A Two-year Assessment of the IRA's Subsidies to the Electric Vehicles in the US: Uptake and Assembly plants for batteries and EVs

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Abstract

In this paper, we assess electric vehicle (EV) tax credits in the US Inflation Reduction Act (IRA), the largest significant action in favour of climate change in US history.

We find that the provisions of the IRA have so far done little to increase the uptake of EVs by US households, accounting at best for 10% of monthly new light vehicle sales since the IRA was passed. This is well below most ex-ante estimates of EV uptake under the legislation.

In contrast, the IRA has triggered EV battery plant projects in the United States, reinforcing the move by automakers to secure their supply chain since the Covid crisis. In total, current and projected GWh capacity would allow 17.0 million EVs to be powered annually by 2030, compared to the 1.2 million EVs sold in 2023. Thus, to date, the IRA has created a potentially huge imbalance between supply and demand in the US EV market. We show that automakers have adopted different strategies to capture EV market share in the United States, depending on whether they are incumbents or start-ups, whether they are based in allied countries, or whether they have an edge in EV technology.

JEL Codes: F18, H23, L11, Q58

Keywords: Inflation Reduction Act, electrical vehicles, subsidies, tax credit, automotive industry

1. Introduction

By passing the Inflation Reduction Act (IRA) into law in August 2022, US President Joe Biden took significant action in favour of clean energy and climate change. For the international community, this event marked the re-entry of the United States into the Paris Agreement with concrete step to tackle greenhouse gas (GHG) emissions and thus reduce global warming. In particular, the passenger vehicle sector, which is responsible for 22% of US GHG emissions, has received significant attention in the IRA legislation through various subsidy schemes[1]. On the demand side, the IRA includes a tax incentive of up to $7,500 for households to purchase an electric vehicle (EV), while on the supply side, manufacturers can benefit from tax breaks when producing (part of) electric batteries. Both incentives are tied to some North America assembly and local component requirements for EVs and batteries. However, if the EV is purchased through leasing, American households can still benefit from the $7,500 tax incentive without any assembly or local content requirements - a loophole in the legislation achieved by policymakers in South Korea and the European Union (EU), among others (Buckberg, 2023; Bown, 2023a, 2023b).

Two years after passing the IRA, what can be said about EVs in the United States in terms of uptake and manufacturing for vehicles and batteries? Especially, can we observe a boosting effect of the legislation on EV sales? And is there any ongoing relocation effect on EV and battery manufacturing in the United States?

This two-year assessment is important to determine whether the legislation is well designed to achieve its goals, i.e. the mass electrification of the US vehicle fleet by 2030, on the one hand, and bringing manufacturing back to the United States, on the other hand. A third intended goal is de-risking away from the China's current dominance over manufacturing key goods such as the lithium-ion battery (Reinsch et al., 2024; Mehdi and Moerenhout, 2023).

To some extent, our assessment can be related to the work of Coffin and Walling (2024), which analyses the sales and trade of EVs and their batteries in the United States. Other similarities can be found with Klier and Rubenstein (2022) or Bellan (2024), whose works have tracked EV and battery assembly plant projects since the advent of the IRA. However, our work differs in that we conduct the analysis at the model/brand/group level rather than the industry/macro level. This allows us to disentangle differences in the strategies of battery producers and automakers, focusing on two dimensions. The first dimension is based on the nationality of control, as it may impose a different set of constraints on business conduct depending on whether the company belongs (or not) to an 'allied' nation through a Free Trade Agreement (FTA) or a Critical Minerals Agreement (CMA). The second dimension has to do with the legacy of the automaker, i.e. whether it is an incumbent or a start-up, as the former can modulate with the shift away from internal combustion engines (ICEs), whereas the latter, by definition, cannot as solely producing EVs.

Finally, as a natural extension of our work, we assess how well the responses of different stakeholders to the IRA incentives are aligned to avoid imbalances between supply and demand in the battery and EV markets.

For carrying out our evaluation, we use various data sources and make an extensive use of automotive media websites. Among other, we draw on Kelley Blue Book EV sales, Cox Automotive, Experian Automotive and InsideEVs which are reliable sources of automotive news and data. Annual reports of carmakers operating in the United States for EV sales and, eventually, manufacturing constitute another important piece of information. Finally, data coming from the United States Census Bureau is used to check the consistency of EV imports into the United States with the information contained in reports and automotive media websites[2].

[1] Figures for transport emissions are for 2021 and come from the Congressional Budget Office (CBO, 2022).

[2] In this paper, EVs we consider are vehicles that have a battery as the sole source of power and propulsion. Hybrid vehicles are not included in the data of sales, trade and imports presented below.

2. The details of the IRA legislation in relation to EVs

In this section, we take a closer look at EV subsidies under the IRA legislation, distinguishing between subsidies designed to stimulate supply-side activity from those designed to encourage demand-side purchasing behaviour. It should be noted that the eligibility rules for the tax credit have been heavily criticised, particularly by battery and EV manufacturers, who have found them overly complex. The US Department of the Treasury has gradually clarified the eligibility conditions regarding the taxpayer, the vehicle, and the critical mineral and battery component requirements. The following is an attempt to summarize these conditions, the intended goals, and the reactions of policymakers abroad.

2.1. Sections 30D and 45X of the IRA legislation

The incentives related to EVs are mainly contained in two different provisions of the IRA legislation[3]. The Clean Vehicle Tax Credit (Section 30D) relates to the purchase of EVs, while the Advanced Manufacturing Production Tax Credit (Section 45X) is about the production of batteries. The two provisions cannot be and understood in isolation from each other, though.

2.1.1. Subsidies to stimulate demand-side purchasing behaviour (Section 30D)

The 30D tax credit aims to address the potential demand shortages by providing a tax break of up to $7,500 for consumers who purchase an EV[4]. It comes with eligibility requirements designed to bring EV and battery manufacturing back to the U.S. First, to qualify for the tax credit, vehicles must undergo final assembly in North America. In addition, to receive half of the credit ($3,750), at least 50 percent of the battery components must be manufactured or assembled in North America. This requirement increased to 60 percent in 2024 and will gradually increase to 100 percent by 2029. Finally, to qualify for the other half of the credit ($3,750), the battery must contain a certain percentage of critical minerals produced either in the United States or in a country with which the United States has a free trade agreement (FTA). This percentage requirement also increased to 50 percent in 2024 and will reach 80 percent by 2029.

The United Sates has an FTA in force with 20 countries and, in first instance, with its immediate neighbours, Canada and Mexico. Importantly for our purpose, neither the EU nor Japan benefit from an FTA with the US, unlike, for example, South Korea[5]. However, countries with which the United States has a Critical Materials Agreement (CMA), such as Japan, or which are under discussion (Argentina, Indonesia, and the EU) are also expected to be eligible (Shen et al., 2024), Finally, an EV whose critical minerals have been mined, processed or recycled by a Foreign Entity of Concern (FEOC) will no longer be eligible from the end of 2024, in addition to the previous loss of eligibility from the end of 2023 if battery components are manufactured or assembled in a FEOC. Recently, the U.S. Treasury Department has defined more precisely a FEOC or an entity "owned, controlled, or subject to the jurisdiction or direction of a government of a foreign country" such as China, Russia, Iran, or North Korea[6].

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[3] Readers interested in other provisions of the IRA legislation designed to promote the supply and demand of EVs could read, for instance, Coffin and Walling (2024).

[4] Corporates taxpayers may also receive the 30D credits. In what follows, we concentrate on households taxpayers.

[5] The full list of countries with which the US has an FTA is as follows, in alphabetical order: Australia, Bahrain, Canada, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Israel, Jordan, Mexico, Morocco, Nicaragua, Oman, Panama, Peru, Singapore and South Korea.

[6] The definition includes entities that are "headquartered, incorporated or performing relevant activities" in those countries, "if 25 percent or more of its voting rights, board seats or equity interest are held by the government of those countries, or if the entity is effectively controlled by a[n] FEOC through a license or contract with that FEOC."

The restriction regarding FEOC aims at prompting investments related to battery manufacturing on US territory, as China is one of the leading countries in battery supply, controlling the entire production chain, including upstream activities such as mining and refining of critical materials. In 2023, China accounted for approximately 75% of the production of lithium-ion batteries – the only battery currently used in EVs (Coffin and Walling, 2024) and expected to remain the most widely used for a long time (Castelvecchi, 2021)[7].

The other conditions related to Section 30D are that the adjusted gross income (AGI) of households purchasing an EV cannot exceed $300,000 for married couples (and $150,000 for individuals) to be eligible for the tax credit of (up to) $7,500. In fact, most American households meet this condition, so it is not really binding[8]. Lastly, there is a price cap conditions on the EV itself: tax credit eligibility requires that the manufacturer's suggested retail price (MSRP) be less than $80,000 for SUVs, vans and pickup trucks and less than $55,000 for vehicles under 14,000 pounds.

2.1.2. Subsidies to stimulate supply-side activity (Section 45X)

In addition to demand-side credits for vehicle purchases, the IRA includes supply-side incentives under the 45X tax credit aimed at reducing the production costs of battery and its components in the United States. Specifically, under this provision, the federal government provides subsidies for domestic battery production of up to $35 per kWh, plus an additional $10 per kWh for module assembly. Assuming average battery prices of around $140 per kWh in 2023, these production incentives could account for nearly one-third of the total battery price. For most observers, this is "nothing short of a game-changer" as the battery is the most expensive component of an EV (Mehdi and Moerenhout, 2023)[9]. In their view, U.S. subsidies for battery production would make a "US-made battery" competitive with a "Chinese-made battery". It should be noted that encouraging battery production in a particular location also means encouraging the assembly of cars in that location since, for reasons of weight, batteries are rarely transported over long distances. Indeed, trade data show that battery packs – the last step in the battery supply chain, see Box 1 – account for a very small share of international trade compared to critical minerals, cells or modules[10].

At the same time, the ability of the 45X tax credit to fully close the US competitive battery gap with China should not be taken for granted. Some argued that battery manufacturing costs in the US –

[7] In general, an EV requires at least 13 different critical metals to be produced. Given where supply is currently coming from, the thresholds given under Section 30D may be easiest to achieve for lithium and more difficult for nickel (Cook, 2023). Under the status quo, cobalt is unlikely to make a meaningful contribution toward qualifying for the tax credit, because it is mostly mined in the Democratic Republic of the Congo (DRC) and processed in China. As such, there is a stronger case to increase market penetration rates of lithium iron phosphate (LFP) batteries, which do not contain nickel or cobalt.

[8] Given that the 90th (respectively 95th) percentile adjusted income stood at $234,000 (resp. $316,100) in 2023, this means less than 10% of US households are above the $300,000 threshold. Data are from the US Census.

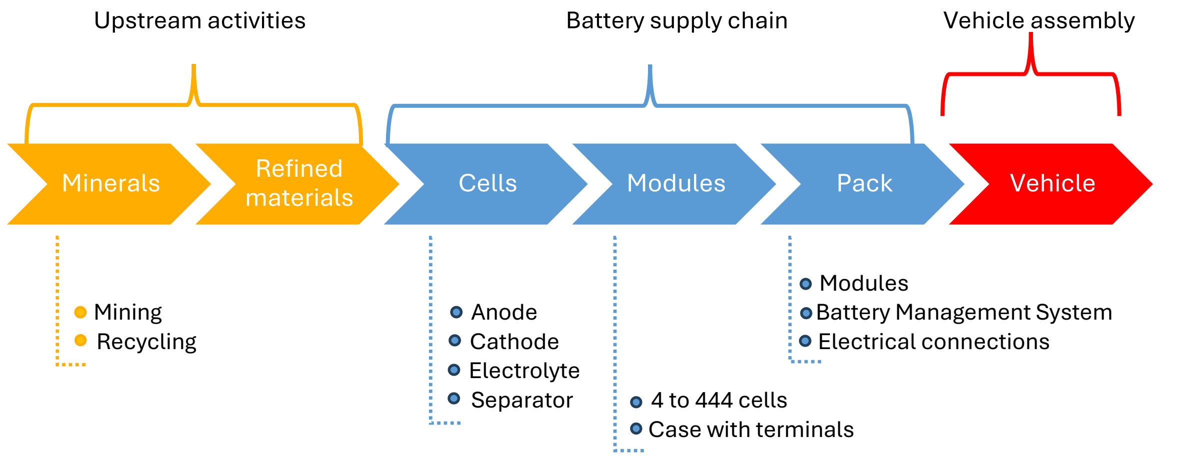
[9] Battery costs per kilowatt-hour (kWh) have declined from about $1,000 per kWh in 2010 to $128 in 2023 (BloombergNEF, 2023). On a regional basis, battery price is lowest in China, at $126 per kWh. In the USA and Europe, batteries were 11% and 20% more expensive respectively. The higher prices reflect the relative immaturity of these markets, higher production costs and lower volumes. China also saw intense price competition in 2023, as battery manufacturers increased production capacity to capture a share of the growing demand for batteries.

[10] Based on the location decisions announced by manufacturers in North America through 2029, Klier and Rubinstein (2024) found that about 56 percent of battery packs are expected to be produced in final assembly plants and 36 percent in cell plants. They calculated the median distance between cell plants and pack plants to be only 40 miles. They found no example of stand-alone battery module plants: they are located with either battery cell plants or battery pack plants.

and Europe – may remain higher than in Asia, due to higher energy, equipment, land and labor costs, despite local production subsidy policies to offset some of these costs.

Importantly, the tax credit begins phasing down in 2030 in increments of 25 percent per year, thus fully phases out for components sold after 2032. That means that the window to benefit from tax credits for battery production (its components such as cells and modules) is a fairly short one, in particular once time-to-built for the plant is taken into account.

Box 1: The traditional electrical vehicle supply chain



Note: People interested in the engineering of battery can read Coffin and Walling (2018), Coffin and Horowitz (2024), Antony et al. (2024), Reinsch et al.(2024).

Source: Adapted from Coffin and Horowitz (2024).

2.2. Section 45W or the option of leasing as a loophole to Section 30D

Reaction to the passing of the IRA abroad, first in South Korea and then in the European Union, both "allies", was epidermal (Bown, 2023a; Crawford, 2023). In early September 2022, less than a month after the IRA was signed into law, the South Korea's Trade Minister demanded action on behalf of Korean auto companies. One objection was that Hyundai's popular Ioniq models, which was assembled in South Korea would not be eligible to tax credit, until the US plant was operational in 2025 (Bown, 2023b). In the EU, the political reaction was slower to materialize but even fiercer when it became clear that EVs manufactured in Europe would no longer be eligible for the tax credit offered to EVs manufactured in North America. Even more, by creating strong incentives for multinational to locate their production facilities in North America for assembly of EVs and their batteries, in addition of offering cheaper energy than in Europe, the IRA was seen as threatening the EU's industrial competitiveness (Bown, 2023a). Finally, during French President Macron's state visit in December 2022, President Biden indicated that there would be some flexibility or accommodation on the IRA.

The flexibility was given through a loose interpretation of Section 45W in the IRA legislation, which provides a tax credit of $7,500 for businesses buying an EV without any conditions on local requirements for components and minerals or assembly. Assuming the lessor passes on the $7,500 in the form of a lower lease payment, a household may be interested in leasing an EV to a commercial fleet operator rather than buying it outright, especially if neither the EV nor the taxpayer meets the eligibility requirements (Buckberg, 2023). Put differently, and by way of illustration, a wealthy American couple with an income of more than $300,000 can still benefit from a $7,500 tax credit by leasing an EV, assembled in Germany, and a selling price in excess of $80,000. Table 1 compares the condition eligibility of consumer tax credit (Section 30D) *versus* commercial tax credit (Section 45W).

Note that the Section 45W is silent on critical minerals and battery components from China or other FEOCs.

Table 1. Eligibility conditions to Consumer tax credit *versus* Commercial tax credit
(new vehicle under 14,000 lbs.)

	Consumer tax credit (Section 30D)	Commercial tax credit (Section 45W)
Maximum	$7,500 of which: $3,750 is for critical minerals $3,750 is for battery content	$7,500 (vehicles up to 14,000 lbs.)
Assembly Requirement	North America	None
Critical Minerals	Increasing each year	None
No critical minerals from China or other "foreign entities of concern"	From 2025	N.A.
Battery Components	Increasing each year	None
No battery components from China, other "foreign entities of concern"	From 2024	N.A.
MSRP Cap Truck/SUV/Van Car	$80,000 $55,000	None None
Income Cap	$150K single/$300K married	None
Relative price limits		Lesser of 15% cost basis or incremental cost vs. ICE equivalent

Source: Buckberg (2023).

2.3. The expected impact of Sections 30D (or 45W) and 45X on EV prices

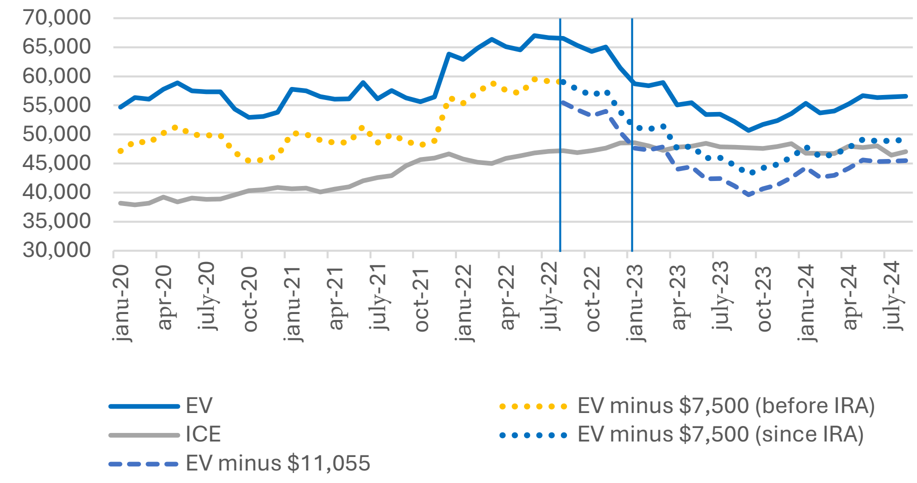
Assume that the consumer EV tax credit is set at the maximum level and is fully passed on to households ($7,5000 for either buying or leasing a car). With an average (sales-weighted) EV price of $66,524 in August 2022, this means that the federal tax credit was equivalent to 11.3% of the EV price at that time, bridging almost 40% of the average price gap between EV and ICE (Figure 1)[11]. Indeed, price parity is seen as a contributing factor to the EV purchase decision: the smaller the price gap with ICE, the higher the EV uptake, *ceteris paribus*. The $7,500 consumer tax credit helps, as shown by the dotted line in Figure 1.

Adding the battery production tax credit of $45 per kWh and assuming an average EV battery size of 79 kWh[12], the federal tax credit would rise to $11,055 per EV. Again assuming full pass-through to EV price, this amount would help make the purchasing of an EV at least as more profitable than the purchasing of an ICE since January 2023 (Figure 1). Of course, the decision to buy one vehicle rather than another is based on other considerations (buying or leasing costs, electricity versus gasoline costs, maintenance, insurance, state taxes and fees), but range anxiety is also very important.

[11] The average price gap was exactly $19,315 in August 2022 (source: CoxAutomotive). It should be noted that the weight of Tesla vehicles in the total number of EV sales has a significant impact on the average EV price (weighted by sales). See Allcott et al. (2024) for the difference in EV price evolution between Tesla and non-Tesla EVs. See also Table 2 for average EV prices by automaker/group.

[12] 79 kWh is the average battery size of EVs purchased by American households in 2021 (source: Klier et Rubinstein, 2022).

Figure 1: Average price of new car (in US dollars)



Source: CoxAutomotive; own computations.

3. EV adoption since the advent of IRA

3.1. Electrification of the US fleet: a 2020 election promise of Joe Biden

The mass electrification of the US vehicle fleet was an important element of Joe Biden's campaign for the US presidency in 2020. The electrification of the US fleet was indeed lagging far behind by international standards: in 2021, there were 1.5 million personal EVs in the US, compared to 3 million in Europe (and 6.2 million in China). EVs accounted for just under 3% of new vehicle registrations in the US, compared with more than 15% in a dozen of EU countries[13].

Initially, Biden's EV target was not so much a quantified goal as a means of bringing electric mobility to the middle class, as the bulk of EV purchases had been made by the wealthier[14]. Subsequently, the target for EVs in new vehicle registrations fluctuated according to the compromise reached between the Biden administration, automakers, industry unions and the Environmental Protection Agency. It has risen from 50% by 2030 to 67% by 2032, and since March 2024 has fallen back to an EV share of new vehicle registrations in the range of 35% and 56% by 2032. The US fleet electrification target has therefore always been well behind the EU target of 100% EVs in new registrations by 2035, because of a ban of ICE new registrations at that time.

3.2. The pre-IRA incentives relative to EV purchasing

Since 2009 and the American Recovery and Reinvestment Act (ARRA), US households have been eligible for a federal tax credit of up to $7,500 for the purchase of an EV. However, under the ARRA, unlike the IRA, the tax credit was phased out once the automaker's US sales reached 200,000 units. By definition, this cap did not allow for mass electrification of the vehicle fleet: it limited investment and R&D, and kept the price of EVs high. By the summer of 2022, Nissan and Ford were on the verge of hitting the cap, after Tesla, General Motors and Toyota had already surpassed it.

The IRA thus removes the cap for automakers while maintaining the possibility of a tax credit of up to $7,500 for households, with the conditions summarized in Table 1.

By the time the IRA went into effect in August 2022, 58% of EV models had lost their eligibility for the $7,500 tax credit because they did not meet the domestic assembly requirement criteria

[13] Source: International Energy Agency.

[14] Panzino, 13 March 2020: Biden, Sanders eye broader EV adoption on road to 2020 election, S&P Global.

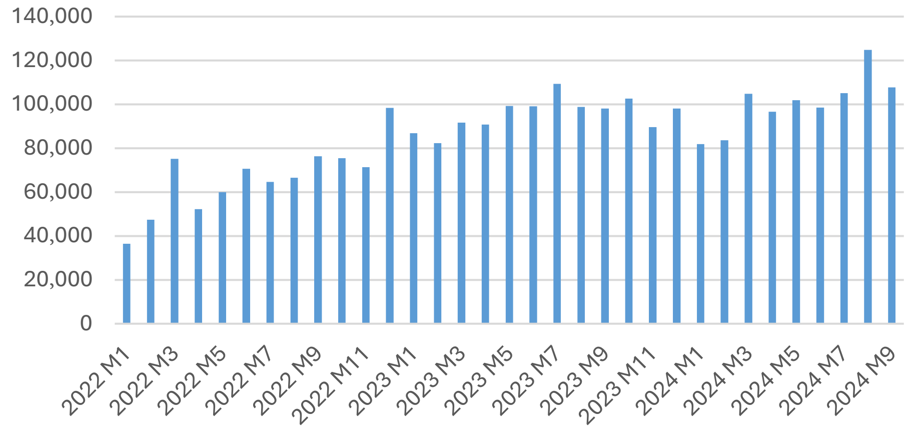
(Buckberg, 2023), adding to the General Motors and Tesla models for which automakers' US sales had reached the 200,000 ceiling[15]. In total, in August 2022, only 11 EV models were eligible, with GM and Tesla models having to wait until January 1, 2023 for the 200,000-unit cap to be lifted and become eligible for the IRA credit[16].

3.3. EV sales in the USA since the IRA: quantity and brands

Against this backdrop, it was difficult to expect the IRA to have a significant impact on EV sales before January 2023, when the cap on popular Tesla and GM models would be lifted. Moreover, the adoption of the IRA came at a time of 'scarcity', when delivery times for a number of car models had increased by several months. For example, the waiting time for Tesla models was more than 200 days in May 2022, compared with around 20 days a year later (Allcott et al., 2024). For all other EVs (excluding Tesla), the average time for models available in dealer inventory before being sold was at its lowest level before the IRA was passed, at 10 days in July 2022, compared to its highest level of 70 days in late 2023. Most observers, whether dealers or manufacturers, didn't expect the IRA to have an immediate impact once it was signed into law, but rather that EV sales would see a nice – or even very nice – spike over the course of 2023. So what has happened?

Overall, US EV sales rose to a record 1.2 million units in 2023, up from 813,000 in 2022 and 385,000 in 2021. In total, there were more than 3 million EVs on the road in the US at the end of 2023. However, the pace of EV sales began to slow at this point, while the stock of EVs increased – two trends that continued into the early months of 2024. Finally, in August 2024, EVs reached their highest monthly sales level of 124,750 units, approaching a 9% share of new vehicle registrations (Figures 2 and 3). Despite the steady increase, EV sales – both in absolute terms and as a share – remain below (or even well below) most *ex-ante* estimates of EV uptake due to the IRA consumer tax credit (see Bistline et al., 2023, for a review).

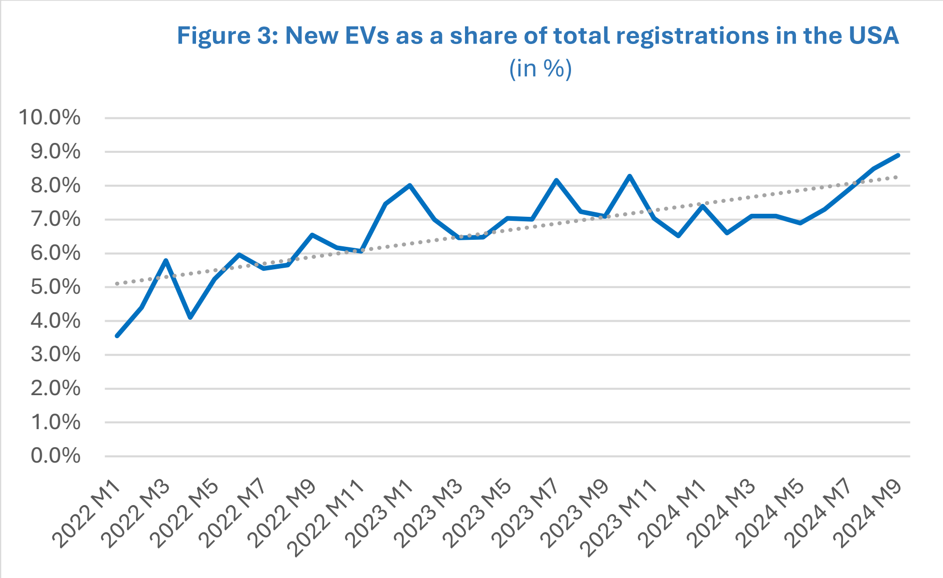
Figure 2: Monthly registrations of new EVs in the USA
(units of light vehicles)



Source: InsideEVs (up to 2023 M12) and Alliance For Automotive Innovation (from 2024 M1 onwards) for EVs sales. Both series are not seasonally adjusted.

[15] In Toyota's case, the tax credit was already being phased out but scheduled to disappear entirely only in October 2022, that is one year after the sales milestone was reached as specified in the ARRA legislation.

[16] See Allcott et al (2024) for eligibility of models depending on ramping up of IRA legislation.



Source: U.S. Bureau of Economic Analysis for the Total Vehicles Sales; InsideEVs (up to 2023 M12) and Alliance For Automotive Innovation (from 2024 M1 onwards) for EVs sales. Both series are not seasonally adjusted.

At a more detailed level, Tesla, an US-based start-up automaker, remains the leading EV seller in the United States, with 55% of EV sales in 2023 on the US territory (compared with 65% in 2022)[17]. Tesla's market loss was mainly to the benefit of automakers headquartered in either the United States (notably General Motors and Rivian), Germany (Mercedes, BMW) or South Korea (Hyundai brand). All the largest market share gainers are incumbent automakers with long track record in the US automotive sector, to the exception of Rivian, which is a US startup entering the EV market a few years after Tesla. Some other automakers have also lost EV market share in 2023, albeit on a smaller scale than Tesla, notably the two incumbents Ford (a US-based automaker) and Kia (belonging to the South-Korean Hyundai-Kia Group). Globally, the first semester of 2024 confirms the trends at work between 2022 and 2023, with two notable exceptions. The first one relies on Kia automaker which fully reversed its downward trend by gaining 2.1 pp of market share over the first semester 2024. The second is about the strong and aggressive EV penetration of Japanese brands (particularly from the Toyota Group, with the ToyotaBZ4X and LexusRZ models) over the first semester of 2024. Meanwhile, by standing at 51%, the market share of Tesla has continued its declining trend over the first semester of 2024.

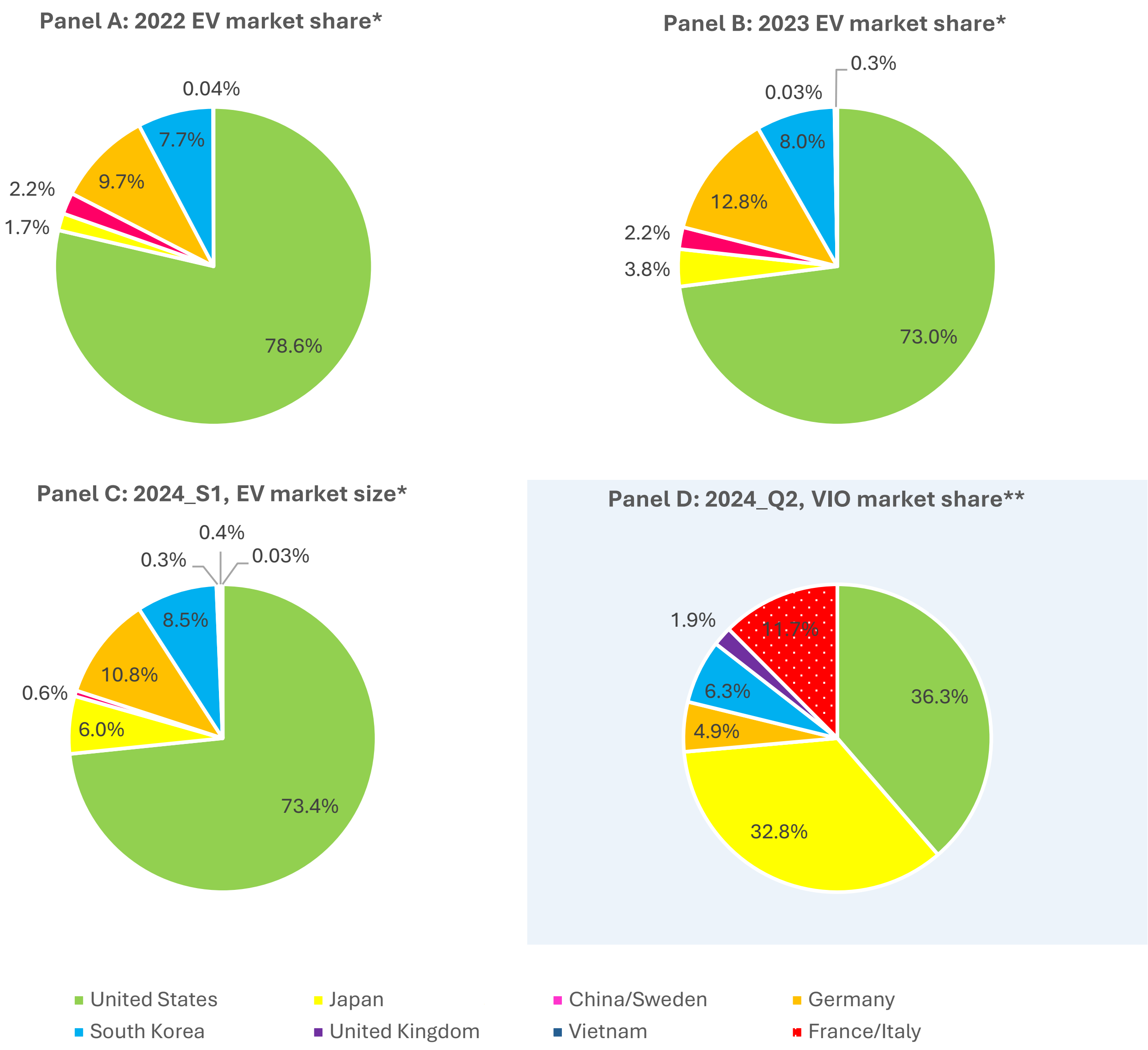
When comparing the developments by nationality of control since 2022 (as in Figure 4, Panels A-C), the US-controlled carmakers still largely dominate the EV market with a share of 73.4% in the first half of 2024, due to the still strong presence of the start-up Tesla, which keeps its first-mover advantage, together with the ramp-up of the start-up Rivian and the incumbent General Motors. This is followed by the three German-controlled groups, which account for a 10.8% share of the EV market in the first half of 2024, driven mainly by BMW and Mercedes-Benz, with Volkswagen showing slower EV sales growth in the US. The market share of the three South Korean-controlled automakers (Hyundai, Kia and Genesis) belonging to the same Hyundai-Kia group is 8.6% in the first half of 2024, with all three brands participating in the growth of EV sales in the US.

Finally, Japanese-controlled automakers account for a 6% share of the EV market, all six of them contributing to the increase in EV sales on US territory (Honda, Mazda, ...), but more importantly those of the Toyota group. Last but not least, other nationalities of control for either an incumbent

[17] Appendix 1 provides a list of EV models sold in the US, their automakers and automotive groups by nationality of control, and a categorisation of whether EV automakers are incumbents or startups.

automaker (France/Italy for Stellantis[18]; United Kingdom for Daimler; China for Volvo Cars) or start-up automakers (China for Geely, Vietnam for Vinfast) account for only a very tiny market share, less than 0.5% in each case. In units, that accounts for at best 2,500 EVs per automaker on an annual basis[19]. One consequence of this low sales volume is that the EV model is rarely assembled at different locations (in different countries), which means that entering markets other than the country where the model is assembled leads to international trade (see below).

Figure 4: EV market share of automakers by nationality of control (panels A-C) compared to their VIO market share (panel D)
US market



* EVs in % of new registrations.
** Vehicles in operation (VIO), i.e. all vehicles registered in the United States whatever their powering.
Sources: Kelley Blue Book EV Sales; Experian; computations of the author.

[18] The multinational Stellantis includes 15 brands, of which Citroën, Peugeot, Fiat, Chrysler or Jeep.

[19] US EV sales in the first half of 2024 totalled 575,300 units. A doubling of those sales means that total sales in 2024, in first approximation, would be around 1.2 million, which is similar to the sales observed in 2023.

It is worth mentioning that, for Japanese-controlled automakers, their US EV market share of 6% is in sharp contrast with their US vehicles in operation (VIO) market share of 32.8 % where ICE would be also included[20] (Panel D). The latter figure shows two things. First, how popular Japanese brands have long been in the US, almost as popular as US brands. And second, that Japanese brands are still lagging behind in the transition to fully electric models, having long favoured the development of hybrid models. If the pace of US fleet electrification accelerates, the extent to which Japanese brands will be able to offer EV models to compete with more installed EV automakers will be crucial. A similar conclusion can be drawn for Stellantis, the French/Italian multinational group with a very small presence in the US EV market, compared to a US market share of 11.7% when all vehicles are considered (Panel D). For the German- and South Korean-controlled automakers, the story is different due to their historically much lower US market shares: penetrating the US EV market further and more aggressively would mean penetrating the US automotive market as well[21]. Moreover, protecting their (small) current EV market advantage is crucial, especially at a time when the incumbent manufacturers, either Japanese (Toyota, Honda) or American (Ford, etc.), as well as of the Stellantis group (Peugeot, Citroën, Chrysler, etc.), still appear to be lagging behind in terms of all-electric models.

The next two sections are devoted to an analysis of whether the EVs purchased by American households were assembled domestically or, on the contrary, imported to be eventually leased to qualify for the $7500 tax credit.

3.4. Estimates of EV imports in the USA by automakers and countries of origin

To measure EV imports, we consult automakers' annual reports and websites to identify the assembly plant for each EV model sold in the US, and supplement this with automotive media. In most cases there is no ambiguity, as each EV model is generally assembled in one location (one country). Where there is some ambiguity, we infer the assembly location from US imports of EVs (in dollars) provided by the United States Census Bureau.[22].

Using this approach, we find that 24.8% of EVs sold in the US in 2023 will be imported from abroad (up from 19.9% in 2022). We also find significant differences between automakers. For example, the South Korean-based Hyundai Group, which also includes the Kia and Genesis brands, imported 98.2% of the EVs it sold in the US in 2023, with only the Genesis GV70 model assembled in the US. The German-based groups, namely Volkswagen, BMW and Mercedes-Benz, which together include a dozen brands, imported 57.1% of the EVs they sold in the US. German-brand EVs were mainly imported from Germany (67.4% of German-brand EV exports to the US), followed by Belgium (18.5%), Hungary (11.1%) and the UK (3.0%), where German groups have assembly plants for models purchased by American households. At the other extreme, Tesla continues to assemble all its EV models in the United States, despite several announcements that it intends to set up plants in Mexico or India.

Overall, Asia is the leading continent of origin for EVs imported into the US, accounting for 22.3% of total US EV imports in 2023, followed by Europe at 16.6% (Table 3, Panel B). Within each continent, South Korea and Germany are the main countries of origin, accounting for 14.2% and 9.4% respectively of total US EV imports. This equates to around 92,300 and 61,200 units respectively according to our calculations (Table 3, Panel A), which is not very high in absolute

[20] More precisely, the 32.8% figure refers to vehicles in operation (VIO) on US territory, a stock measure that includes all registered vehicles (new and used), whatever their powering (ICE, VE, PHEV,...) at a given point in time (Q2 2024 in our case).

[21] Hughes-Cromwick (2021) provides an interesting argument of why US incumbent automakers have lost significant market share to Japanese manufacturers, and never regained it. They were locked, she argues, into their large vehicle product line for years albeit a demand for small cars surged after the global spike in oil prices.

[22] Electrical vehicles are reported under the 6-digit Harmonized Tariff System (HTS) code 870 380.

terms, reflecting the small size of the US EV market and the problem faced by a automaker when deciding between local assembly and imports from foreign facilities. The question of volume seems to us to be a crucial and delicate one. As Mayer et al (2024) demonstrate, "to sell, you have to produce locally or at least continentally', distance limiting sales for both ICEs and EVs. The rule seems to be that once a model is close to a certain level of sales, it is necessary to invest locally. So, there would be 1) a test of the market through exports, then 2) local investment. The IRA's legislation therefore poses a particular challenge to automakers: it forces them to decide on local investment before they have had a chance to test the EV market because of its insufficient development. Worse still for an automaker, the IRA's legislation fails to stimulate demand for EVs.

It is worth noting that Mexico has not been a major source of US EV imports to date, with only three EV models (of Chevrolet and Ford brands) imported into the United States in 2023, but rising to five EV models (Honda brand in addition to Chevrolet and Ford) in the first half of 2024. If the project of Tesla's assembly plant in Mexico, suspended in the context of the current US presidential administration, were to be relaunched and finalised, this means that things could turn out very differently, putting at risk the intended goal of manufacturing back in the United States.

Table 2: Sales, imports and EV prices in the United States by nationality of control (group) in 2023*

Nationality of control(group)	Share of EV imported in the US EV sales of the automaker/group	Share of the automaker/group in the US EV sales	Average EV price per unit, Feb 2024**	Relative EV price to Tesla price
American	**5.2%**	**72.5%**	**$ 47,537**	**1.09**
Tesla	0.0%	55.1%	$ 46,580	1.00
General Motors	1.6%***	6.4%	$ 33,980	0.73
Ford	56.2%	6.1%	$ 47,845	1.03
Rivian	0.0%	4.2%	$ 76,999	1.65
Lucid	0.0%	0.5%	$ 77,400	1.66
Fisker	100. 0%	0.2%	$ 38,999	0.84
German	**57.1%**	**13.4%**	**$ 65,911**	**1.42**
Volkswagen	46.3%	5.9%	$ 56,029	1.20
BMW	100.0%	4.1%	$ 66,151	1.42
Mercedes-Benz	24.8%	3.4%	$ 80,705	1.73
South Korean	**98.2%**	**7.9%**	**$ 42,207**	**0.91**
Hyundai	98.2%	7.9%	$ 42,207	0.91
Japanese	**83.9%**	**3.7%**	**$ 46,130**	**0.99**
Toyota	100.0%	1.2%	$ 47,071	1.01
Nissan	65.3%	1.7%	$ 45,999	0.99
Subaru	100.0%	0.7%	$ 44,995	0.97
Mazda	100.0%	0.01%	$ 35,485	0.76
Chinese	**100.0%**	**2.2%**	**$ 51,550**	**1.11**
Volvo	100.0%	2.2%	$ 51,550	1.11
Vietnamese	**100.0%**	**0.3%**	**$ 37,802**	**0.81**
Vingroup	100.0%	0.3%	$ 37,802	0.81
United Kingdom	**100.0%**	**0.02%**	**$ 72,000**	**1.55**
Jaguar	100.0%	0.02%	$ 72,000	1.55
All sales	**24.8%**	**100.0%**	**$ 50,552**	**1.09**

*Sales of (new) electrical vehicles in the US in 2023 : 1 189 051 units.

** Base price of models weighted by sales.

*** In the first half of 2024, General Motors' share of US imported EVs increased to 27.7% due to growing sales of the Silverado model assembled in Mexico.

Source: Kelley Blue Book, annual reports of carmakers; computation of the author.

Table 3: US EV imports by country/continent of origin

PANEL A

In units	2022	2023	2024_S1
Imports from Europe	52 196	107 702	52 907
o/w Imports from EU	48 314	104 635	50 068
o/w Imports from Germany	30 949	61 231	30 777
o/w Imports from Belgium	11 907	23 491	8 480
o/w Imports from Hungary	1 672	10 053	5 362
o/w Imports from Austria	0	2 669	3 787
o/w Imports from Slovakia	3 787	7 191	1 500
o/w Imports from Italy	0	0	163
Imports from Asia	70 282	144 821	93 449
o/w Imports from South Korea	59 419	92 326	58 105
o/w Imports from Japan	1 541	37 151	29 837
o/w Imports from Vietnam	0	3 129	2 152
o/w Imports from China	9 322	12 215	3 355
Imports from North America	39 604	41 981	34 391
o/w Imports from Mexico	39 458	41 484	33 645
o/w Imports from Canada	146	497	746
TOTAL	328 992	648 595	374 332

PANEL B

In %	2022	2023	2024_S1
Imports from Europe	15.9%	16.6%	14.%
o/w Imports from EU	14.7%	16.1%	13.4%
o/w Imports from Germany	9.4%	9.4%	8.2%
o/w Imports from Belgium	3.6%	3.6%	2.3%
o/w Imports from Hungary	0.5%	1.5%	1.4%
o/w Imports from Austria	0.0%	0,4%	1.0%
o/w Imports from Slovakia	1.2%	1.1%	0,4%
o/w Imports from Italy	0.0%	0.0%	0.04%
Imports from Asia	21.4%	22.3%	25.0%
o/w Imports from South Korea	18.1%	14.2%	15.5%
o/w Imports from Japan	0.5%	5.7%	8.0%
o/w Imports from Vietnam	0.0%	0.5%	0.6%
o/w Imports from China	2.8%	1.9%	0.9%
Imports from North America	12.0%	6.5%	9.2%
o/w Imports from Mexico	12.0%	6.4%	9.0%
o/w Imports from Canada	0.0%	0.1%	0.2%
TOTAL	100.0%	100.0%	100.0%

Source: own elaboration based on US EV sales by model and location of its assembly plant.

3.5. EV leasing in the USA

The United States has a long tradition of leasing in the vehicle sector. In 2023, according to Experian data, 34.2% of new EVs in the US were leased, with marked differences between models, partly depending on whether the model was assembled in the US or imported from abroad. For example, the i4 model (from the German-based BMW brand and assembled in

Germany) and the Ioniq5 model (from the Korean-based Hyundai brand and assembled in Asia) were 78.9% and 50.7% leased respectively, while Tesla models (assembled in the US) were 'only' 22.0% leased. Similarly, Allcott et al. (2024) conclude that vehicles that lost 30D purchase credit eligibility in August 2022 – because they were not assembled in North America – experienced particularly large shifts to leasing in 2023. Based on data from Experian, the first half of 2024 shows that in a context of growing interest in leasing (with 46.6% of new EV registrations being leased), EVs not assembled in North America were disproportionately leased, with the Toyota bZ4X model (assembled in Japan) achieving a high record leasing rate of 87.8%. In contrast, all Tesla models (assembled in the US) achieved a low leasing rate of 27.8%.

Allcott et al. (2024) found that the year 2023 was marked by a drop in EV lease prices – measured as the present value of the down payment and monthly payments – relative to purchase prices, implying a pass-through of the 45W credits to consumers leasing EVs. For vehicles not assembled in North America, the benefits of leasing over buying an EV increase from $2,700 in January 2023 to $9,200 by the end of the year, or $6,500. This means that almost 85% of the $7,500 tax credit was passed on to households leasing an EV assembled outside North America. In contrast, for EVs assembled in North America, the benefits of leasing over purchasing increased from $5,400 in January 2023 to $7,500 by the end of the year, or 'only' $2,100[23]. For EV automakers assembling EVs outside North America, offering generous leasing was a loophole in the 30D consumer credit eligibility conditions to capture EV market share in the US (Buckberg, 2023; Allcott et al, 2024).

Interestingly, Goldstein et al. (2023) compared the costs of buying and leasing 14 EVs in all 50 US states, adding to traditional financing and lease costs, other costs such as operating costs (fuel and maintenance), insurance costs as well as fiscal costs (state tax and fees net eventually from federal tax credit). They found that leasing a Kia Niro rather purchasing it allows the highest savings for households, equivalent to $3,385 per year. Other models of the South Korean-headquartered group allow annual savings in the range of $1,538 (Hyundai Ioniq) to $1,846 (Hyundai Kona). The two other EV models assembled outside North America of their sample (namely the Volvo XC40 controlled by the Chinese-headquartered group Geely and the i4 from the German-based BMW brand) are also proposing notable savings, of respectively $2,769 and $2,462 per year. This is in sharp contrast to the Chevy Bolt EV/EUV (from the US-based General Motors group) or the Ford F-150 Lightning (from the other US-based incumbent, Ford), for which leasing is a more expensive option than buying when additional costs are taken into account.

South Korea's Hyundai Group is widely acknowledged to have adopted the most aggressive leasing strategy since 2023 to increase its US EV market share, a fruitful strategy as evidenced in Figure 1 (panels A-C). The Japanese automaker Honda, which has a long tradition of leasing for ICE, seems to start following the same strategy for its EV in 2024.

[23] Based on Figure 8 in Allcott et al.(2024), each group has been weighted by EV sales in 2023. In a context of rising interest rates, as in 2023, it becomes be more profitable to lease a vehicle than to buy it (on credit).

4. EV and batteries plants in the United States since the advent of IRA

Several studies have been devoted to tracking the impact of the IRA on the EV ecosystem in the United States. In particular, to which extent the IRA legislation has been successful is bringing EV and battery manufacturing back to the US and securing the battery supply chain has received attention, with specialist websites or academic researchers publishing frequent updated tracking.

Often, such tracking of IRA's impact on the US EV ecosystem is reported in monetary units (dollars) or, eventually, in terms of jobs created. This is a useful way of making an assessment, as it provides insight into investment and economic growth, or still in terms of public funding to achieve the goal of clean energy vehicles. In our work, we take a different approach by carrying out an evaluation in terms of EV units or, eventually, energy units (kWh or GWh). This allows us to shed light on the potential mismatch between the demand for EVs by US households and their supply by US reshoring manufacturers.

4.1 EV assembly plants

According to Third Way data, prior to the adoption of the IRA, there were 30 assembly plants in the United States, out of a total of 50, that were producing or expected to produce EVs by 2025.

Shortly after IRA passing, there have been no major announcement of new EV assembly plants in the US, although some automakers made statements in this direction at some point of time, (for example, Audi). Many US incumbent automakers have continued to produce ICE while modernising some production lines for EVs in a dual-track approach. Other incumbent automakers (such as VW, BMW and Volvo) or start-up (such as Tesla) have pressed ahead with EV plant projects announced prior to the adoption of the IRA. But by no means have EV assembly plant projects been largely driven by the IRA, which has merely helped automakers to confirm their pre-IRA EV plants.

A few months after the adoption of the IRA, the ability to enter the US EV market through leasing may explain why building new facilities in the United States – and retooling existing ones – has not been the preferred option of EV automakers.

But perhaps even more importantly, EV assembly in North America is a necessary but not sufficient condition for an EV to get eligible to consumer tax credit 30D. In other words, if we take into account the time needed to secure the battery supply chain, including upstream activities, and the time needed to build and operate the battery factory, it can take several years. Comparatively, the time to build an EV assembly plant is shorter, with a project both cheaper and less complex than in the case of a battery assembly plant. For all these reasons, decisions on EV assembly plants are made after or at the same time as decisions on battery assembly plants. Following this line of reasoning, the IRA legislation stimulates first battery assembly plants, then EV assembly plants, not the opposite.

4.2 Battery assembly plants

As a preliminary insight, it is worth noting that Shen, Slowik and Beach (2024) recently provided an in-depth and comprehensive assessment of the availability of critical minerals, particularly lithium, to secure the battery supply chain in the United States through 2032. Based on a tracking of current and ongoing mining and extraction projects, they found that there is no threat of shortages of critical minerals when we consider projects in the United States and countries with which the United States has signed an FTA or a CMA. For example, lithium mining and refining capacity in the United States alone could power 10.5 million new (300-mile range) EVs by 2032 (Shen, Slowik and Beach, 2024, p. 30). Adding existing and potential capacity in the FTA and CMA partners would increase this figure to nearly 40 million new EVs by 2032.

In what follows, we focus instead on battery pack plants, the final stage of the battery supply chain (Box 1). As Coffin and Horowitz (2018) have already noted, for some projects it can be difficult to distinguish what falls under the third stage from other stages of the battery supply chain.

To carry out our assessment, we proceeded as follows. First, we updated – and completed – previous tracking of battery assembly plant projects since the introduction of the IRA. In particular, we made extensive use of Plante and Rindels (2022), Klier and Rubenstein (2022) and Bellan (2024). Following standard practice, only gigafactories are considered, i.e. factories with a production capacity of at least one gigawatt-hour (GWh) per year or 1 million kilowatt-hours (kWh). In the case of the US, the average size of an EV battery pack is 79 kWh, a metric we used to convert GWh into EVs or vice versa when the information is missing from the announcement by the battery manufacturer and/or automaker customer[24]. Other relevant information gathered is about the nationality of control for the battery manufacturer, the business model followed by the automaker to secure its battery supply, as well as the location of the battery assembly plant in North America. The nationality of control and the business model are of particular interest because, while the FEOC definition prohibits a Chinese-controlled battery manufacturer from entering the US market through direct investment, some business models can still be used by a Chinese company to enter the US market without building its own facility there. Finally, the location of battery assembly plants gives insights into the ability of the IRA legislation to effectively bring production back on US territory rather than in neighbouring countries (Mexico and Canada) with which the United States has a FTA.

In Table 4, battery plant capacities in terms of GWh are allocated according to the nationality (of control) of, respectively, the automaker (Panel A) and the battery manufacturer (Panel B), as well as according to the business model linking the automaker and the battery manufacturer (Panel C). Finally, Panel D distinguishes according to the location of the battery pack plant in North America.

As of 1 October 2024, there are 37 battery plants in operation, under construction or announced in North America[25]. This corresponds to an increase of 15 new projects compared to the situation in July 2022, prior to the passage of the IRA. Bellan (2024) argues that the Covid crisis had already prompted onshoring of battery manufacturing in the United States: for EV manufacturers facing delivery delays, securing the supply chain had become strategic. Considering a battery as a simple 'commodity' traded on a market was no longer a viable option for most automakers, who took a more active role in battery development and even production, partnering with start-ups specialising in battery chemistry (mainly in Silicon Valley) or with incumbent battery manufacturers (mainly from Asia).

Based on our estimates, those 37 battery plants would allow annual production of 1,352 GWh per year, enough to power 17.022 million EVs per year by 2030. To put this in perspective, the capacity is equivalent to 14 times the number of EVs sold in the US in 2023, or 110% of the annual (average) newly registered cars in the period 2014-22023[26]. This is a clear sign of overcapacity. It should be noted that with around 320,000 EVs sold in Canada in 2023 and almost 0 in Mexico, these two countries seem unable to compensate for sluggish sales in the US.

Looking at the automaker customer nationality, the share of battery capacity unsurprisingly roughly mimics the current market share, with US-based automakers accounting for the bulk in GWh capacity, followed by German-based automakers (Panel A). Japanese automakers would

[24] With this metric, one GWh can power 12,660 EVs.

[25] The Appendix 2 provides the complete list of the battery plants with their GWh and EVs capacities.

[26] Between 2014 and 2023, an average of 16.1 million of new cars were registered in the US each year (source: BEA).

secure more batteries than South Korean automakers, which can be interpreted as a sign that the former are catching up in the race towards vehicle electrification[27]. In the case of Tesla, it is worth noting that a gigafactory project in Mexico has been suspended until after the US presidential election in November, as Donald Trump has promised if elected to impose a 100% tariff on vehicles manufactured in that country.

In terms of battery manufacturers nationality, South Korean companies account for almost half of the total capacity of battery assembly plants in operation, under construction or announced (Panel B). LG Energy Solution is the obvious leader, operating in the US mainly through joint ventures with General Motors, Hyundai, Honda and Stellantis. A strategy of pure integration is favoured by the German car manufacturers, notably with PowerCo, the battery cell owned by the Volkswagen group, which will equip the group's EVs brands in North America. Finally, US-based automakers Tesla and Ford operate mainly through licensing agreements with CATL, one of the most influential battery cell manufacturers based in China.

The Licence Royalty Service (LRS) model deserves special attention as a gateway for CATL to indirectly access the US market. More specifically, in this business model, the battery manufacturer does not hold equity in the manufacturing facilities, but licenses its technology and collects patent and service fees. The LRS model is typically win-win, allowing automotive customers (Tesla and Ford in our case) to produce EVs that qualify for the IRA tax credit, while giving CATL access to the US market without direct investment in manufacturing facilities, which is prohibited in the US for a Chinese-controlled company.

The licensing partnership with CATL is a hot topic for US lawmakers[28]. Ford, for example, has been under political pressure to scale back its battery and EV plant project in Marshall, Michigan, because of its licensing agreement with CATL. In the spring of 2024, CATL approached other major automakers, including General Motors. To date, no agreement has been reached between General Motors and CATL. As of 1 October 2024, the LRS model accounted for 139 GWh of battery capacity, or 10% of total operating and announced capacity (Panel C). That could power 1.728 million EVs annually.

Finally, in terms of countries in the North American region, 86% of battery projects are located in the US, with the remainder in Canada and none in Mexico. Thus, in terms of supply-side incentives, the IRA has so far been successful in attracting battery manufacturing to the United States. Two European automotive groups have battery projects in Canada, either almost operational (Stellantis) or under construction (Volkswagen). It is worth noting that, in the case of Volkswagen, the government of Canada will provide annual production subsidies and capital grants for an amount equivalent to what the German automaker could have received via IRA if it had located the plant in the US[29]. This case clearly illustrates the 'subsidy race' that governments engage in to attract companies to their territory. The contract with Volkswagen is written in such a way that if the US incentives are reduced, the Canadian incentives will be reduced proportionally. The same incentive package would *a priori* apply to Stellantis.

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[27] Possibly, some of the GWh capacity built by Japanese automakers can be used to power plug-in hybrid electric vehicles (PHEVs) rather than pure EVs, for which they have well-developed technology. However, the battery size of a PHEV is comparatively much smaller than that of an EV.

[28] Amy Hawkins (18 March 2024): CATL, the little-known Chinese battery maker that has the US worried, *The Guardian*.

[29] Brian Platt (20 April 2023): Canada matched Joe Biden subsidies to win Volkswagen battery plant, pledging up to $13 billion, *Bloomberg News*.

Table 4. Battery pack plants in North America, in operation and announced as of October 1, 2024*

By nationality of the automaker customer	in GWh	in % of total
Germany	205	15%
South Korea	97	7%
Japan	135	10%
Vietnam	12	1%
France-Italy	107	8%
USA	620	46%
of which Tesla	299	22%
of which General Motors	236	17%
To be determined	175	13%
Total	1,352	100%
By nationality of the battery manufacturer**	**in GWh**	**in % of total**
South Korea	654	48%
of which LG Energy Solution	414	31%
Japan	220	16%
of which operating with AESC (Japan-headquartered/China-controlled)	86	6%
USA	281	21%
of which licensing with CATL (China-headquartered)	139	10%
Germany	124	9%
Sweden	60	4%
Vietnam	12	1%
Total	1,352	100%
By business model	**in GWh**	**in % of total**
Acquisition	222	16%
Joint venture	614	45%
Multi-years contract	102	8%
Licensing	139	10%
To be determined	275	20%
Total	1,352	100%
By USMCA country member***	**in GWh**	**in % of total**
USA	1,162	86%
Canada	190	14%
Mexico	0	0%
Total	1,352	100%

* Only gigafactories are considered here, i.e. factories with a manufacturing capacity of at least one gigawatt-hour (GWh) per year or 1 billion watt-hours.

**Nationality is defined according to the headquarter of the parent company. Otherwise, if the nationality of control is different, we specify.

*** The United-States-Mexico-Canada Agreement (USMCA) entered into force on July 1, 2020. It substituted the North America Free Trade Agreement (NAFTA).

Sources: Battery company websites; Plante and Rindels (2022); Klier and Rubenstein (2022); Bellan (2024).

5. Further reflections and conclusion

The main issue for mass fleet electrification in the US over the next 10 years is not supply shortages. On the contrary, projects all along the value chain, from mineral extraction to battery pack production, show that demand shortfalls will be a major challenge. This conclusion comes as a surprise two years after the adoption of the IRA, when strict, complex eligibility requirements for the tax credit were seen as a major obstacle to bringing battery and component manufacturing back to the US.

To date, the provisions of the IRA have done little to increase the uptake of EVs by US households. Many observers estimate that EVs will not even reach 10% of new vehicle registrations by 2024.

With EV sales at such low levels, the surge in investment in battery assembly plants appears disproportionate and creating risk of overcapacity. It should be noted that some projects have already been scaled back or suspended due to sluggish demand for EVs. One policy implication is that the IRA's provisions to subsidise EV demand are not properly designed. In particular, the incentives should more target low-income US households for whom the price of an EV remains too high, a conclusion similarly reached by Bauer, Hsu, and Lutsey (2021). Indeed, uptake of EV in the US still remains a question of wealthy people. For instance, data from Experian shows that, the class income registering the most new vehicles in the US in June 2023, namely the $50-100K, accounted for 32% of new registrations but only for 19% of new EV registrations. The gap is similar for households with an income below $50,000 (19.2% and 7.2% respectively). By contrast, the households with an income above $250,000 have an inverse gap: at that date, they accounted for 9.8 % of new registrations but 19 % of new EV registrations.

International experience, and European experience in first instance, shows the importance of EV subsidies in triggering EV purchases among low-to-middle income households. However, the US market, even more than other markets, is sensitive to the issue of vehicle range because of its vast territory. It is therefore also important to ensure that the charging infrastructure is well distributed across the country, something that the IRA and the Infrastructure Investment and Jobs Act of 2022 have so far failed to encourage through various provisions.

The overcapacity in battery production in the United States raises a number of issues. First, there is the problem of wasting in public resources, as many countries engage in a “subsidy race”, a problem illustrated in this paper by the case of Volkswagen and Stellantis, which have received a similar package of incentives in Canada to those they can obtain in the United States. This is not an isolated case, however, with the media providing many examples of “subsidy race” across countries and across lower state/region levels. Second, building overcapacity in battery production also creates a problem of wasting in natural resources, as battery plants are land-consuming, production of battery components are water-consuming and, upstream, mining and refining activities are environment-damaging and polluting. Third, on the international scene, it creates more tension than it solves in the race to electrify vehicles, with each country trying to sell its excess capacity abroad. The case of China is a good example of this, with its battery production alone matching worldwide demand in 2023 (BloombergNEF). The US President Biden's response in May 2024 was to increase tariffs on batteries from China.

Most observers believe that global battery capacity could exceed demand by more than double, reaching, according to BloombergNEF, almost 2,600 GWh. The United States, along with other subsidising countries (Canada, the EU, India, to quote a few), is clearly contributing to such a global battery excess. This oversupply situation puts at risk on worsening international relations, creating polarisation at a time when coordination actions would be better. Success is by no means guaranteed for the companies involved in this battery market grab, and some of them are already on the verge of bankruptcy, the latest example being the case of Northvolt, a Sweden-based battery manufacturer involved in Canada.

As regards the US EV market, automakers have so far adopted different strategies, depending on whether they are incumbents or start-ups, whether they are based in allied countries or whether they have an edge in EV technology. Let's summarize at these differences in automakers' strategies.

On the one hand, unlike their German and South Korean counterparts, Japanese automakers are still lagging behind in penetrating the US EV market, which can be explained by the fact that their technological development to date has favoured hybrid models rather fully electric models. However, 2024 could mark a turning point, as suggested by the rise of Japanese brands in US sales in the first half of this year.

On the other hand, German automakers are more involved in EV assembly and battery production in the US (and North America in general) than South Korean counterparts. The latter are more likely to use the leasing loophole to enter the US market, importing EV models from South Korea. Projects of battery plant into the US indicate however that thing can turn different in the medium term.

Overall, Chinese-based or Chinese-controlled automakers appear to be permanently locked out of the US EV market, whether through imports or foreign direct investment. Polestar, which is controlled by China's Geely, has failed to launch its new model, the Polestar 2, which aims to compete with the Tesla 3. President Biden's decision to increase tariffs on Chinese-made EVs in May 2024, and the threat of Donald Trump as the next president, appear to have seriously hampered the brand's plans. Even CATL, the Chinese battery manufacturer, appears to be threatened by its licensing deals with automakers such as Tesla and Ford, which use them to power their EVs in the US.

Despite the efforts of competitors, including incumbent US automakers General Motors and Ford, the US EV market is still dominated by US start-up Tesla, which has kept its advantage of first moving. Tesla's decision after the election of the next US president will be an important one, since developing the Gigafactory in Mexico, as the automaker would like to do, would signal a certain loss of attractiveness of the US territory and, in a way, the failure of the IRA to bring battery and EV assembly back to the US.

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Appendix 1

Table A: Electrical vehicles sold in the United States over 2022-2024

MODELS	BRANDS/AUTOMAKERS	GROUPS	Nationality of control	Legacy of automaker
Acura ZDX*	Acura	Honda	Japan	Incumbent
Audi e-tron	Audi	Volkswagen	Germany	Incumbent
Audi Q4 e-tron	Audi	Volkswagen		
Audi Q8 e-tron	Audi	Volkswagen		
BMW i3	BMW	BMW	Germany	Incumbent
BMW i8	BMW	BMW		
BMW iX	BMW	BMW		
BMW i4	BMW	BMW		
BMW i5	BMW	BMW		
BMW i7	BMW	BMW		
Brightdrop Zevo 600 / 400	General Motors	General Motors	USA	Incumbent
Cadillac Lyric	General Motors	General Motors		
Chevy Bolt EV/EUV	Chevrolet	General Motors		
Chevrolet Blazer	Chevrolet	General Motors		
Chevrolet Equinox*	Chevrolet	General Motors		
Chevrolet Silverado	Chevrolet	General Motors		
Fiat 500e*	Fiat	Stellantis	France/Italy	Incumbent
Ford E-Transit	Ford	Ford	USA	Incumbent
Ford F-150 Lightning	Ford	Ford		
Ford Mustang Mach-E	Ford	Ford		
Genesis G80	Genesis	Hyundai	South Korea	Incumbent
Genesis GV60	Genesis	Hyundai		
Genesis GV70	Genesis	Hyundai		
GMC Hummer	General Motors	General Motors	USA	Incumbent
Fisker Ocean	Fisker	Fisker	USA	Start-up
Honda Prologue*	Honda	Honda	Japanese	Incumbent
Hyundai Ioniq	Hyundai	Hyundai	South Korea	Incumbent
Hyundai Ioniq5	Hyundai	Hyundai		
Hyundai Ioniq6	Hyundai	Hyundai		
Hyundai Kona	Hyundai	Hyundai		
Jaguar I-Pace	Jaguar	Jaguar	United Kingdom	Incumbent
Kia EV6	Kia	Hyundai	South Korea	Incumbent
Kia EV9	Kia	Hyundai		
Kia Niro	Kia	Hyundai		
Lexus RZ	Lexus	Toyota	Japan	Incumbent
Lucid Air	Lucid	Lucid	USA	Start-up
Mazda MX-30	Mazda	Mazda	Japan	Incumbent
Mercedes EQB	Mercedes	Mercedes	Germany	Incumbent
Mercedes EQE	Mercedes	Mercedes		
Mercedes EQS	Mercedes	Mercedes		
Mini Cooper	Mini Cooper	BMW	Germany	Incumbent
Nissan Leaf	Nissan	Nissan	Japan	Incumbent
Nissan Ariya	Nissan	Nissan		
Polestar 2	Polestar	Geely	China	Start-up
Porsche Taycan	Porsche	Volkswagen	Germany	Incumbent
Rivian EDV500/700	Rivian	Rivian	USA	Start-up
Rivian R1S	Rivian	Rivian		
Rivian R1T	Rivian	Rivian		
Subaru Solterra	Subaru	Subaru	Japan	Incumbent
Tesla Cybertruck*	Tesla	Tesla	USA	Start-up
Tesla Model 3	Tesla	Tesla		
Tesla Model S	Tesla	Tesla		
Tesla Model X	Tesla	Tesla		
Tesla Model Y	Tesla	Tesla		
Toyota BZ4X	Toyota	Toyota	Japan	Incumbent
Vinfast VF8	Vinfast	Vingroup	Vietnam	Start-up
Volvo C40	Volvo	Geely	China	Incumbent
Volvo XC40	Volvo	Geely		
VW ID.4	Volkswagen	Volkswagen	Germany	Incumbent

* Models sold since 2024. Otherwise models also sold in 2022 and/or 2023.

Source: Wikipedia and annual reports of automakers; elaboration by the author.

Appendix 2

Table B: Battery pack plants in North America, operating and announced as of 1st October 2024*

Battery company	Location	Automaker customer	Production start year	Capacity in GWh **	Capacity in EV
CATL	Ciudad Juárez, Chihuahua, Mexico	Ford, Tesla	SUSPENDED	n.a.	n.a.
CATL	Marshall, Michigan	Ford	2026	20	228,000
CATL	Sparks, Nevada (extension)	Tesla	2025	119	1,500,000
AESC	Bowling Green, Kentucky	Mercedes	2026	40	506,329
AESC	Smyrna, Tennessee	Nissan	2012	16	200,000
AESC	Woodruff, South Carolina	BMW	2026	30	379,747
iM3NY	Endicott, New York	TBD	2022	38	481,013
LG NRJ Solution	Queen Creek, Arizona	TBD	2024	53	670,886
LG NRJ Solution	New Castle, Indiana	GM	TBD	40	500,000
LG NRJ Solution	Lansing, Michigan	GM	2024	45	569,620
LG NRJ Solution	Holland, Michigan	GM	2025	20	253,165
LG NRJ Solution	Holland, Michigan (extension)	Toyota	2025	20	253,165
LG NRJ Solution	Lordstown, Ohio	GM	2022	45	569,620
LG NRJ Solution	Jeffersonville, Ohio	Honda	2025	40	506,329
LG NRJ Solution	Windsor, Ontario, Canada	Stellantis	2024	40	506,329
LG NRJ Solution	Spring Hill, Tennessee	GM	2024	50	632,911
LG NRJ Solution	Savannah, Georgia	Hyundai, Kia, Genesis	2025	30	300,000
LG NRJ Solution	Montgomery, Alabama	Hyundai, Kia	2024	32	400,000
Mercedes-Benz	Woodstock, Alabama	Mercedes-Benz	2024	25	316,456
Microvast	Clarksville, Tennessee	TBD	2022	4	50,633
Northvolt	McMasterville & Saint-Basile, Quebec, Canada	TBD	2026	60	759,494
ONE	Van Buren Township, Michigan	TBD	2024	20	253,165

Continued (…/…)

Continued (…/…)

Battery company	Location	Automaker customer	Production start year	Capacity in GWh **	Capacity in EV
Panasonic	De Soto, Kansas	Tesla, Lucid, Mazda	2025	30	379,747
Panasonic	Sparks, Nevada	Tesla, Mazda	2016	39	493,671
Panasonic	TBD, Oklahoma	Tesla	TBD	35	443,038
Samsung	Kokomo, Indiana	Stellantis	2025	33	417,722
Samsung	Kokomo, Indiana	Stellantis	2027	34	430,380
Samsung	New Carlisle, Indiana	GM	2026	36	455,696
SK On	Commerce, Georgia	Ford, VW	2025	22	300,000
SK On	Glendale, Kentucky	Ford	2025	40	506,329
SK On	Glendale, Kentucky	Ford	PAUSED	40	506,329
SK On	Bartow County, Georgia	Hyundai	2026	35	443,038
Tesla	Fremont, California	Tesla	2022	51	650,000
Tesla	Austin, Texas	Tesla	TBD	30	375,000
Tsusho	Liberty, North Carolina	Toyota	2025	30	375,000
VinFast	Sanford, North Carolina	VinFast	2025	12	150,000
VW	Chattanooga, Tennessee	VW	2022	9	120,000
VW	St Thomas, Canada	VW	2027	90	1,139,241
TOTAL				**1,351.7**	**17,022,051**

* Only operating or announced battery pack plants are considered here. Moreover, the plants tracked are all located in North America with the aim of primarily serving the US light-duty EV market.
** Capacity in Gigawatt-hour (GWh) and/or in electrical vehicle (EV) are those reported by the battery company or the automaker customer. When only one capacity is given, the conversion in GWh (or numbers of EVs) is made considering than the battery capacity of a typical US EV is 79 kilowatt-hours. Recall that 1 Gigawatt-hour = 1 000 000 kilowatt-heure.
Notes: TBD means to be determined. Unless indicated otherwise, the locations are within the United States. ACT refers to Amplify Cell Technology; BMW, Bavarian Motor Works; CATL, Contemporary Amperex Technology Co., Limited; Envision AESC, Envision Automotive Energy Supply Corporation; GM, General Motors; ONE, Our Next Energy; SKI, SK Innovation; and VW, Volkswagen.
Sources: Battery company websites; Plante and Rindels (2022); Klier and Rubenstein (2022); Bellan (2024).