0,05	0,08	-0,03	-0,63	0,53
	GDP per capita BOX_COX	9,58	1,09	0,92	8,77	0,00
	Home Charging	-426 370,53	58912,99	-0,80	-7,24	0,00
	Tax Incentives	242 071,44	56763,71	0,36	4,26	0,00
	Subsidy	128 339,29	36297,03	0,24	3,54	0,00
2	(Constant)	-263 080,50	72827,13		-3,61	0,00
	Lithium Carbonate BOX_COX	-0,15	0,14	-0,10	-1,08	0,28
	GDP per capita BOX_COX	9,08	1,23	0,87	7,39	0,00
	Home Charging	-433 878,54	59559,06	-0,82	-7,28	0,00
	Tax Incentives	247 316,46	57102,98	0,37	4,33	0,00
	Subsidy	128 708,46	36314,64	0,24	3,54	0,00
	Lithium x GDP BOX_COX	2,85E-6	0,00	0,10	0,87	0,38

Note: Dependent Variable is EV Sales

According to Table 11, the equation for the moderated regression analysis looks the following:

$$
\begin{aligned}
EV\ Sales = -263\,080{,}50 - \ 0{,}15 \cdot Lithium\ Carbonate\ Price + \ 9{,}08 \\
\cdot\ GDP\ per\ capita + 2{,}85 \cdot 10^{-6} \\
\cdot\ (GDP\ per\ capita\ \ \cdot Lithium\ Carbonate\ Price) + \ 128\,708{,}46 \\
\cdot Subsidy + \ 247\,316{,}46 \cdot Tax\ Incentives - 433\,878{,}54 \\
\cdot Home\ Charging
\end{aligned}
$$

Equation 8 Regression Model According to Coefficient Table

The moderated regression analysis tested if the relationship between lithium carbonate price and EV sales is moderated by GDP per capita, while taking into consideration different incentives. The results suggest that when GDP per capita is a moderated variable, it is not significant in the equation and therefore does not change the strength of how lithium carbonate price would impact EV sales. This means that for example the price of lithium carbonate would not matter more in countries where the GDP per capita is lower (Aguinis & Gottfredson, 2010). However, the GDP per capita itself is statistically significant in the equation (p<0.05) and therefore is directly able to predict EV sales, meaning that the higher the GDP per capita is the more sales there are.

5 Discussion and Conclusion

This study analyzed the impact of lithium carbonate price fluctuations on electric vehicles sales to compare if there are differences between emerging and developed markets. Generally, these markets differ in things like consumer behavior and purchase power, and with electric vehicles becoming more popular the study is current (Meszaros et al., 2021; Schvartz et al., 2024). To measure the relationship between lithium stock prices and electric vehicle sales in different markets and investigate on whether lithium stock price can forecast electric vehicle sales in different markets, different statistical analysis methods were used. The descriptive analysis provided a basic understanding of the research data and variables, while comparative analysis gave an understanding of the differences in EV sales between emerging and developed markets. Correlation analysis, on the other hand, measured the relationship of lithium carbonate price on EV sales in general, while regression analysis gave a more in-depth analysis on their relationships, taking GDP per capita and different incentives into the mix to provide information on the markets. This chapter will provide a summarization of the findings gathered from previous chapters, while discussing the results. With the help of the results, the decision-making in EV supply chains can be proved. This is because the results show what impacts EV demand. Also, the focus for governments could shift towards consumer-based incentives, while evaluating whether GDP per capita could be used to forecast trends in EV sales. After, an analyzation of limitations of this research is gathered, such as data availability. This is followed by a concluding chapter of the research with giving ideas for future research.

5.1 Summary of Findings

In this section, the summary of key findings is presented, and these are discussed with the help of literature and theories, such as law of supply and demand, cost pass-through and income elasticity of demand, that are presented earlier in the study. Through data collection from publicly accessible secondary data and with various statistical analysis methods, the research studied the impact of lithium carbonate price fluctuations on EV sales and compared the results between emerging and developed markets.

From descriptive analysis, the patterns observed already in literature review were confirmed, such as subsidies and home charging incentives are more popular in countries with higher GDP. Although the most common incentives given in emerging countries are tax incentives, with descriptive statistics it was recognized that higher the GDP per capita, the more tax incentives were observed. Tax incentives were also found to be more present the more EVs were sold during a month. Because developed countries attract more innovation and have higher returns in technology and their skills are higher compared to emerging countries, this could explain why home charging incentives are more popular there (Matsuyama, 2019). These findings indicate that there are differences in consumer patterns between the markets, emerging and developed, which are told to be mainly differentiated by their GDP per capita (Bekaert et al., 2023). These initial trends helped on providing a foundation for the next analyses methods that tested the hypotheses and answered the research question.

With data not being normally distributed, it made an impact on comparative and correlation analysis methods. When comparing markets in their EV sales, it was observed that even though emerging markets had a few higher monthly scores, developed markets have a higher mean rank (≈156) in EV sales per month than emerging markets (≈133). The differences in EV sales in these different markets were found out to be statistically significant through the Mann-Whitney U test. According to the results, the hypothesis H1a was accepted. These findings align with the income elasticity of demand theory, that states higher-income countries, such as developed countries, are more prone to purchasing luxury products, which EVs are classified as (AlKathiri et al., 2024; IEA, 2025, p. 10–14). The reason for them to be considered as luxury items, could be because currently in many countries electric vehicles are more expensive than their combustion engine vehicle equivalents (IEA, 2025, p. 10–14). Also, according to the theory, income elasticity of demand, developed countries tend to focus more on sustainable measures, which could have led to more EV sales (AlKathiri et al., 2024).

The Spearman's rank correlation test between the relationship of EV sales and lithium carbonate price resulted in a negative correlation of -0.06. The results, however, were not considered statistically significant, as the p-value was above 0.05. On top of this, only a small percentage (0.8%) of the variance between the two could be explained. The weak, but negative correlation is in accordance with the law of supply and demand. The theory states that when lithium carbonate prices would increase the demand of the vehicles decreases, indicating a negative relationship (Buechner, 2018). This is because, the change in material costs effects production costs, which then also increases the cost of the end-product, EV, which then decrease the amount of EVs sold (Buechner, 2018). Even though the results were not statistically significant, it was observed that the mean price of lithium carbonate fluctuated with the mean of EV sales, though the response was detected to be delayed. This would suggest a delayed cost pass-through within the EV industry, which means that only after a certain time has passed, the price fluctuations of lithium carbonate reach the price of EV sales, and thereafter the consumer react accordingly (RBB Economics, 2014).

Regression analysis was the core analysis method used in this research. It helped on describing the relationships between lithium carbonate price, GDP per capita, subsidy, tax incentives, as well as home charging incentives in relation to EV sales. Because none of the continuous variables were normally distributed, they were successfully transformed to fit normality. To clarify, this was done because normal distribution is the prerequisite of a regression analysis (van den Berg, 2025). The moderated regression analysis tested if the relationship between lithium carbonate price and EV sales is moderated by GDP per capita, while taking into consideration different incentives. It was found that when GDP per capita is a moderator variable, it only increases the variance of the regression slightly (0.21%.). The results suggest that the GDP per capita is not a moderator variable between EV sales and lithium carbonate price, which then suggest that the strength of the relationship between lithium carbonate and EV sales is not dependent on GDP per capita. However, when looking at the variables individually, GDP per capita, home charging incentives, subsidies and tax incentives were all found to be statistically significant in the equation, and thus suggest a relationship with EV sales. Their p-value was below the significance level alpha 0.05. Even though the findings indicate that GDP per capita is not a moderator in the relationship between EV sales and lithium carbonate price, it nevertheless, has a relationship with the EV sales on its own.

Overall, the results suggest that when GDP per capita is a moderated variable, it is not significant in the equation and therefore does not change the strength of how lithium carbonate price would impact with EV sales (Aguinis & Gottfredson, 2010). The GDP per capita, however, is statistically significant itself in the equation and therefore is directly able to predict EV sales, meaning that the higher the GDP per capita is the more sales there are. Therefore, we can conclude that the market of EV sales does have a relationship with lithium carbonate price fluctuations, but they however do not change the relationship of how lithium carbonate price impacts electric vehicle sales.

5.2 Limitations

As the purpose of this research is to study the impact of lithium price fluctuations on EV Sales per month between emerging and developed countries, there have been limitations when conducting the study. These limitations mainly revolve on the data obtained from various different sources.

The data used in the research is obtained from publicly accessible secondary data. This means that most of the data is from sources that are publicly available, while lithium carbonate price can be viewed publicly, but to download the data a small fee is to be paid (Trading Economics, 2025a). Finding suitable data has posed as a challenges, since many countries have started collecting monthly EV data just recently. This impacted the number of countries selected per market, as well as the country selection process itself, especially for emerging markets, but also for developing markets. For example, in 2021 Hungary had quarterly data available (see Appendix 1) that was modified in the research to fit monthly data, and Japan started collecting monthly data as of 2021 (JADA, 2025). The impact of availability of data also limited the timeframe of the study, making the observations per country to 288 in EV sales data. On top of this, there was some bias also when selecting between countries. For example, Finland was selected based on personal interest of the country. Most data and reports for EV sales were in the country's native language, making the need to use a translator, Google Translate, to translate the information to English. For Brazil, China, Japan and Finland data, this was the case.

Downloadability of the data can also be considered a limitation in the study. EV monthly sales were downloadable straight to Microsoft Excel for China and Finland, also lithium carbonate price could be downloaded, but the monthly average of closing price needed to be calculated in Microsoft Excel. For other countries, Japan, Hungary, USA and Brazil, the data was manually copied from reports. Additionally, the incentives data was obtained from different literature and government websites (Zhao et al., 2024; European Alternative Fuels Observatory 2025a). This means that the research is subject to things such as typos when copying the data from online sources.

5.3 Future Research

With presumably more monthly EV sales data available in the upcoming years and increasing adoption of EVs in many countries, this research could be replicated in the future to gain more insight and improve the findings. This increase of data would further increase the sample size and make the timeframe longer. Also taking in more countries per market group would strengthen the research even further. On top of this, using the same study, but adding other modeling methods, such as panel data regression or time series forecasts, would strengthen the analysis. With these methods, integration of technological, environmental and political variables could be used to describe the overall market dynamics.

This study grouped all EVs in the same category, but future research could evaluate if there is a difference between, BEV, PHEV and HEV adoptions in these different market groups in consideration of the price fluctuations of lithium carbonate. Also, adding heavy- and light-duty vehicles into the mix could strengthen the research, especially as according to IEA (2025, p. 57) light-duty vehicles had more electrified vehicles compared to other vehicle types during 2024. Another focus for future research is to examine the incentives more profoundly, if there is a difference on how these impact EV sales between different markets. In this study incentives were dummy variables, but future research could implement the amount of subsidies, or tax percentages into the mix. Also, the impact of incentives given to companies could be taken into consideration. Zhao et al. (2024) had observed that monetary incentives in China are less fruitful than other benefits in the long run. This could be researched if it is the case in all emerging countries, and does it apply to developed countries. It could be taken even further by investigating if one incentive is clearly more beneficial than the other. For example, does providing decreased parking increase the adoption more than incentives concerning home charging, and are there regional or market differences with these.

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Appendices

Appendix 1. Data Sources for Hungary EV Sales

All data retrieved July 17, 2025.

Description	Title	Published	Source	URL
2020 January Passenger vehicle registration	Passenger car registrations: -24.0% in January 2021	2021, February 17	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-24-0-in-january-2021/
2020 February Passenger vehicle registration	Passenger car registrations: -21.7% first two months of 2021; -19.3% in February	2021, March 17	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-21-7-first-two-months-of-2021-19-3-in-february/
2020 March Passenger vehicle registration	Passenger car registrations: +3.2% first quarter of 2021; +87.3% in March	2021, April 16	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-3-2-first-quarter-of-2021-87-3-in-march/
2020 Q1 EV registration	Fuel types of new cars: battery electric 5.7%, hybrid 18.4%, petrol 42.2% market share in Q1 2021	2021, April 23	ACEA	https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-battery-electric-5-7-hybrid-18-4-petrol-42-2-market-share-in-q1-2021/
2020 April Passenger vehicle registration	Passenger car registrations: +24.4% four months into 2021; +218.6% in April	2021, May 19	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-24-4-four-months-into-2021-218-6-in-april/
2020 May Passenger vehicle registration	Passenger car registrations: +29.5% five months into 2021; +53.4% in May	2021, June 17	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-29-5-five-months-into-2021-53-4-in-may/
2020 June Passenger	Passenger car registrations:	2021, July 16	ACEA	https://www.acea.auto/pc-registrations/passenger-car-

vehicle registration	+25.2% first half of 2021; +10.4% in June			registrations-25-2-first-half-of-2021-10-4-in-june/
2020 Q2 EV registration	Fuel types of new cars: battery electric 7.5%, hybrid 19.3%, petrol 41.8% market share in Q2 2021	2021, July 23	ACEA	https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-battery-electric-7-5-hybrid-19-3-petrol-41-8-market-share-in-q2-2021/
2020 August Passenger vehicle registration	Passenger car registrations: +11.2% eight months into 2021; －23.2% in July and －19.1% in August	2021, September 16	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-11-2-eight-months-into-2021-23-2-in-july-19-1-in-august/
2020 September Passenger vehicle registration	Passenger car registrations: +6.6% nine months into 2021; -23.1% in September	2021, October 15	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-6-6-nine-months-into-2021-23-1-in-september/
2020 Q3 EV registration	Fuel types of new cars: battery electric 9.8%, hybrid 20.7% and petrol 39.5% market share in Q3 2021	2021, October 22	ACEA	https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-battery-electric-9-8-hybrid-20-7-and-petrol-39-5-market-share-in-q3-2021/
2020 October Passenger vehicle registration	Passenger car registrations: +2.2% ten months into 2021; -30.3% in October	2021, November 18	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-2-2-ten-months-into-2021-30-3-in-october/
2020 November Passenger vehicle registration	Passenger car registrations: -0.04% 11 months into 2021; -20.5% in November	2021, December 17	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-004-11-months-into-2021-20-5-in-november/
2020 December Passenger	Passenger car registrations: -2.4% in 2021; -	2022, January 18	ACEA	https://www.acea.auto/pc-registrations/passenger-car-

vehicle registration	22.8% in December			registrations-2-4-in-2021-22-8-in-december/
2020 Q4 EV registration	Fuel types of new cars: battery electric 9.1%, hybrid 19.6% and petrol 40.0% market share full-year 2021	2022, February 2	ACEA	https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-battery-electric-9-1-hybrid-19-6-and-petrol-40-0-market-share-full-year-2021/
2022–2023 January EV registration	Passenger car registrations: +11.3% in January 2023, battery electric 9.5% market share	2023, February 21	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-11-3-in-january-2023-battery-electric-9-5-market-share/
2022–2023 February EV registration	Passenger car registrations: +11.5% in February, battery electric 12.1% market share	2023, March 21	ACEA	https://www.acea.auto/pc-registrations/passenger-car-registrations-11-5-in-february-battery-electric-12-1-market-share/
2022–2023 March EV registration	New car registrations: +28.8% in March, battery electric 13.9% market share	2023, April 19	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-28-8-in-march-battery-electric-13-9-market-share/
2022–2023 April EV registration	New car registrations: +17.2% in April, battery electric 11.8% market share	2023, May 17	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-17-2-in-april-battery-electric-11-8-market-share/
2022–2023 May EV registration	New car registrations: +18.5% in May, battery electric 13.8% market share	2023, June 21	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-18-5-in-may-battery-electric-13-8-market-share/
2022–2023 June EV registration	New car registrations: +17.8% in June, battery electric	2023, July 29	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-17-8-in-june-battery-electric-15-1-market-share/

	15.1% market share			
2022–2023 July EV registration	New car registrations: +15.2% in July, battery electric 13.6% market share	2023, August 30	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-15-2-in-july-battery-electric-13-6-market-share/
2022–2023 August EV registration	New car registrations: +21% in August; battery electric exceeds 20% share for the first time	2023, September 20	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-21-in-august-battery-electric-exceeds-20-share-for-the-first-time/
2022–2023 September EV registration	New car registrations: +9.2% in September; battery electric 14.8% market share	2023, October 20	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-9-2-in-september-battery-electric-14-8-market-share/
2022–2023 October EV registration	New car registrations: +14.6% in October; battery electric 14.2% market share	2023, November 21	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-14-6-in-october-battery-electric-14-2-market-share/
2022–2023 November EV registration	New car registrations: +6.7% in November; battery electric 16.3% market share	2023, December 20	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-6-7-in-november-battery-electric-16-3-market-share/
2022–2023 December EV registration	New car registrations: +13.9% in 2023; battery electric 14.6% market share	2024, January 18	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-13-9-in-2023-battery-electric-14-6-market-share/
2024 January EV registration	New car registrations: +12.1% in January 2024;	2024, February 20	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-12-1-in-

	battery electric 10.9% market share			january-2024-battery-electric-10-9-market-share/
2024 February EV registration	New car registrations: +10.1% in February 2024; battery electric 12% market share	2024, March 21	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-10-1-in-february-2024-battery-electric-12-market-share/
202 March EV registration	New car registrations: -5.2% in March 2024; battery electric 13% market share	2024, April 18	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-5-2-in-march-2024-battery-electric-13-market-share/
2024 April EV registration	New car registrations: +13.7% in April 2024; battery electric 11.9% market share	2024, May 22s	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-13-7-in-april-2024-battery-electric-11-9-market-share/
2024 May EV registration	New car registrations: -3% in May 2024; battery electric 12.5% market share	2024, June 20	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-3-in-may-2024-battery-electric-12-5-market-share/
2024 June EV registration	New car registrations: +4.3% in June 2024; battery electric 14.4% market share	2024, July 18	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-4-3-in-june-2024-battery-electric-14-4-market-share/
2024 July EV registration	New car registrations: +0.2% in July 2024; battery electric 12.1% market share	2024, August 29	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-0-2-in-july-2024-battery-electric-12-1-market-share/
2024 August EV registration	New car registrations: -18.3% in August 2024; BEV market share	2024, September 19	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-18-3-in-august-2024-bev-market-share-down-by-almost-one-third/

	down by almost one third			
2024 September EV registration	New car registrations: -6.1% in September 2024; year-to-date battery-electric market sales -5.8%	2024, October 22	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-6-1-in-september-2024-year-to-date-battery-electric-market-sales-5-8/
2024 October EV registration	New car registrations: +1.1% in October 2024; year-to-date battery-electric sales -4.9%	2024, November 21	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-1-1-in-october-2024-year-to-date-battery-electric-sales-4-9/
2024 November EV registration	New car registrations: -1.9% in November 2024; year-to-date battery-electric sales -5.4%	2024, December 19	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-1-9-in-november-2024-year-to-date-battery-electric-sales-5-4/
2024 December EV registration	New car registrations: +0.8% in 2024; battery-electric 13.6% market share	2025, January 21	ACEA	https://www.acea.auto/pc-registrations/new-car-registrations-0-8-in-2024-battery-electric-13-6-market-share/