Fiscal Policies and the EV Transition: Why the United States Fell behind in Electrification

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

The rapid rise of electric vehicles (EVs) and autonomous vehicles (AVs) has sparked considerable interest among the public and governments worldwide. They bring with them the opportunity to reduce carbon emissions, mitigate air pollution, and reduce our dependence on fossil fuels. Despite this, EVs have had varying levels of success in becoming the next wave of transportation. This is apparent when looking at the various stages of the EV transition in different countries. European countries that have prioritized sustainable transportation lead the world in EVs purchased per capita, while the United States has lagged, despite being a leading innovator in EV technology. Meanwhile, China has burst onto the scene, becoming the top global market for EVs. This is not the only area in which these countries differ; they also implement different policy approaches regarding EVs.

The intersection of technology and policy has become increasingly more complex; especially with new technologies, there is often a lag before legislation can be implemented. Policymaking must take into account not only the interests of the citizens it affects, but also industry stakeholders, competitors, and innovators. Understanding the nuances of EV policy allows us to better analyze the efficacy of policy and how it affects economic, political, and cultural factors shaping EV technology. As these technologies are still new and developing, research in these fields will allow us to become more well-informed and prepared for the cultural and political implications of such a massive shift in transportation.

In this study, I will be investigating the research question: *in what ways do policies on EVs between the US, Europe, and China differ and how do these policies affect the EV transition?* From this, comparing policies between these countries can help to formulate a better understanding of the efficacy of certain strategies in the push for electrification and sustainable transportation. In addition, understanding the dynamics of EV adoption and policy allows citizens to advocate for successful policies that align with their economic and social interests, as well as making these technologies more affordable and equitable for those that are working towards a more sustainable and innovative future.

Background

The main sociotechnical system for paper is the automotive car market and the legal policies of countries as they pertain to electric vehicles. With recent public concern over climate change, this has created an opportunity for hybrids and EVs to enter the scene. Their main selling point is lower environmental impact, and EVs have also been advertised to be more technologically advanced and have lower lifetime costs due to maintenance and fuel compared to internal combustion engine vehicles (ICEs). For those whose values align with themes such as environmentalism and technological innovation, EVs are a top choice. In fact, they are becoming more popular in many countries as the technology matures, offering longer range, better performance, and reduced charging times over previous generations.

An interesting phenomenon that then arises is the rate at which EVs are being adopted differs between countries. Countries in Europe and China have seen EVs become a large percentage of car sales. The United States, however, has lagged as many consumers are purchasing larger pickup trucks and SUVs, meaning EVs only make up ~10% of the total market share. This highlights how the attitudes of various countries regarding the core values behind EVs differ and how this ultimately affects the way each country approaches the EV transition.

Environmentalism has also led to policies that attempt to promote more sustainable practices. Some of the most progressive policies can be found in Europe, where some countries are requiring car manufacturers to phase out the sale of gas cars. This has been extremely effective in penetrating the car market, especially in Norway, where around 80% of all new vehicles sold are EVs (IEA, 2023; Chappell, 2021). In China, a country where automobile technology has progressed extremely rapidly in the past few years, government incentives and support in the EV industry has led to the country becoming the world's leading EV producer and consumer. China's "Made in China 2025" master plan has led to a combination of private companies, state-owned enterprises, and technology startups flooding into China's auto market. Government action has an impact on influencing market trends and illustrates an interesting interplay between consumers and policymakers. The US is not without similar policies; tax breaks for consumers and incentives for companies to build EV infrastructure exist, but we have lost the title of top innovator for EVs. Additional investigation and analysis need to be conducted to determine what the best policy approach is for encouraging electrification and paving the way for a new era of sustainable transportation for all.

Literature Review

The EV landscape is constantly changing due to the rapid rise of new technological advancements and changing consumer trends. Globally, the rate of EV adoption is expected to grow exponentially, with some estimates suggesting EVs will have a majority market share within the next decade (Jung, Schroder, & Timme, 2023). As such, governments and companies must continually adjust policies as the market changes and what stage of the EV transition the country is in.

There are many policies that governments have implemented that have impacted the rate of electric vehicle (EV) adoption in their respective jurisdictions. They can be split into two categories, each focusing on certain phases of EV ownership: (1) policies affecting the acquisition of EVs and (2) policies affecting ownership. The former attempts to make EVs more attractive than internal combustion engine vehicles (ICEVs) by levying taxes, tariffs, or other fiscal policies on vehicles to affect sale prices, or introducing stringent regulations for the types of vehicles that are available to purchase (Santos & Davies, 2020; Jung, Schroder & Timme, 2023; Danielis, 2023). The latter grants privileges and benefits for the duration of ownership. These can include access to HOV lanes on highways, reserved parking spaces, and exemption from congestion-free zones (Santos & Davies, 2020; Helveston, 2021). These policies have their own unique benefits and drawbacks, as well as varying levels of efficacy in influencing EV adoption.

According to (Danielis, 2023), "there is strong empirical evidence that fiscal policies have a significant impact on the type of purchased car," and these policies take different forms depending on the maturity of the EV market within the country. In a study conducted by Song, Chu, & Kim, (2023) investigating the factors that affect if a person would purchase an EV, they concluded that "in any market, government incentives, which directly affect economic value, will have a large effect on EV purchase" (page 355). At this point, it seems that economic reasons, rather than ideological ones, have a larger impact upon a person's willingness to purchase EVs. Many countries that have been successful in increasing EV adoption rates have made the cost of buying and owning an EV competitive with ICEVs, but there are certain caveats associated with this price control that do not make it universally applicable to other countries (Danielis, 2023; Graham, Belton, & Xia, 2021).

STS Framework

A useful framework for analyzing this sociotechnical system is the diffusion of innovations theory, which states that different societies integrate new technologies at different rates (Everett, 1962). EVs are part of a sociotechnical system, where the actors, consisting of consumers, politicians, and companies, all influence the technology and its level of advancement. When all these interest groups are working collaboratively, innovation and advancements are fostered. When the actors are in opposition with each other, technology will have a harder time being adopted and implemented. Lack of interest and low market performance for EVs can also stifle innovation, leading to a negative feedback loop. For this paper, the three countries chosen offer a variety of societies in different stages of the EV transition. By analyzing the effectiveness of policies in each country, this will help build a better understanding of how policy, consumers, and companies work together, and if they have a cohesive or dysfunctional relationship with each other. From there, weak spots can be identified, and improvements can be suggested to help the technology catch back up to speed.

Methods

Three unique countries that employ very different policies are considered: the US, China, and Norway. For each of these countries, I will look at their major fiscal policies that attempt to influence the market and their impact on the EV scene. For the US, California and New York City will be studied, as California is the largest EV market in the US and NYC provides a comparison between two densely populated, high GDP per capita major cities and the differences between their EV markets (https://afdc.energy.gov/data/10962). The largest cities that have the highest rates of EV adoption were considered for Norway and China as well, as this will likely give the most robust estimate for where the EV transition has its greatest effect. In the case of China, while Beijing is the most populous city, Shanghai is the EV capital of China; touting Tesla's gigafactory, EV manufacturer Nio's headquarters, this city has seen a highest rates of EV adoption in the country (van Wyk, 2023). Investigating this unique city and its EV friendly policy will reveal the methods that fostered this growth.

A comparative approach similar to that used by Danielis (2023), would be feasible for this investigation. Danielis's method compares the total fiscal burden placed on the consumer when buying an EV versus a hybrid electric vehicle (HEV) after applying all relevant fiscal policies in different countries in Europe. This then shows if the country's fiscal policies are successful in making EVs economically competitive, which influences the country's EV adoption rates. For this study, the USA and China are considered, allowing comparison not only of fiscal policies, but effect of different levels of government involvement in the EV industry as well.

To analyze these policies, I will compare their effect on the total cost of acquisition and ownership of comparable car models over five years in each country. A base model Tesla 3 and a hybrid Toyota Corolla will be used, since a large portion of each country's population can afford one and this style of car is popular in each country. Statistical data used for this study are provided in Table I. Values in Table I were obtained on March 12, 2024, from Tesla's and Toyota's websites (Tesla, n.d.; Toyota, n.d.)

Table I – Statistical Data for Tesla Model 3 and Toyota Corolla Hybrid

CAR MODEL	TESLA MODEL 3 STANDARD RANGE RWD				TOYOTA COROLLA 1.8 HYBRID LE FWD			
CITY, COUNTRY	Los Angeles, USA	New York City, USA	Oslo, Norway	Shanghai, China	Los Angeles, USA	New York City, USA	Oslo, Norway	Shanghai, China
MSRP (EXC. TAX) (USD)	38990	38990	37522	29240	23500	23500	32375	23000
CO2 EMISSIONS (G/KM)	0.00				100.00			
NOX EMISSIONS (G/KM)	0.00				0.0035			
HP	257				140			
WEIGHT (KG)	1777.00				1295.00			
FUEL EFFICIENCY	13.5 kWh/100 km				4.4 L/100 km			

This data was used to calculate associated taxes and fees when purchasing and using the vehicle. Recent changes to EV policy will be mentioned in the analysis, as it is an important factor to consider for the overall fiscal burden.

The fiscal policies investigated in this paper can be split into two categories: *acquisition costs* and *ownership costs*. Acquisition costs include subsidies, tax credit, registration fees and sales tax/value added tax; expenses that are paid at the time of purchase. Ownership costs are associated with the annual fees for the license plate, taxes based on congestion, vehicle use taxes, and road improvement fees; expenses that are paid for the duration of the ownership and use of the vehicle, including fuel. These differ between countries and the specific policies in each category are detailed in Table II. These policies were compiled from the state or country's government websites detailing vehicle fees and other reporting agency websites (State of California Department of Motor Vehicles, n.d.; New York State Department of Motor Vehicles, n.d.; State Taxation Administration of The People's Republic of China, n.d.; The Norwegian Tax Administration, n.d.; Liu & Mayburov, 2023; European Alternative Fuels Observatory, European Commission, n.d.; California Department of Tax and Fee Administration, n.d.; New York City Department of Taxation and Finance, n.d.).

Table II – Taxes implemented on acquisition and ownership of cars in each country

	Acquisition Costs		Ownership Costs
City, Country	**Sales Tax/VAT**	**Registration Tax**	**Taxes and Fees**
Los Angeles, USA	9.5%	$71, $3 Alternative Fuel/Technology Fee, Annual Renewal	Highway Patrol, Vehicle License, Transportation Improvement, Road Improvement, misc. fees
New York City, USA	8.8%	Tax based on weight of vehicle, Biannual Renewal	Vehicle Use tax, Supplemental Metropolitan Commuter Transportation District, and Vehicle License fees
Oslo, Norway	25%, 0% for BEV	One-off tax based on vehicle weight, CO2 and NOx emission, and scrap	Greenhouse gas tax, Vehicle use tax replaced by insurance tax
Shanghai, China	17% VAT, 10% Purchase Tax	None	Vehicle Use tax, Vehicle License Plate fee

The policies from each country will be applied to the two vehicles to determine the cost to the consumer over a period of five years. In the US, ownership taxes and fees are paid when the registration is renewed, which is annually in LA and biannually in NYC.

The price of fuel and electricity over the five-year span will also be considered. Prices were determined using the average across the state/country, and it was assumed that EV users would charge at home at residential electricity prices and that vehicles were driven 5000 miles a year (International Energy Agency, 2023; Trading Economics, n.d.; Global Petrol Prices, n.d.; Northeast Information Offices, U.S. Bureau of Labor Statistics, n.d.; Statista, n.d.). This may cause an under/overestimation in fuel prices due to the size and road type in each city, as well as the type of driving. Mileage for the Model 3 was determined using the official power consumption per 100 kilometers value from the Norwegian website (Tesla, n.d.). The combined mileage from city and highway driving was used for the Corolla.

There are additional limitations in the statistical data. By using each country's MSRP instead of keeping it constant, it captures other factors affecting EV affordability, such as competition from other manufacturers, the purchasing power of the population, and political policies affecting the affordability of different vehicles. For example, prices can increase with the implementation of subsidies or decrease if they are removed. This means that while a BEV may be more expensive than the HEV in one country, keeping the price constant may make it more affordable in other countries. For this study, I prefer to consider the MSRP specific to each country, as it encapsulates the interplay between policymakers and companies, where companies are able to adjust their prices in response to policies. This makes for a more accurate representation of the political and economic landscape, and demonstrating if these two groups are working cohesively or not. This relates to the original objective of this paper, which is to analyze the effectiveness of policies in different countries at various stages of the EV transition, using the diffusion of technology framework.

Results

The fiscal policies in Table II were applied to the two vehicles, and graphs were created for each component of acquisition and ownership cost. Initial observations were made based on the gathered values, starting with LA and NYC in the USA, then Norway, and lastly, China.

Figure 1 depicts the tax applied upon initial purchase of the vehicle. For LA and NYC, sales tax is determined by the state's government and can vary in counties within the state, instead of a federally imposed VAT or purchase tax. For this reason, the county sales tax containing the most populated zip code was used, since it is more statistically likely that a purchaser would live in this area. EVs are exempt from the 25% VAT applied to the Corolla in Norway (Danielis, 2023). The Chinese policy dictates that both EVs and HEVs are subject to the VAT, but EVs are exempt from the purchase tax applied to all vehicle sales (Lo, Fan, Zhang, & Mi, 2022).

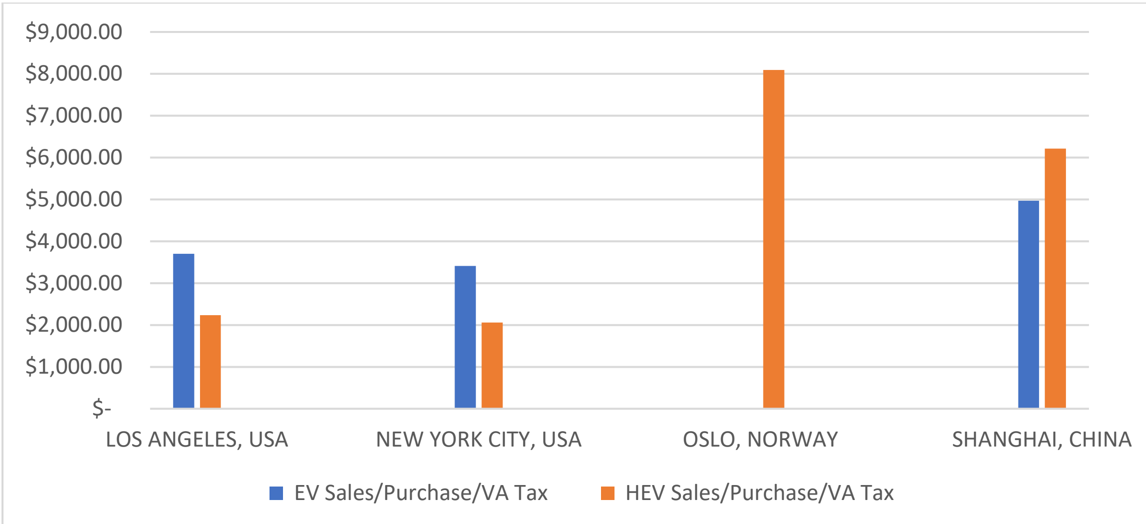

Figure 1: Sales, Purchase, and/or value-added tax for EVs and HEVs

In figure 2, the registration tax for each country is provided. In the US, registration fees are separated from the ownership fees but are paid at the same time when obtaining the original or renewed registration. Since 2023, Norway has reinstated the vehicle weight tax for EVs, to penalize heavier, more polluting cars. Tax exemptions for CO_2 and NO_x emissions as well as the greenhouse gas (air conditioning) tax are still in effect (The Norwegian Tax Administration, n.d.). Super-low emission vehicles like the hybrid Corolla are still taxed extremely heavily, placing favor on zero-emission vehicles (ZEVs). In China, I was unable to find a policy pertaining to a registration tax, but such a policy may exist behind a wall of fog.

Subsidies and tax credits are still in effect within the US to promote EV sales. A federal tax credit of 7500 USD to be applied on tax returns can be claimed upon purchase of an EV and state initiatives to provide subsidies for EV exist on a first-come, first-serve basis (Internal Revenue Service, n.d.). Funding for these subsidy programs comes from an annual funding plan developed by

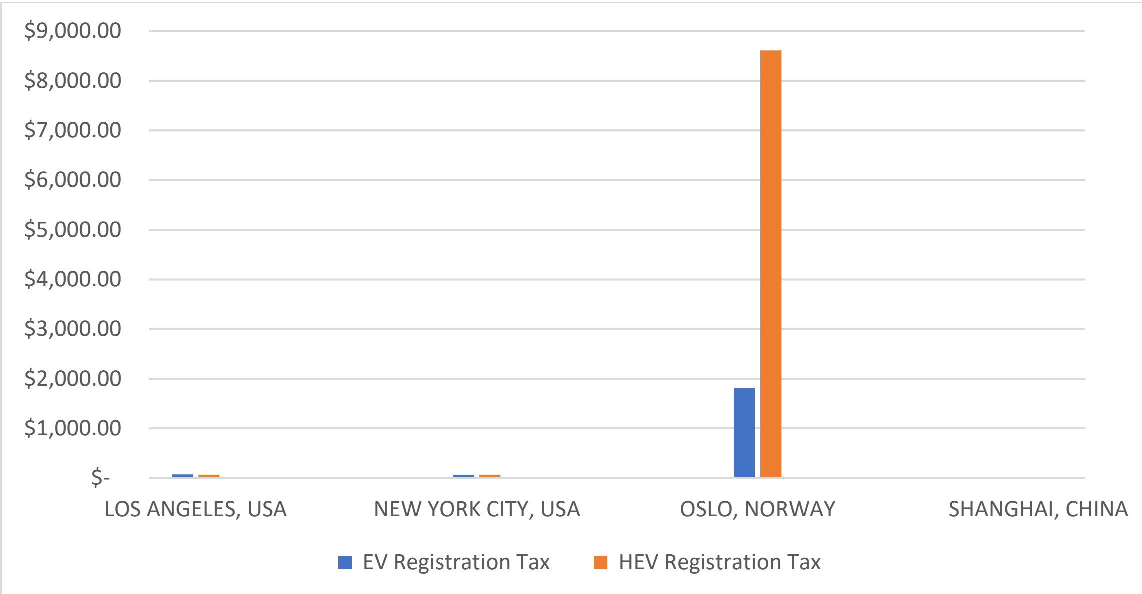

Figure 2: Registration Tax for EVs and HEVs

the state environmental protection agencies (Alternative Fuels Data Center, n.d.). For 2023, qualifying individuals can receive 2000 USD as a rebate. As of 2022, China removed EV subsidies, followed by Norway in 2023.

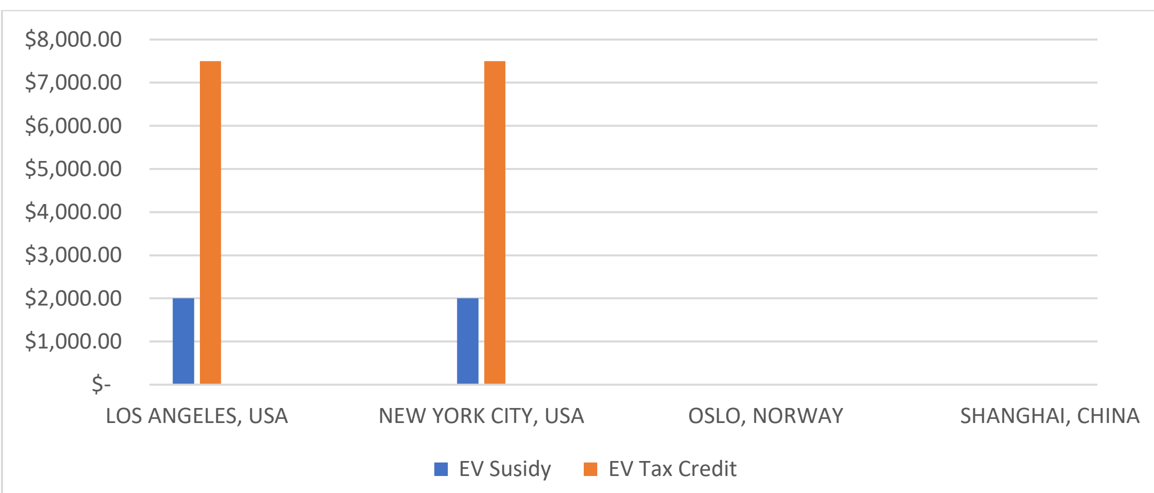

Figure 3: Subsidies and Tax Credits offered for EVs

Total acquisition costs for each vehicle comprised the MSRP and any sales and registration taxes minus subsidies and tax credits. Results are tabulated in figure 4. Without considering the ownership costs, Norway is the only country where the Model 3 costs less than the Corolla. The Model 3 is more competitive in China than in the US.

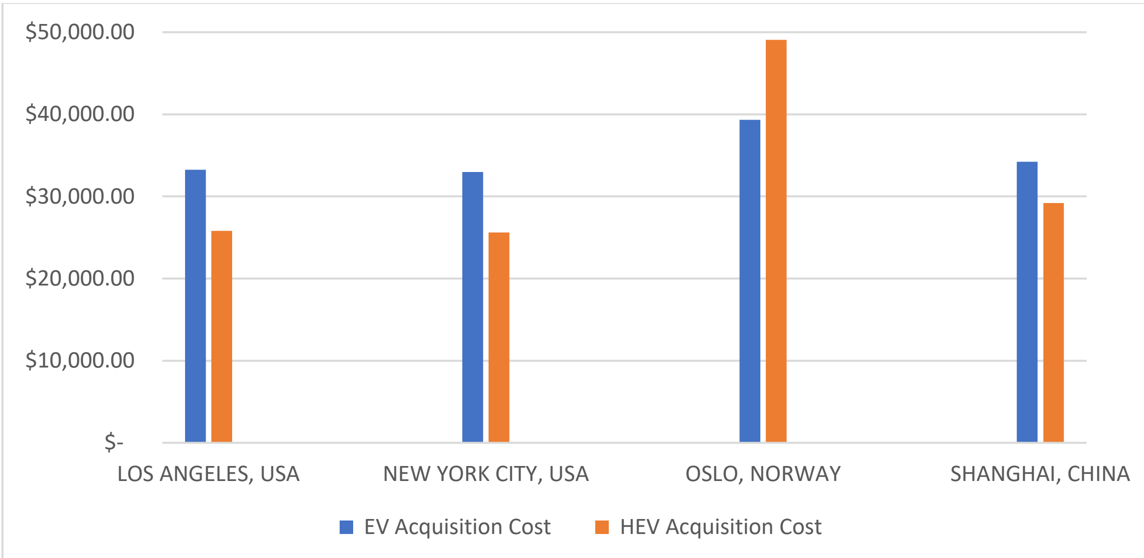

Figure 4: Total Acquisition Cost for EVs and HEVs

In figure 5, the total ownership costs over a period of 5 years are shown. Detailed values for each type of fee described in Table 2 can be found in the Appendix. An interesting finding is that

California charges a Vehicle License fee that is 0.65% of the value of the car, which was assumed to not depreciate over the period of ownership. This makes it more expensive to own an EV because of the higher MSRP. EVs are exempt from ownership tax in Norway. The are two values for Shanghai because of laws surrounding license plate distribution in China. To reduce the number of vehicles used in major cities, China has restricted the distribution of license plates. In Shanghai, residents need to enter an auction with hundreds of thousands of others to bid on available license plates, of which only a very small fraction win. From January 2021 to April 2022, the final bidding price for a plate soared to 93,190 CNY (14,336 USD). Prices hovered around 90,000 CNY over this period.

Another strategy implemented by residents was to buy a license plate outside the city for around 250 USD and drive it into Shanghai, but city officials have begun implementing stricter regulations.

The two values show the extremes of ownership costs, as this is a policy unique to China. EV owners receive a free plate, which is a massive incentive (Zhang, 2022).

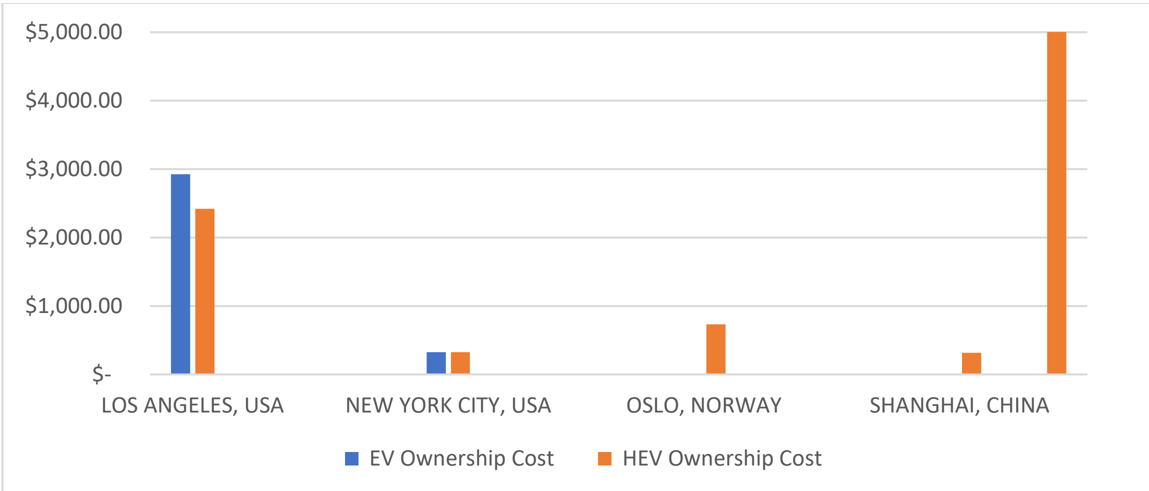

Figure 5: Total Ownership Cost for EVs and HEVs over a five-year period

Figure 6 denotes the total cost of fuel and electricity over 5 years and 25,000 miles driven. Tax was included in the fuel price for US cities, and additional excise duties were applied for Norway and China (International Energy Agency, 2023) (The Norwegian Tax Administration, n.d.). Tax on the residential prices of electricity were included for all countries. In all cases, the price of fuel is much higher than electricity. It should be noted that the price of fuel and electricity could fluctuate rapidly in response to the global oil and energy industries, but oil prices would need to drop unrealistically low to be comparable to electricity.

Finally, figure 7 shows the total fiscal burden for each vehicle, which was the sum of acquisition, ownership, and fuel/electricity costs. In the US, the fiscal burden of buying a Model 3 is greater than the Corolla. The opposite is true for Norway and China. It should be noted that if the MSRP of both vehicles was held constant, the Model 3 could have been cheaper in certain countries. Additionally, if the number of miles driven per year was greater, the savings on fuel would make EVs less expensive in countries where the prices are very close.

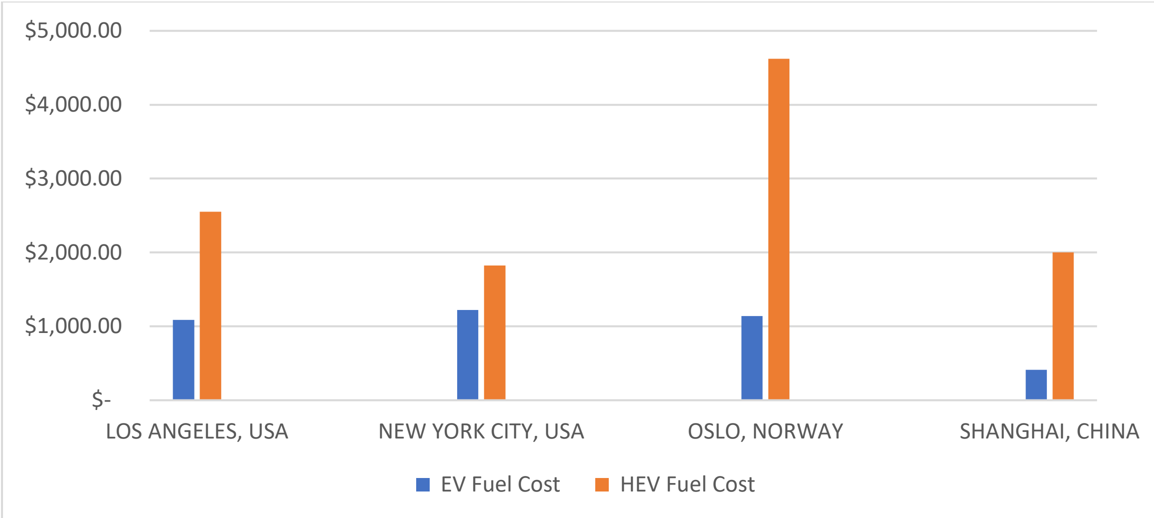

Figure 6: Total Fuel Cost for EVs and HEVs

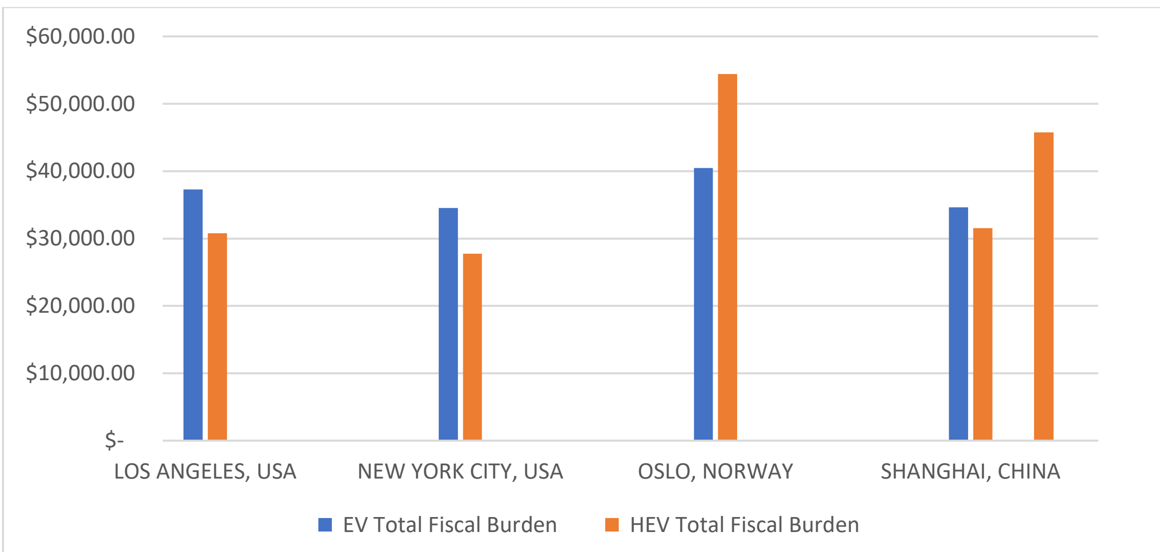

Figure 7: Total Fiscal Burden for EVs and HEVs

Discussion

From the results, Norway's strong fiscal measures have a positive effect on incentivizing EVs, even with the reinstatement of the weight tax. Norway has been scaling back their incentives for EVs by removing some tax exemptions and subsidies, as most of their new vehicle sales are now electric, but even so, this shows that taxes levied on ICEs still have a strong impact on the fiscal burden. The expense for owning even an HEV is markedly higher than an EV, showing that there is a strong emphasis on reducing the sale of ICEs in favor of EVs and ZEVs. This transition is highlighted by exempting EVs and ZEVs from all the taxes and fees placed on ICEs. By making it a national goal for all new vehicle sales to be ZEV by 2035, their fiscal policies have reflected this and have made EVs and ZEVs economically competitive.

From the Norwegian model, the most effective policy is the exemption from the large VAT applied to fuel cars and taxes paid for CO_2 and NO_x emissions, which alone account for around 15,000 USD in savings. These taxes would be even higher for larger, more polluting vehicles. This style of policymaking is aggressive, and with a European preference on smaller cars as opposed to SUVs and light-duty trucks, the emissions taxes make sense to implement without major pushback from car manufacturers or consumers. The difference between the fiscal burden for an HEV and an EV are the highest for Norway, and this corresponds with the high EV penetration rates seen in the Norwegian auto market (Chappell, 2021).

The next most competitive country for EVs is China. This country has seen a lot of evolution in the car industry in recent years, spurred by strong government policies. These policies have not only made manufacturing cheaper, but also incentivized electrification. Shanghai is also the location of Tesla's Gigafactory and Chinese electric automaker Nio; unsurprisingly, it is one of the largest EV markets in China. While specific prices for the Model 3 in Shanghai could not be obtained, Tesla's website claims they are ≥10,000 USD cheaper than other countries. With additional competition from Nio, prices could be even lower than that. Combined with fiscal policies that provide subsidies (since been removed in 2022) and tax exemptions, EVs are extremely favorable.

At this point, China is closer to Norway than the US in EV market maturity, as they have moved on from subsidies as the main incentive. Instead, the most effective policies are the 10% purchase tax exemption and the license plate cost. The license plate policy is very aggressive; it severely limits one's ability to drive a car while addressing concerns such as excess smog due to pollution and congestion within the city and promoting alternative modes of transportation. This can be considered an extreme way to regulate traffic, like how toll roads and congestion pricing are applied in high-density areas, but this policy would face many political challenges in other countries.

In the US, the lack of federal fiscal policies is replaced by state-wide policies. Comparing California to New York, there are many more fees and taxes implemented in California. These policies also differ from those of Norway and China; the presence of a subsidy shows that the EV market has not been substantially developed and EVs are not exempt from the sales tax or ownership fees. Additionally, fees must be paid whenever the registration is renewed, further adding to the fiscal burden. The MSRP of the Model 3 is also significantly higher than the Corolla; it is closer to a luxury sedan than a budget-friendly car, and this price difference affects the sales tax and any percentage-based fees applied to the car.

The fiscal policies enacted by the US are more passive and do not provide a strong incentive to purchase EVs. Instead of placing a fee or tax on more polluting vehicles, policies focus more on providing a small incentive to make EVs more affordable. However, a moderate portion of this incentive is negated by charging annual registration renewals and other miscellaneous fees, as in the case of California. Combined with the higher initial MSRP, EVs are not seen as competitive in the US auto market. The policies that regulate car ownership and those attempting to give benefits to EVs are not cohesive; to an extent, the policies counteract each other instead of complementing the benefits of EVs. In order for EVs to be competitive in the US, policies need to be refocused to negatively affect heavier and more polluting vehicles, which will highlight the main benefits of EVs. This can be accomplished by adapting and appropriately scaling the approaches employed by Norway, such as the emission or weight-based tax.

Conclusion

In conclusion, countries that have had the most effective policies to incentivize the EV transition utilize strong fiscal measures to either make EVs more competitive in price to HEVs and

ICEs or disincentivizing ICEs. One way this can be done is by offering subsidies that lower the MSRP of EVs, which has been implemented in all three of the chosen countries but have been more effective in Norway and China. In the US, the high price of EVs and fees associated with registering and driving a vehicle often offset the benefits offered by the subsidy. Additional measures, such as exempting EVs from these fees, could make subsidies more effective. Consideration of how fiscal policies work effectively together is important, as their benefits could be negated by other policies. As the EV market matures and stabilizes, countries often remove subsidies to recoup budget losses associated with those programs, but still implement tax benefits. Tax policies can be in the form of an emissions tax, a weight tax, or sales tax. By exempting EVs from taxes, these policies disincentivize heavier, more polluting cars and could even induce a shift in transportation modes for more efficient, higher capacity public transportation. In Norway and China, these methods have been effective for EV adoption even after subsidies have been removed. A caveat is that these policies often coincide with strong government action, which can be problematic to implement in other countries. Modifications can be made to usher in similar, lower-level policies that slowly ramp up, so that the market has time to adjust.

It was found that as countries progress along the EV transition, different policies are enacted that are effective in certain phases. The governing styles of each country also affect what policies can and cannot be enacted, but understanding what policies were the most effective can help develop policies that can be implemented in even the most unique situations.

Additional work can be done to further investigate how additional policies, such as road use tax, tolls, congestion charges in densely populated areas, and other benefits can help to offset the cost of an EV. The supply chain can also be investigated, to compare how China has been able to reduce the cost of producing an EV.

References

Alternative Fuels Data Center. (n.d.). *California Laws and Incentives*. Retrieved from https://afdc.energy.gov/laws/all?state=CA#Laws%20and%20Regulations

Alternative Fuels Data Center, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (n.d.). *Electricity Laws and Incentives in New York*. Retrieved from https://afdc.energy.gov/fuels/laws/ELEC?state=ny#:~:text=Electric%20Vehicle%20(EV)%20Rebate%20Program,of%20a%20new%20eligible%20EV.

California Department of Tax and Fee Administration. (n.d.). *California City and Country Sales and Use Tax Rates*. Retrieved from https://www.cdtfa.ca.gov/taxes-and-fees/rates.aspx

Chappell, B. (2021, October 8). 9 in 10 cars now being sold in Norway are electric or hybrid. *NPR*. Retrieved from https://www.npr.org/2021/10/08/1044330824/norway-electric-vehicle-car-sales-evs

Danielis, R. (2023). Fiscal Policies on New Passenger Cars in Europe: Implications for the Competitiveness of Electric Cars. *Sustainability, 15*(23), 16407. doi:10.3390/su152316407

EnergyBot. (n.d.). *Compare New York electricity rates*. Retrieved from https://www.energybot.com/electricity-rates/new-york#:~:text=Last%20updated%20March%202024,higher%20than%20the%20national%20average).

European Alternative Fuels Observatory, European Commission. (n.d.). *Incentives and Legislation, Norway*. Retrieved from https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/norway/incentives-legislations

Everett, R. (1962). *Diffusion of Innovations.* New York: The Free Press.

Global Petrol Prices. (n.d.). *Noway Gasoline Prices, 11-Mar-2024*. Retrieved from https://www.globalpetrolprices.com/Norway/gasoline_prices/

Graham, J. D., Belton, K. B., & Xia, S. (2021). How China Beat the US in Electric Vehicle Manufacturing. *Issues in Science and Technology, 37*(2), 72-79. Retrieved from https://issues.org/china-us-electric-vehicles-batteries/

Helveston, J. P. (2021). Why the US Trails the World in Electric Vehicles. *Issues in Science and Technology, 37*(2). Retrieved from https://issues.org/china-norway-ev-tesla/

IEA. (2023). *Global EV Outlook 2023.* Paris: IEA. Retrieved from https://www.iea.org/reports/global-ev-outlook-2023

Internal Revenue Service. (n.d.). *Credits for new and clean vehicles purchased in 2023 of after*. Retrieved from https://www.irs.gov/credits-deductions/credits-for-new-clean-vehicles-purchased-in-2023-or-after

International Energy Agency. (2023, February 9). *Fuel excise tax*. Retrieved from https://origin.iea.org/policies/16905-fuel-excise-tax

Jung, F., Schroder, M., & Timme, M. (2023). Exponential adoption of battery electric cars. *PLoS ONE, 18*(12). doi:10.1371/journal.pone.0295692

Liu, L., & Mayburov, I. A. (2023). China's Vehicle Tax System as a Prerequisite for Green Energy Transport Rollout. *Journal of Financial Studies and Research, 2023*(2023). doi:https://doi.org/10.5171/2023.951861

Lo, K. L., Fan, Y., Zhang, C., & Mi, J. J. (2022). Energy-saving and Emission Reduction Effects of China's Auto Tax Policy. *Procedia Computer Science, 214*(2022), 79-85. doi:10.1016/j.procs.2022.11.151

Ministry of Finance of the People's Republic of China. (2022, October 9). *Notice of the Ministry of Finance on releasing the 2023 energy conservation and emission reduction subsidy budget in advance*. Retrieved from https://jjs.mof.gov.cn/zxzyzf/jnjpbzzj/202211/t20221114_3851441.htm

New York City Department of Taxation and Finance. (n.d.). *Sales Tax*. Retrieved from The Official Website of the City of New York: https://portal.311.nyc.gov/article/?kanumber=KA-01675#:~:text=The%20total%20sales%20and%20use,tax%20rate%20of%204.0%20percent

New York State Department of Motor Vehicles. (n.d.). *Passenger vehicle registration fees, use taxes and supplemental fees*. Retrieved from https://dmv.ny.gov/registration/registration-fees-use-taxes-and-supplemental-fees-passenger-vehicles

New York State Energy Research and Development Authority. (n.d.). *Inflation Reduction Act: Vehicles*. Retrieved from https://www.nyserda.ny.gov/All-Programs/Inflation-Reduction-Act/Vehicles

Northeast Information Office, U.S. Bureau of Labor Statistics. (n.d.). *Average Energy Prices, New York-Newark-Jersey City - December 2023*. Retrieved from https://www.bls.gov/regions/northeast/news-release/averageenergyprices_newyork.htm#:~:text=New%20York%20area%20households%20paid,per%20therm%20a%20year%20earlier.

Santos, G., & Davies, H. (2020, July). Incentives for quick penetration of electric vehicles in five European countries: Perception from experts and stakeholders. *Transportation Research Part A: Policy and Practice, 137*, 326-342. doi:10.1016/j.tra.2018.10.034

State of California Department of Motor Vehicles. (n.d.). *Registration Fees*. Retrieved from https://www.dmv.ca.gov/portal/vehicle-registration/registration-fees/

State Taxation Administration of The People's Republic of China. (n.d.). *Vehicle Purchase Tax Law of the People's Republic of China*. Retrieved from https://www.chinatax.gov.cn/eng/c102441/c5211948/content.html#:~:text=Article%204%20The%20tax%20rate%20for%20vehicle%20purchase%20tax%20is%2010%25.

Statista. (n.d.). *Average household electricity prices in China from September 2020 to March 2023*. Retrieved from https://www.statista.com/statistics/1373587/household-electricity-price-china/#:~:text=Household%20electricity%20prices%20in%20China%20amounted%20to%207.6%20U.S.%20dollar,kilowatt%2Dhour%20in%20March%202023.

Statistics Norway. (2024, February 15). *Electricity Prices*. Retrieved from https://www.ssb.no/en/energi-og-industri/energi/statistikk/elektrisitetspriser

Tesla. (n.d.). *Your Model 3*. Retrieved from Tesla: https://www.tesla.com/no_no/model3/design#payment

The Norwegian Tax Administration. (n.d.). *Road tax on fuel*. Retrieved from https://www.skatteetaten.no/en/business-and-organisation/vat-and-duties/excise-duties/about-the-excise-duties/road-tax-on-fuel/

The Norwegian Tax Administration. (n.d.). *What is the one-off registration tax?* Retrieved from https://www.skatteetaten.no/en/person/duties/cars-and-other-vehicles/importing/which-duties-do-you-have-to-pay/one-off-registration-tax/what-is-the-one-off-registration-tax/

Toyota. (n.d.). *2024 Corolla Full Specs*. Retrieved from Toyota: https://www.toyota.com/corolla/2024/features/mpg/1882

Trading Economics. (n.d.). *China Gasoline Prices*. Retrieved from https://tradingeconomics.com/china/gasoline-prices

van Wyk, B. (2023, May 18). *China's Top 15 electric vehicle companies*. Retrieved from The China Project: https://thechinaproject.com/2023/05/18/chinas-top-15-electric-vehicle-companies/

Zhang, P. (2022, April 23). In Shanghai, people are still more than willing to pay $14,230 to get a fuel license plate. *CNEVPOST*. Retrieved from https://cnevpost.com/2022/04/23/in-shanghai-people-still-more-than-willing-to-pay-14230-to-get-a-fuel-license-plate/

Appendix

Table III – Acquisition, Ownership, and Fuel Costs for Tesla Model 3 and Toyota Corolla Hybrid LE in Los Angeles, California, USA

		LOS ANGELES, CA, USA	
ACQUISITION COSTS	**ACQUISITION COSTS**	TESLA MODEL 3	TOYOTA COROLLA
	MSRP	$ 38,990.00	$ 23,500.00
	SALES TAX	$ 3,704.05	$ 2,232.50
	REGISTRATION	$ 74.00	$ 71.00
	SUBSIDY	-2000.00	$ -
	TAX CREDIT	-7500.00	$ -
TOTAL	**TOTAL**	**$ 33,268.05**	**$ 25,803.50**
OWNERSHIP COST FOR 5 YEARS			
YEARLY	HIGHWAY PATROL	$ 32.00	$ 32.00
YEARLY	VEHICLE LICENSE	$ 253.44	$ 152.75
YEARLY	TRANS. IMPRV.	$ 194.00	$ 194.00
YEARLY	OTHER FEES	$ 11.00	$ 11.00
AFTER 1 YR	ROAD IMPROV.	$ 118.00	$ 118.00
TOTAL		**$ 3,220.18**	**$ 2,704.75**
TOTAL ACQUIS. AND OWNER.		**$ 36,488.23**	**$ 28,508.25**
FUEL PER 1000 MILES			
	PRICE + TAX	$ 0.20	$ 4.90
	MILEAGE	69.26	48.00
TOTAL		**$ 43.47**	**$ 102.08**
OVERALL FISCAL BURDEN			
	ACQUIS. COST	$ 33,268.05	$ 25,803.50
	OWNERSHIP	$ 3,220.18	$ 2,704.75
	FUEL, 5K MILES/YR	$ 1,086.75	$ 2,552.08
TOTAL		**$ 37,574.98**	**$ 31,060.33**

Sources: Alternative Fuels Data Center, n.d.; State of California Department of Motor Vehicles, n.d.; California Department of Tax and Fee Administration, n.d.; Internal Revenue Service, n.d.

Table IV - Acquisition, Ownership, and Fuel Costs for Tesla Model 3 and Toyota Corolla Hybrid LE in New York City, New York, USA

	NEW YORK, NEW YORK, USA	
ACQUIS. COST	TESLA MODEL 3	TOYOTA COROLLA
MSRP	$ 38,990.00	$ 23,500.00
SALES TAX	$ 3,411.63	$ 2,056.25
REGISTRATION	$ 66.50	$ 66.50
SUBSIDY	-$2,000.00	$ -
TAX CREDIT	-$7,500.00	$ -
TOTAL	**$ 32,968.13**	**$ 25,622.75**
OWNERSHIP COST FOR 5 YEARS		
USE TAX (YEARLY)	$ 15.00	$ 15.00
SUPPL. METRO. COMMUTER TRANS	$ 25.00	$ 25.00
VEHICLE LICENSE	$ 25.00	$ 25.00
	$ -	$ -
	$ -	$ -
TOTAL	**$ 458.00**	**$ 458.00**
TOTAL ACQUIS. AND OWNER.	**$ 33,426.13**	**$ 26,080.75**
FUEL PER 1000 MILES		
PRICE + TAX	$ 0.24	$ 3.50
MILEAGE	69.26	48.00
	$ 52.16	**$ 72.92**
ACQUIS. COST	$ 32,968.13	$ 25,622.75
OWNERSHIP	$ 458.00	$ 458.00
FUEL, 5K MILES/YR	$ 1,304.10	$ 1,822.92
TOTAL	**$ 34,730.23**	**$ 27,903.67**

Sources: Alternative Fuels Data Center, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, n.d.; New York City Department of Taxation and Finance, n.d.; New York State Department of Motor Vehicles, n.d.; New York State Energy Research and Development Authority, n.d.; EnergyBot, n.d.

Table V - Acquisition, Ownership, and Fuel Costs for Tesla Model 3 and Toyota Corolla Hybrid LE in Oslo, Norway

	OSLO, NORWAY, EUROPE			
ACQUIS. COST	TESLA MODEL 3	TOYOTA COROLLA		
MSRP	$ 37,522.00	$ 32,375.00		
VALUE ADDED TAX	$ -	$ 8,093.75		
REGISTRATION	$ 1,817.00	$ 8,610.00		
SUBSIDY	$ -	$ -		
TAX CREDIT	$ -	$ -		
TOTAL	**$ 39,339.00**	**$ 49,078.75**		
OWNERSHIP COST FOR 5 YEARS				
GREENHOUSE GAS TAX FOR A/C	$ -	$ 146.40		
TOTAL	**$ -**	**$ 732.00**		
TOTAL ACQUIS. AND OWNER.	**$ 39,339.00**	**$ 49,810.75**		
FUEL PER 1000 MILES				
PRICE + TAX*	$ 0.21	$ 2.61	(6 NOK/kWh)	$/l
MILEAGE	69.26	4.40	L/100KM	
	$ 45.64	**$ 184.89**	**excise duties = $0.44/l**	
ACQUIS. COST	$ 39,339.00	$ 49,078.75		
OWNERSHIP	$ -	$ 732.00		
FUEL, 5K MILES/YR	$ 1,141.09	$ 4,622.31		
TOTAL	**$ 40,480.09**	**$ 54,433.06**		

Sources: The Norwegian Tax Administration, n.d.; European Alternative Fuels Observatory, European Commission, n.d.; Global Petrol Prices, n.d.; Statistics Norway, 2024

Table VI - Acquisition, Ownership, and Fuel Costs for Tesla Model 3 and Toyota Corolla Hybrid LE in Shanghai, China

	SHANGHAI, CHINA		
ACQUIS. COST	TESLA MODEL :	TOYOTA COROLLA	
MSRP	$ 29,239.32	23000	
VAT	$ 4,970.68	$ 3,910.00	
PURCHASE TAX	$ -	$ 2,300.00	
SUBSIDY	$ -	$ -	
TAX CREDIT	$ -	$ -	
TOTAL	**$ 34,210.00**	**29210**	
OWNERSHIP COST FOR 5 YEARS			
VEHICLE USE TAX	$ -	$ 66.78	
VEHICLE LICENSE	$ -	250.00	14500.00
	$ -	0.00	
	$ -	0.00	
TOTAL	**$ -**	**316.78**	**14500.00**
TOTAL ACQUIS. AND	**$ 29,526.78**	**29526.78**	**37566.78**
FUEL PER 1000 MILES			
PRICE + TAX	$ 0.08	$ 1.13	
MILEAGE	69.26	4.40	
	$ 16.52	**$ 80.05**	
ACQUIS. COST	$ 34,210.00	29210.00	29210.00
OWNERSHIP	$ -	316.78	14500.00
FUEL, 5K MILES/YR	$ 412.97	2001.23	2001.23
TOTAL	**$ 34,622.97**	**31528.01**	**45711.23**

Sources: Ministry of Finance of the People's Republic of China, 2022; State Taxation Administration of the People's Republic of China, n.d.; Trading Economics, n.d.; Statista, n.d.; Lo et al., 2022; Liu and Mayburov, 2023; Zhang, 2022