36th International Electric Vehicle Symposium and Exhibition (EVS36)
Sacramento, California, USA, June 11-14, 2023

EV Supply Modelling: Implications of Global EV Adoption Targets for Mexico's Light-Duty Auto Industry

Francisco Pares[1,2], Pablo Busch[1,2], Minal Chandra[1], Gil Tal[1]
[1] *University of California at Davis, Electric Vehicle Research Center, address, email*
1605 Tilia Street, Davis, CA, 95616
[2]*Ph.D Student, Energy Graduate Group*

Email: fapares@ucdavis.edu

Executive Summary

To reduce greenhouse gas emissions, developed nations are increasingly adopting electrification for the light-duty (LDV) sector. This shift is both a challenge and an opportunity for vehicle producers worldwide. Estimating the implications of rising demand requires understanding the current global LDV supply and the effect of international goals. To help design policies facilitating the EV transition, we develop the MOdel for iNternational Ev Trade (MONET) using data from 2013-2021.We then use it to perform scenario analyses of future demand changes focusing on the Mexican auto industry as a major supplier to the North American market. We find that Mexico's light-duty vehicle LDV market will remain relatively stable in size, with a maximum estimated growth of 33% from 3.8 million in 2019. However, the EV market is expected to expand significantly, representing between one third to 45% of all LDV production required by 2035.

Keywords: Electric vehicle supply, supply chain, global, policy, modeling.

1 Background and Motivation

Roadmaps to meet greenhouse gas (GHG) emissions reduction targets in industrialized nations increasingly include extensive vehicle electrification as an efficient, clean, and comfortable transportation decarbonization solution, particularly for the light-duty sector. For vehicle producers around the world, this shift represents both, a challenge to adapt their operations to meet consumer demands, and an extraordinary opportunity to rethink business as usual and restructure production and supply chains to become leaders in the development and sales of clean transportation technology.

The Mexican auto industry is the fifth largest light duty vehicle (LDV) exporter in the world, the single largest foreign supplier to the US[1] with close to 15% of the market, and a significant contributor to the Canadian, European, and South American markets.

Representing close to 1 million direct jobs, attracting nearly 20% of the country's foreign direct investment (FDI), and contributing roughly 4% of the gross domestic product with a revenue surplus of US $77 billion in 2021[2], as depicted in **Figure 1**, it is hard to overstate how critical the Mexican automotive industry has become for the national economy in the past 15 years.

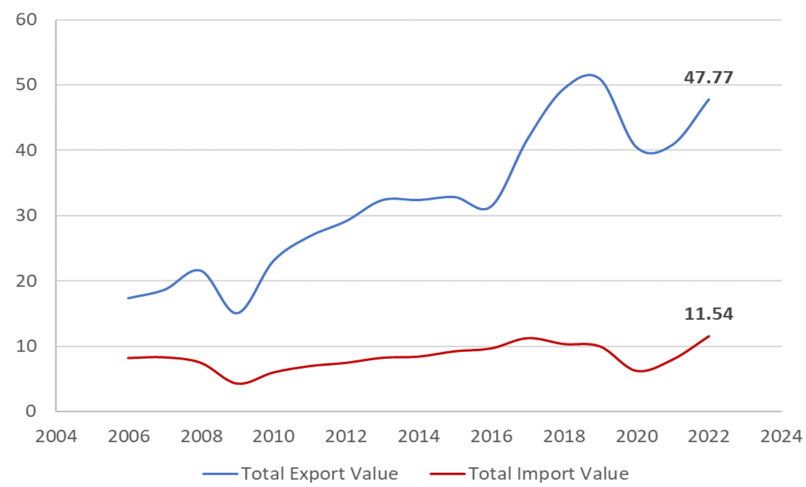

Figure 1: *Mexico International Vehicle Commerce: Net Monthly Cash Flow ($ in Billions)* [2]

The remarkable revenue surplus that Mexico has experienced from the automotive industry can be explained by a national and regional industrial policy that has geared automotive production towards serving the export market rather than the internal demand[3]. As a result of this strategy, production tagged for export has risen from 70% in 2005 to a historical maximum of 91% in 2021[1]. Mexico's automotive industry attracts foreign currency through selling premium vehicles in the export market and supplying the internal market with low-cost imports. In 2021, for example, Mexico exported close to 2.2 million vehicles with a weighted average unit price of approximately US $20,000, primarily to the US, while it imported a comparatively small 0.65 million vehicles with a weighted average unit price of close to US $13,000 with the US, India, China, and Japan as the leading sources[4].

1.1 Current Mexican auto industry landscape and near-term plans

The automotive industry in Mexico has shown growth in vehicle production volumes since 2010, with a peak of nearly 4 million LDV units produced in 2017. **Figure 2** shows the total LDV production for 2022 by the major OEMs operating in the country, highlighting their relative shares of the global and regional supply. On average, Mexico supplies close to 10% of global manufacturing for these major OEMs. However, when examining the regional supply figures, it becomes clear that the OEMs have made significant investments in developing capacity in Mexico. For example, nearly 50% of Nissan's total production in the region, 25% of GM and Stellantis, and 75% of VW's production in the region come from Mexico[5].

Only four OEMs have started large-scale production of EVs in Mexico, with only one fully Battery Electric Vehicle (BEV) model, namely the Mustang Mach-E, three Plug-in Hybrid Electric Vehicles (PHEVs), including the BMW 3 series, the Audi Q5, and Q5 Sportback[5]. Additionally, with a very nascent and comparatively small production in the country, JAC has made some important investments in the country and rolled out a suite of three full BEVs and three PHEVs in 2020[5], [6].

OEMs operating in the country have begun announcing significant investments to update their existing material and human infrastructure to accommodate the transition and position themselves as early suppliers to the North American market. Most notably, in 2019, Ford spearheaded the initiative and launched the production of its first fully electric light-duty vehicle, the Mustang Mach-E, reaching 65,000 units produced in 2021 with plans to expand to 200,000 units by 2023[7]. Additionally, companies from around the world providing EV ancillary products and services such as, charging stations[8], battery manufacturing[9]–[11] or lithium mining[12], [13] are also announcing their investments in Mexico to support and capitalize on the development of the industry.

Mexico's low production costs, robust trade infrastructure, strategic geographic location at the doorstep of one of the most vigorous consumer markets in the world, as well as its membership in a number of trade partnerships, most notoriously the United States-Mexico-Canada Agreement (USMCA), puts the country in a privileged position to leverage the rapid transition nations are undertaking to meet emissions targets, particularly as the US adopts a nationwide goal for EVs to make up 50% of its roughly 17 million yearly vehicle sales by 2030[14].

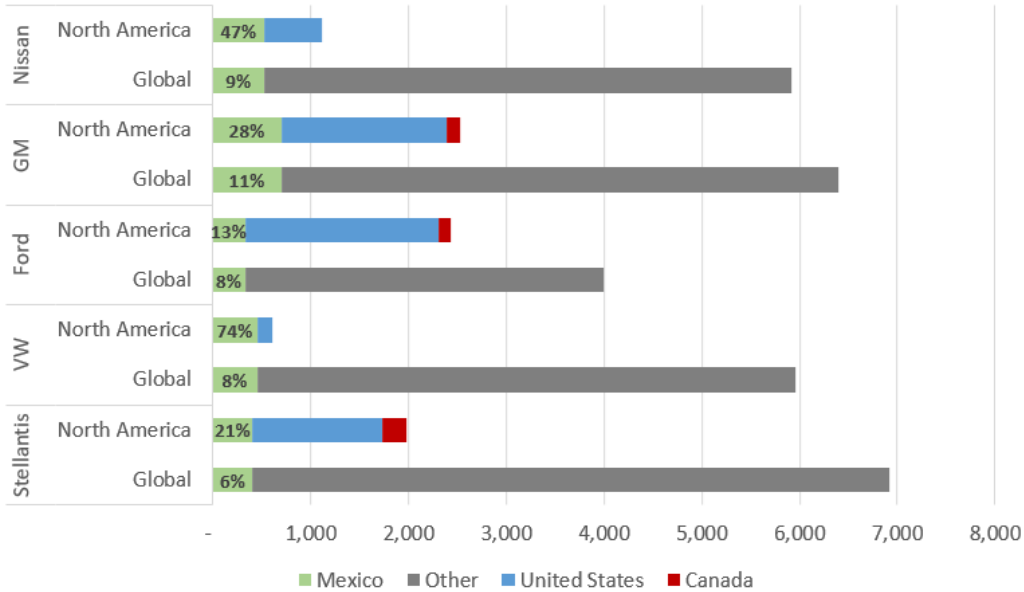

Figure 2: *Mexico's 2022 total LDV production by major OEM operating in the country (in thousands), and the share of global and regional production it represents.*

Understanding the current global supply and demand of LDVs and the impact of international agreements and EV adoption policies, especially in Mexico's largest export markets, are critical to estimate the impact of producing EVs and related products on Mexico's economy, environment, labor, and workforce education needs. Our research aims to provide information and tools to help design public policy to support the country's capacity to respond to the global shift to EVs and leverage its position for success. To do this, we developed a global LDV supply model capable of analyzing different propulsion technologies and performing scenario analyses of future demand changes for Mexico, the North American region, and the world.

2 MONET

The MOdel for iNternational Ev Trade (MONET) is a global LDV supply model. It includes all nations worldwide, aggregated into 65 individual countries and aggregate regions (henceforth countries). MONET has been conceived as a tool to inform policy and industrial strategic planning, allowing for testing, and analyzing different global EV adoption scenarios and the impact of demand adjustments given international EV adoption goals and policies for individual countries or regions over time.

We have identified three broad modeling categories that informed our research: (1) Integrated energy and transportation system models[15]–[17], (2) Electric Vehicle Supply Chain and Demand Models[18]–[20], and (3) Global Trade Models[21]–[23]. Building on existing literature, MONET addresses multiple gaps in the current landscape of global transportation, demand, and trade models. First, while all the analyzed models focus on the demand side of transportation, MONET also provides insight into the supply side. Second, MONET is designed for LDV and EV market analysis, while with most of the analyzed models focus on the supply chain for batteries for EVs and/or the raw materials to build them. Third, available literature on international EV demand growth fails to account for international trade relationships, potentially resulting in an inaccurate understanding of the regional market supply composition and may lead to critical misrepresentations of future market scenarios. MONET is the first to account for global trade relationships in scenario planning for global EV demand and the necessary supply required to meet it. Fourth, a big contribution of MONET is the ability to spatially connect supply and demand data for vehicles using the current network of international trade relationships. Lastly, the realization of accurate LDV trade flows also enables the quantification and tracking of valuable EV components, including lithium-ion battery critical materials, throughout the global supply chain.

3 Methods

Figure 3 illustrates the modeling process for MONET. First, available datasets are harmonized and merged to produce a unified global LDV supply and demand dataset. Then, countries' production and sales values are combined with their corresponding global trade data in a bilateral trade matrix (BTM), and calibrated using the RAS matrix balancing algorithm[24] to estimate trade volumes, regions of origin, regions of destination, and the relationship between global demand and the required supply of vehicles. A new matrix is then created containing the ratios of each element in the BTM to its corresponding regional sales, serving as a tool to calculate required regional supply adjustments in response to variable global demand inputs based on base year market conditions. Finally, this tool allows us to create a scenario family that accounts for international agreements and EV adoption policies, adjust market assumptions, and focus on different regions and trade interdependencies.

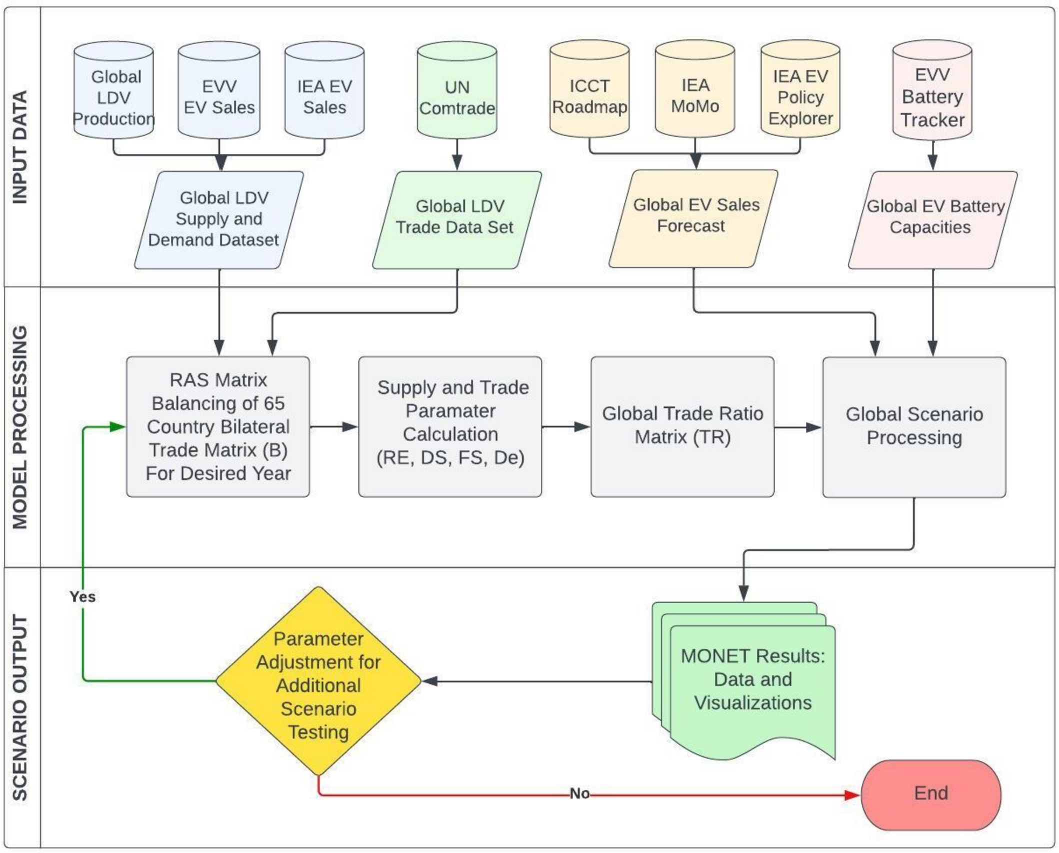

Figure 3: *MONET Operation Flow diagram*

3.1 LDV Production and Sales Data Set

3.1.1 LDV Production and Sales Data Set

The LDV Production and Sales dataset is contains information on the production and sales of vehicles from 2013-2021 for the 65 countries in MONET. The dataset includes the variables year, region, ISO country codes, country name, brand, model, type of propulsion (ICE, BEV, or PHEV), quantity produced or sold, and a binary variable indicating whether the entry refers to a sale or production.

Input Data

1. **Global Production data**[25]
   Contains data on worldwide LDV production from 2001 - 2023, including annual vehicle, engine, and powertrain production per country, and detailed technical information about vehicle models produced such as battery capacity and engine power output.

2. **IEA EV Sales and Total Market Share data**[26]**:**
   Includes annual EV and PHEV unit sales per country from 2013 - 2022 broken down by make, model, and propulsion.
3. **EV Volumes: EV Sales data**[27]**:**
   Includes annual EV, PHEV unit sales from 2011 - 2020 in the 30 major country markets, representing around 80% of total global sales. Also includes 4 aggregated major regions: World, EU, Other EU, and Rest of the World. Particularly interesting from this data set is the percent different EV sales represent out of total country LDV sales. This information is helpful to calculate ICE vehicle sales in different markets.

3.1.2 Global LDV Trade Data Set

The Global LDV Trade dataset contains information on the trade of vehicles between countries around the world. The dataset includes the variables source and target regions, country names, and ISO country codes, the quantity of vehicles traded between countries and a binary variable indicating whether the entry refers to an import or export.

Input Data

We used Comtrade[4] to extract the 2019 vehicle import and export volumes for all available countries. Comtrade is a United Nations (UN) repository of official trade statistics collected and submitted by national customs authorities and managed by the United Nations Statistics Division (UNSD). Additionally, we obtained the 2019 import and export data for North American countries from the Mexican Automotive Industry Association (AMIA)[28] and Mexico's National Institute for Geography and Statistics (INEGI)[5], the United States International Trade Commission (USITC)[29], and the Canadian International Merchandise Trade (CIMT)[30] to validate the accuracy of the volumes provided by Comtrade.

3.1.3 Global EV and LDV Sales Forecast

The Global EV and LDV Sales Forecast are vectors of demand by country by 2035, predicted using key international policies and measures for EV deployment, including legislation, targets, and ambitions.

Input Data and Information

1. **ICCT Roadmap**[15] **and IEA MoMo**[16]**:** The data from the ICCT and MoMo consist of future LDV sales projections for the year 2050 for different countries and regions of the world.
2. **IEA Global EV Policy Explorer**[31]**:** This tool highlights key policies and measures that support the deployment of EVs and zero-emission vehicles (ZEVs) for light and heavy-duty vehicles. It summarizes current measures as well as announced targets and ambitions by region and country.

3.2 Bilateral Trade Matrix

Using the *Trade dataset*, we create a two-dimensional square array indicating the exporting regions on the vertical axis, the importing regions on the horizontal axis, and the trade volumes between them. This bilateral trade matrix provides broad information on the LDV supply and demand interdependencies between the different countries.

From the *Production and Sales* data set*,* we extract the 2019 (pre COVID-19 pandemic market disruptions) production volumes **(*P*)** and sales volumes **(*S*)** for all countries. We then calculate a correction factor (***Cf***) by dividing aggregate production ($\sum \boldsymbol{P}$) by aggregate sales ($\sum \boldsymbol{S}$), eq **(1),** and apply it to ***P*** to balance the model input and output volumes.

$$\boldsymbol{Cf} = \frac{\sum \boldsymbol{P}}{\sum \boldsymbol{S}} \qquad (1)$$

3.3 Reconciling global trade volumes through RAS Matrix Balancing

Global trade data is notorious for presenting conflicting information between the export volumes of a product reported by a country and the volumes reported by the importing counterpart countries[32]. To reconcile the data in the BTM, adjusting the volumes of trade for each country to fit the observed ***S*** and ***P*** values for 2019 while also matching the total reported exports volumes (***E***) per country, we employed the RAS matrix balancing algorithm. To obtain vector ***E***, we assume exports for each of the 65 countries in our analysis equal to the sum of the reported imports from their 64 counterpart countries to minimize inaccuracies or biases in the trade data. Assuming a perfect balance of goods as shown in **Figure 4(A)**, we calculate target import values (***I***) such that no country has a surplus flow without a corresponding deficit. Hence, we derive eq **(2)**.

$$\boldsymbol{I} = \boldsymbol{S} + \boldsymbol{E} - \boldsymbol{P} \tag{2}$$

Using the calculated vectors ***E*** and ***I***, we apply RAS to produce a balanced BTM ***B*** where the sum of each row equals its corresponding value in ***E***, and the sum each column its corresponding value in ***I***.

3.4 Accounting for Re-exports, Domestic Supply, and Domestic Exports

A common practice in international trade is to import goods from one country and then export them to another country without changing the nature or form of the goods. This practice is known as re-exporting. Re-exporting can improve market access for certain countries by facilitating the movement of goods, but it also creates statistical discrepancies in trade data because, typically, when a country re-exports previously imported goods, these are recorded as exports even though they were not produced domestically[33]. This can distort trade statistics and make it difficult to accurately track the origin and destination of goods in international trade, especially given the varying rules that different countries have for classifying and reporting re-exports.

A widely used practice in international trade analysis to resolve this issue is to apply an assumption of proportionality[34], [35] in which imports destined for re-exports (***RE***) may be estimated by applying the ratio of ***E*** over the total inputs to the country (***P+I***), **eq (3)**. Correspondingly, imports for domestic consumption (**FS**), may be estimated by applying the ratio of ***S*** over ***P+I***, **eq (4)**. The assumption also allows estimating the proportion of domestic production destined to supply the local market (***DS***) by applying the ratio of ***S*** over the ***P+I***, **eq (5)** as well as the proportion of domestic production destined to be exported (***DE***) by applying the ratio of ***E*** over ***P+I***, **eq (6)**. **Figure 4(B)** illustrates the assumption of proportionality and the resulting trade parameter calculations:

$$\boldsymbol{RE} = I * E/P + I \tag{3}$$

$$\boldsymbol{FS} = I * S/P + I \tag{4}$$

$$\boldsymbol{DS} = P * S/P + I \tag{5}$$

$$\boldsymbol{DE} = P * E/P + I \tag{6}$$

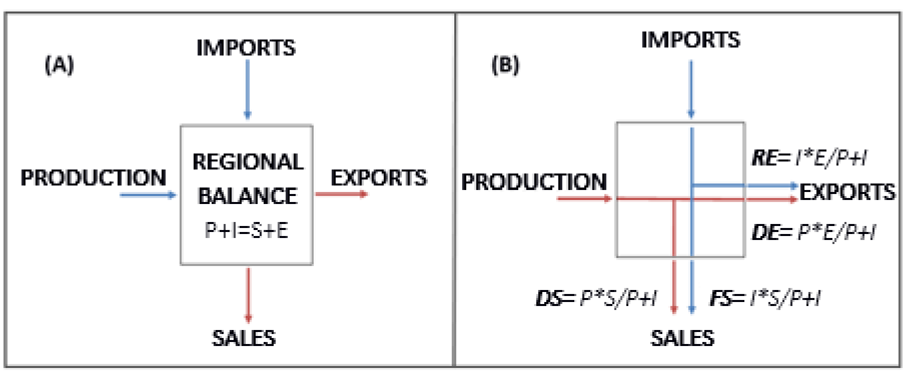

***Figure 4**: Diagram illustrating the regional input/output balance of vehicles**(A)**. Diagram illustrating the application of the proportionality assumption **(B)**.*

Applying this process across all regions, we can remove re-export values from the original balanced import-export matrix ***B***, effectively obtaining a new matrix ***F*** in which column values now exclusively represent imports destined to be sold in importing countries, ***FS***, and row values represent countries' domestic exports, ***DE***. We then assign ***DS*** to the diagonal of ***F*** such that the row sums are exactly equal to ***P*** and the column sums exactly equal to ***S***, as illustrated in **Figure 4(B).**

Finally, using element-wise division, we calculate a new matrix ***TR*** composed of the ratios of each element of the columns to the corresponding given value of ***S***, **eq (7)**. That is, the ratio of a country's domestic supply or imports received from a trade partner to the total sales recorded in the country.

$$\boldsymbol{TR} = \boldsymbol{F} \oslash \boldsymbol{S} \tag{7}$$

3.5 Vehicle Production Allocation

TR serves as a tool to calculate the required regional production adjustments in response to variable global demand inputs, based on current market conditions and trade relationships. In mathematical terms, ***TR*** allows us to estimate a scenario specific vector of production $\boldsymbol{P_s}$ using a sales vector $\boldsymbol{S_s}$ through **eq (8).**

$$\boldsymbol{P_S} = \boldsymbol{f}\ (\boldsymbol{S_S}, \boldsymbol{TR}) \tag{8}$$

The following steps are required to apply **eq (8)**:

1. Multiply ***TR*** by a given sales vector (a demand scenario) to obtain a scenario specific matrix $\boldsymbol{F_s}$:

$$\boldsymbol{F_S} = \boldsymbol{TR} \odot \boldsymbol{S_S} \tag{9}$$

2. Estimate the production $\boldsymbol{P_s}$ of each country by calculating the sum of each row of ***Fs*** as:

$$\boldsymbol{P_S} = \boldsymbol{DS_S} + \boldsymbol{DE_S} \tag{10}$$

3. Estimate total exports by country $\boldsymbol{E_s}$ to fit $\boldsymbol{P_s}$ through:

$$\boldsymbol{E_S} = \boldsymbol{P_S} + \boldsymbol{FS_S} - \boldsymbol{S_S} \tag{11}$$

4. Balance $\boldsymbol{F_s}$ using RAS with marginal targets $\boldsymbol{E_s}$ and $\boldsymbol{FS_s}$ to reconcile all values in the new BTM.

3.6 Scenarios for EV 2035 production allocation

We created four distinct production allocation scenarios by varying trade relationship assumptions as follows:
S1 - Constant 2019 LDV Trade Ratios: Trade relationships in this scenario are derived from the 2019 LDV international market. The main assumption is that EV international trade relationships in 2035 will resemble the 2019 LDV relationships.
S2 - Higher domestic supply: Using the 2019 LDV TR matrix as a base, this scenario assumes each country with production capacity increases its domestic supply by 40% thus, decreasing imports in each country proportionally to maintain balance.
S2b – Higher domestic supply + Free Trade USMCA: This scenario is similar to S2 in all aspects with the exception that we allocate the increase in domestic supply of the United States between USMCA partner countries in a proportion relative to their current production.
S3 - Global free trade: This scenario considers an increase in the trade flows among countries. We first identify the top twelve countries that produce EV for exports in 2021 and their relative share of the EV global market. Then, we allocate 50% of future country demand supplied by imports among these 12 specialist countries proportional to their current share of the EV global market exports. Effectively, in this scenario, global trade flows are expanded while concentrating supply within specialist countries.

4 Results

4.1 Global light duty vehicle demand forecast for 2035

Figure 5 projects global LDV and EV demand for 2035, with China having the highest projected demand at 34 million LDVs, of which 21.5 million are EVs. The US follows with a demand of 16.6 million LDV, nearly 10 million of which are EVs. Japan and EU countries like Germany, France, the UK, and Italy also show significant EV demand. We estimate global LDV sales to grow 34% between 2019 and 2035, with most of the growth concentrated in emerging markets, such as Middle East/Africa (208%), South Asia (81%), and South America (115%) while more mature markets will slightly reduce their overall LDV demand. Thus, in mature markets, the growth in EV demand will come entirely from a shift in the industry rather than the growth in total LDV sales.

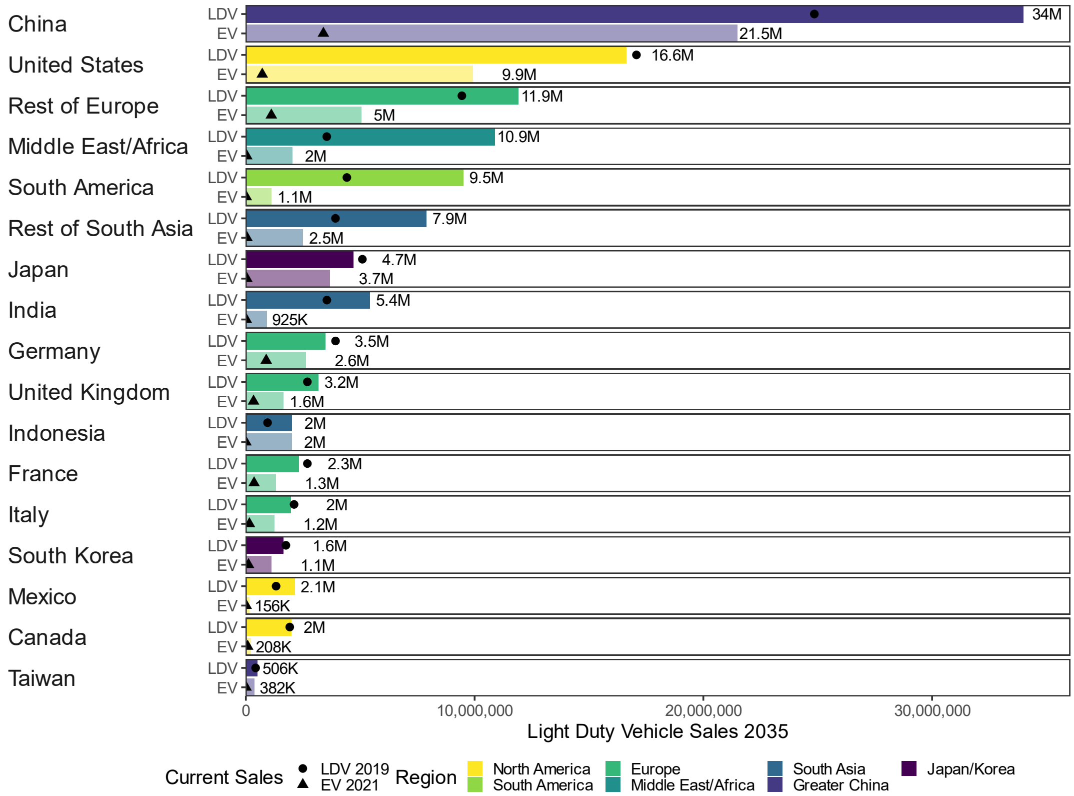

__Figure 5:__ Projected demand for light duty vehicles in 2035. Points mark current sales for LDV (2019) and EV (2021). Labels indicate 2035 sales.

4.2 Current North American LDV and EV Supply Relationships

While Mexico currently supplies a significant share of total LDVs to the North American market, and close to 20% of the US market, it supplies a comparatively lower share of EVs, with only 6% of the US market (**Figure 6**). Most of the 2021 EV demand in US is supplied domestically and by Japan/Korea. Also, most of Mexico's EV production is destined for Europe, and an important share of US EV production goes to supply Greater China.

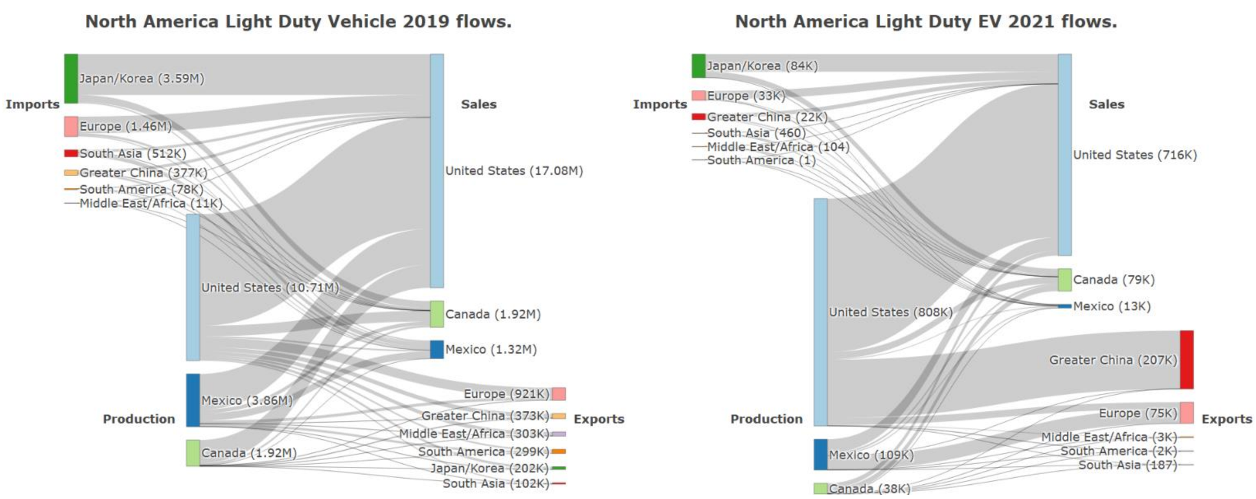

__Figure 6:__ 2019 LDV Supply and Demand Flows for North America (left) and 2021 Light-Duty EV Supply and Demand Flows in North America (right).

4.3 Production in all trade scenarios: Mexico

Figure 7 displays Mexico's current and 2035 LDV and EV production, categorized by major market, under four scenarios. Notably, the higher domestic supply scenario in North America (S2b) results in Mexico producing 2.2 million EVs, while in the higher domestic supply globally and global free trade scenarios (S2 and S3), production decreases to 1.3 and 1.4 million EVs, respectively. Regardless of the scenario, the majority of Mexico's EV production is designated for the US market, highlighting the industry's dependence on its neighbor. Conversely, the LDV production in Mexico is more diversified, with a greater proportion allocated to domestic supply, South America, and Canada.

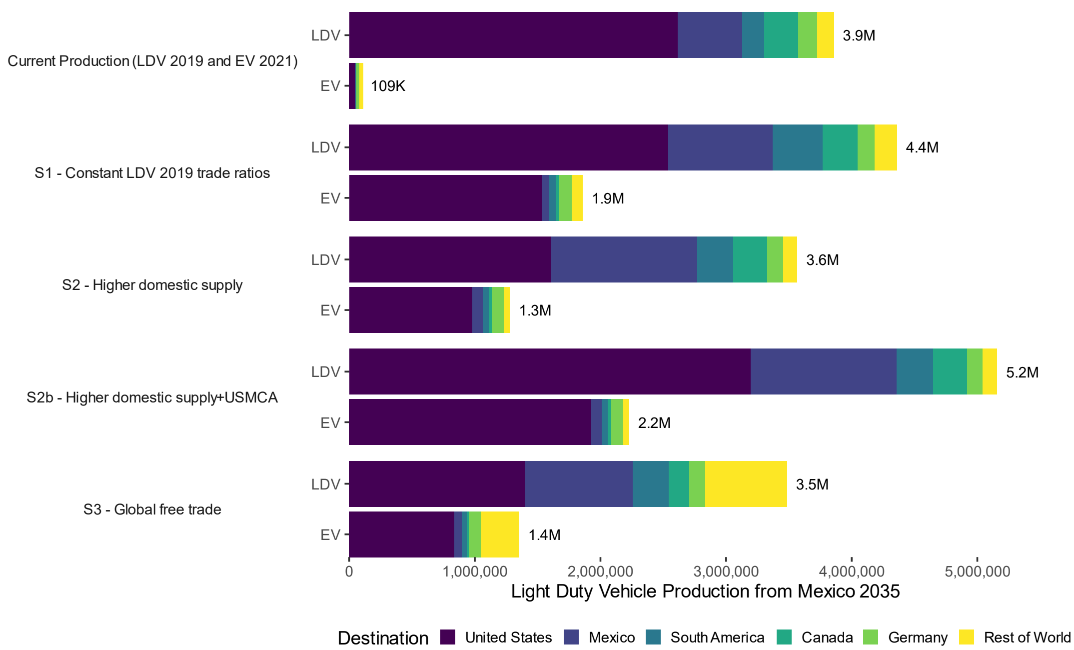

Figure 7: *Mexico's Light duty vehicle production in 2035 under all different scenarios. Only the major export partners are presented in detail. LDV: Light Duty Vehicle. EV: Light Duty Electric Vehicle.*

Our modeling indicates that Mexico's current LDV production capacity of nearly 3.5 million annually must increase by 3% to 49% under all scenarios to meet the projected market demand for 2035. While OEMs could strategically shift their production lines to meet the 36% to 43% EV demand expected by then, lithium-ion batteries (LiBs) will be a critical constraint for EV production as global demand increases rapidly. **Figure 8** shows that in 2021, OEMs in Mexico installed 6.2 GWh of LiBs in 109,350 EVs, all of which were imported, as Mexico lacks any battery production capacity at present. CATL, BMW, and Cenntro Automotive Mexico have announced battery production plans, with CATL estimating a production of 80 GWh. BMW and Cenntro Automotive Mexico have so far only disclosed their committed investment numbers, with $500 million and $200 million respectively. Based on CATL's cost per GWh, we have estimated their combined production at 12 GWh.

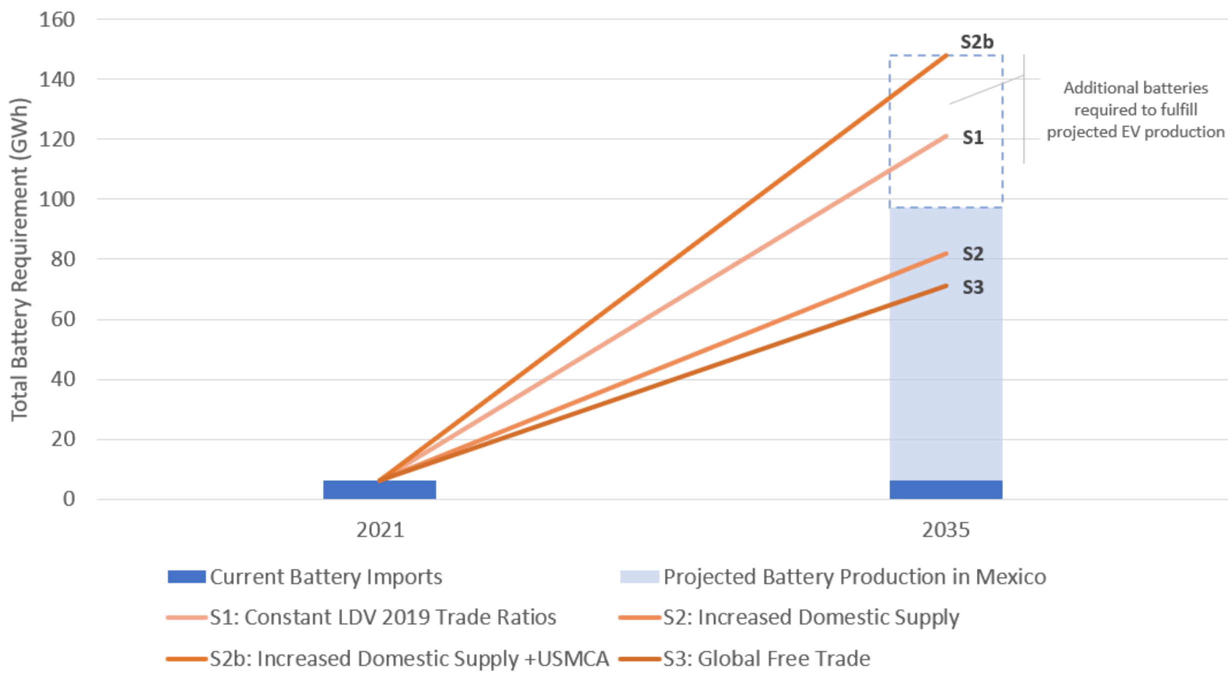

Figure 8: *Current EV battery supply for production in Mexico and the requirement in 2035 under the four production scenarios.*

5 Discussion

Our modelling shows that Mexico is expected to witness a 62% growth in its LDV market by 2035, driven by its high population growth rate and current low vehicle ownership. Similarly, other lower- and middle-income countries and regions are also poised to experience significant expansions in their LDV markets. The expected growth in domestic demand together with the growth in other developing markets will help the Mexican industry grow the total LDV production in most scenarios other than scenario 3 "free trade" where the local market will be shared with higher level of imports.

The most significant advantage that the Mexican automotive industry could have in the global shift to EVs under current policies is by incentivizing North American-made parts, combined with provisions established by the Biden administration in the 2022 Inflation Reduction Act (IRA) that expand tax credits to purchase EVs assembled in North America. This cements Mexico as a strategic investment location for foreign automakers to access the massive North American Market. This is evident in scenario 2B, which reflects higher domestic supply under the USMCA region, yielding the highest EV supply of 2.2 million a year out of 5.2 million LDVs.

While historically highly motorized countries like the US will not experience significant growth in their LDV markets, they will experience a large uptake of EVs by 2035, taking up a considerable proportion of their total LDV sales. For Mexico's export-oriented automakers, this shift presents unique opportunities and risks. All four scenarios in our model suggest that to keep the LDV market share, one third to 45% of the production in 2035 will have to be EVs. Thus, when planning for the EV transition, it's essential to add capacity rather than only replacing it, by investing in new production facilities and equipment.

As indicated in scenario 3, the Mexican auto industry's reliance on the US market could hinder its ability to compete globally in an open market scenario. Additionally, it is a significant factor affecting its transition to electric vehicles, as the US market demands larger battery sizes per vehicle than the global average (**Figure 8**). Therefore, Mexico must maintain a strong relationship with the US market while exploring opportunities to expand its market reach. Mexico could leverage its position by being a pioneer in supplying EVs not only for North America but also for Central and South America, offering a diverse range of EVs from large and expensive ones to more affordable options with smaller batteries. In doing so, Mexico could position itself as a leading supplier to the rapidly expanding markets of lower- and middle-income countries.

Finally, our analysis suggests that the Mexican EV industry is heavily dependent on regional trade agreements and the decision of large international OEMs that can shift production within North America and globally. Diversifying OEM's represented in Mexico and especially promoting new EV-only OEMs may help reduce that dependency and create a more stable industry. Furthermore, developing new markets for LDV's in general and EV's specifically in markets that are expected to grow in the mid- and long-term such as Latin America may also help diversifying the demand, reduce the battery capacity per vehicle demand, and create a long-term change.

6 Conclusions and limitations

This report presents an analysis of current production and sales trends and provides scenarios for international trade. To gain a better understanding of the barriers and opportunities in the transition to the electric vehicle industry, further modeling of the demand for batteries and minerals is critical. We aim to develop our modeling tool to include additional vehicle categories and technologies that better reflect the global market and current and future supply. In future work, we plan to refine these scenarios by interviewing industry experts to explore changes in production and the decision-making processes of international OEMs. We also would like to add additional considerations such as labor, transportation, and others into the tool decision process.

Furthermore, we recognize the importance of considering the entire supply chain, including tier 1-3 suppliers, and suggest a focus on the labor implications of the industry change. While the current analysis focuses only on light duty vehicles and ends in 2035, we acknowledge the need to expand our analysis to include the demand from medium and heavy-duty vehicles, as well as electric transit, to fully understand the demand for batteries and the industry transition.

7 References

[1] AMIA [Mexican Automotive Industry Association], “México en la Producción Mundial de Vehículos [Mexicos Role in Global Vehicle Production],” 2022. https://www.amia.com.mx/about/vehiculos-mexico/.

[2] Secretaría de Economía [Ministry of the Economy of Mexico], “DataMexico,” 2022, [Online]. Available: http://datamexico.org/.

[3] J. L. Zarco, “La industria automotriz en México y el T-MEC: retos y perspectivas,” UNAM, Ed. 2020, pp. 15–27.

[4] U. N. S. Division, “UN Comtrade database [online database],” 2022. https://comtrade.un.org/data/.

[5] INEGI [National Institute for Statistics and Geography of Mexico], “Registro Administrativo de la industria automotriz de vehiculos ligeros [Administrative record of the light vehicle automotive industry],” 2023, [Online]. Available: www.inegi.org.mx/datos primarios/iavl/.

[6] I. Rodriguez, “Después del ‘no’ de BMW, Hidalgo se enfoca en los autos eléctricos chinos,” *Expansión*, 2022. https://expansion.mx/empresas/2021/11/18/jac-autos-electricos-chinos-ex10-produccion-hidalgo.

[7] D. Mihalascu, “Ford Is Boosting Production Of Electric Vehicles In North AmericaNo Title,” *Inside EVs*, 2023. https://insideevs.com/news/655506/ford-is-boosting-production-of-electric-vehicles-in-north-america/.

[8] N. Manthey, “BMW teams up with Evergo for charging network in Mexico,” *electrive.com*, 2023. https://www.electrive.com/2023/02/01/bmw-teams-up-with-evergo-for-new-mexican-charging-network/.

[9] “CATL explores North America sites for $5B EV battery plant, report,” *Automotive News*. https://www.autonews.com/china/catl-explores-north-america-sites-5b-ev-battery-plant-report-says.

[10] National Automotive Dealers Association, “BMW Will Invest $872 Million to Build Electric Vehicles in Mexico,” 2023. https://www.nada.org/nada/nada-headlines/bmw-will-invest-872-million-build-electric-vehicles-mexico-bloomberg#:~:text=BMW AG will invest €,up its global production network.

[11] Mexico News Daily, “US $200 million investment in lithium-ion battery production in Nuevo León,” *Mexico News Daily*, 2023. https://mexiconewsdaily.com/news/lithium-ion-battery-production-nuevo-leon/.

[12] Bnamericas, “Ganfeng eyes strategic investments in Sonora lithium project,” *Bnamericas*, 2022. https://www.bnamericas.com/en/news/ganfeng-eyes-strategic-investments-in-sonora-lithium-project.

[13] KOSUKE SHIMIZU and KENJI KAWASE, “Mexican president eases pressure on China’s Ganfeng Lithium,” *NikkeiAsia*, 2022. https://asia.nikkei.com/Business/Materials/Mexican-president-eases-pressure-on-China-s-Ganfeng-Lithium.

[14] The White House, “FACT SHEET: Securing a Made in America Supply Chain for Critical Minerals,” Washington, D.C., 2022.

[15] ICCT, “Roadmap v1.9 Documentation,” 2022. https://theicct.github.io/roadmap-doc/versions/v1.9/.

[16] IEA, “IEA Mobility Model (MoMo).” Paris, 2020.
[17] O. International Transport Forum, “ITF Transport Outlook Project,” 2021. https://www.itf-oecd.org/itf-transport-outlook-project.
[18] IEA, “Global Energy and Climate Model: Documentation,” 2022. https://www.iea.org/reports/global-energy-and-climate-model.
[19] V. N.-T. B. Jones, R. J. Elliott, “The EV revolution: The road ahead for critical raw materials demand,” *Appl. Energy*, vol. 280, 2020.
[20] J. Dunn, M. Slattery, A. Kendall, H. Ambrose, and S. Shen, “Circularity of Lithium-Ion Battery Materials in Electric Vehicles,” *Environ. Sci. Technol.*, vol. 55, no. 8, pp. 5189–5198, 2021, doi: 10.1021/acs.est.0c07030.
[21] E. B. and R. K. A. Aguiar, E. Corong, D. van der Mensbrugghe, “The WTO Global Trade Model: Technical documentation,” 2019. [Online]. Available: https://www.wto.org/english/res_e/reser_e/ersd201910_e.pdf.
[22] M. T. and v. d. M. D. E. Corong, T. Hertel, R. McDougall, “The Standard GTAP Model, Version 7,” *J. Glob. Econ. Anal.*, 2017.
[23] V. T. and B. S. . F. H. Pant, “The Global Trade and Environment Model:A Projection of Non-Steady State Data Using Intertemporal GTEM,” 2002.
[24] Eurostat, “RAS (Method),” in *Memobust handbook*, no. March, 2014.
[25] InfluenceMap, “InfluenceMap,” 2022. https://automotive.influencemap.org/#production-data.
[26] International Energy Agency (IEA), “Global EV Data Explorer,” 2022. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer.
[27] EV-volumes.com, “xEV Share tracker by country,” 2022. [Online]. Available: https://www.ev-volumes.com/datacenter/.
[28] AMIA, “Ventas Internas de vehículos ligeros,” 2022. https://amia.com.mx/ventas-internas-de-vehiculos-ligeros/.
[29] “USITC DataWeb,” 2023, [Online]. Available: https://dataweb.usitc.gov/.
[30] Statistics Canada, “Canadian International Merchandise Trade Web Application,” 2023. https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2021004-eng.htm.
[31] IEA, “Global EV Policy Explorer,” 2022. https://www.iea.org/data-and-statistics/data-tools/global-ev-policy-explorer.
[32] Esteban Ortiz-Ospina; Diana Beltekian, “International trade data: why doesn’t it add up?,” 2018. [Online]. Available: https://ourworldindata.org/trade-data-sources-discrepancies.
[33] O. Lemmers and K. F. Wong, “Distinguishing Between Imports for Domestic Use and for Re-Exports: A Novel Method Illustrated for the Netherlands,” *Natl. Inst. Econ. Rev.*, vol. 249, no. 1, pp. R59–R67, 2019, doi: 10.1177/002795011924900115.
[34] S.-J. W. Aaditya Mattoo, Zhi Wang, “Trade in Value Added Developing New Measures of Cross-Border Trade,” *Int. Bank Reconstr. Dev. World Bank*, 2013.
[35] D. L. Campbell and L. Lusher, “Trade Shocks, Taxes, and Inequality †,” no. May, 2016, [Online]. Available: https://www.nes.ru/files/Preprints-resh/WP220.pdf.

Presenter Biography

Francisco Parés is an Energy Graduate Group, Ph.D. student at UC Davis. He currently works in the Electric Vehicle Research Center focusing on global vehicle supply and trade in the primary and secondary markets, as well as EV life-cycle assessment. Francisco is interested in the intersection of environmental and social sustainability, economics, and policy. He holds a BSc in Civil Engineering from UABC, and an MSc in Renewable Energy from UAG, Mexico.