Understanding Electric Vehicle Adoption in Portugal: The Role of Primary and Secondary Markets in Shaping Municipal-Level Dynamics and Policy Interventions

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Abstract. Electromobility represents a crucial strategy for mitigating CO_2 emissions in the transport sector, with government incentives and subsidies playing a pivotal role in promoting widespread adoption. However, the improper design and application of these subsidies may result in unintended negative consequences, such as discouraging the resale of new electric vehicles into the used car market. This secondary market constitutes the largest segment of the light passenger vehicle market, accounting for over 85% of total share and is therefore critical for the overall diffusion of electric mobility. We examine the adoption stages of electric vehicles across municipalities in mainland Portugal, classifying them into early (5%), critical mass (25%), and advanced (>50%) phases. Additionally, we demonstrate the interplay between primary and secondary markets, highlighting the significant influence of the latter on adoption dynamics due to its larger size and lower level of development. The findings offer a basis for developing more focused and effective policies aimed at accelerating decarbonization, emphasizing that incentives should be directed towards encouraging companies to rapidly replace their EVs, thereby helping to supply vehicles to the used market. Additionally, stricter quality control of used vehicles must be ensured, along with support for the importation of used EVs.

1 Introduction

Driven by growing environmental concerns, electromobility has emerged as a central strategy for reducing CO_2 emissions in the transportation sector. According to the European Parliament [1], road transport was responsible for approximately a fifth of EU emissions in 2019, with passenger cars being the largest contributors, responsible for 61% of those CO_2 emissions. Empirical evidence demonstrates the environmental advantages of electric vehicles[2] (EVs), particularly their aptitude to significantly reduce Global Warming Potential (GWP) [2]. When comparing similar vehicles, battery electric vehicles (BEVs) reduce GWP

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[2] Electric Vehicle (BEV + PHEV): any vehicle that uses electric propulsion, fully or partially.

by 23% relative to internal combustion vehicles (ICVs), while plug-in hybrid electric vehicles (PHEVs) achieve a 17% reduction – assuming electricity generation from renewable sources [2]. This effectively eliminates reliance on fossil fuels, whereas an ICV requires approximately 15 tonnes of imported oil over its lifetime [3]. By choosing an EV, consumers contribute to lowering local air pollution [3, 4].

However, if the energy sector continues to rely on fossil fuels, there will be global environmental repercussions, especially since 80% of the population in the Global South resides in oil-importing countries. Of the 6.7 million annual deaths linked to air pollution, roughly 90% occur in this region [3]. The expansion of solar and wind power generation faces implementation speed constraints necessary to match the transition from ICVs to EVs. Nonetheless, the automotive sector can enhance grid flexibility, facilitating greater integration of renewable energy sources [3].

EV production also entails environmental impacts, notably the toxicity associated with battery manufacturing [2]. To address this, the industry is increasingly incorporating recycled and sustainable materials in battery production [5]. Furthermore, rising EV adoption may reduce production costs [4], enabling manufacturers to invest in automation and robotics, which improve efficiency and lower costs [5], ultimately making EVs more economically accessible and environmentally impactful. For consumers, modern electric drivetrains demand less maintenance compared to ICVs [5].

Battery end-of-life considerations are also gaining attention, with solutions such as repurposing batteries for energy storage [5, 6]. EVs reaching the end of their life cycle in developed countries often find continued use in developing countries [7]. Additionally, recycling end-of-life EVs enhances remanufacturing efficiency of discarded components and promotes sustainable transportation within a circular economy framework [8].

In line with these considerations, Governments worldwide have actively promoted EV adoption through financial incentives and subsidies, which have proven to be a crucial policy instrument in accelerating market penetration [9]. Despite the effectiveness of subsidies in the early stages of diffusion, the long-term sustainability of the EV market depends on its ability to function without continued public financial support. Identifying the point at which EV adoption becomes self-sustaining is therefore of critical importance. As highlighted in the literature, electric vehicle markets must surpass a critical mass in order to achieve a self-sustaining diffusion process; otherwise, adoption rates may stagnate or even decline when subsidies are reduced or removed [10].

Portugal presents a particularly relevant case for studying this transition due to its pronounced territorial inequalities. Economic development is unevenly distributed, with coastal regions generally more developed than inland areas, and notable disparities between the northern and southern regions of the country. These structural differences suggest that uniform national-level public policies may inadvertently reinforce territorial inequalities. Consequently, public policy design should account for the specific socioeconomic characteristics of individual municipalities rather than relying solely on generalized national approaches.

This work draws on the diffusion of innovation framework originally developed by Everett Rogers, which conceptualizes technology adoption as a process unfolding through five distinct adopter categories: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards [11]. Prior research suggests a strong association between these categories and income levels, with Early Adopters typically belonging to higher-income groups, while Laggards tend to have fewer financial resources [12]. In this context, well-designed subsidy schemes can play a critical role in facilitating transitions between adopter categories, particularly in bridging the so-called “chasm” between Early Adopters and the Early Majority — a transition that marks the shift from niche markets to mass-market acceptance.

Nevertheless, reaching this initial threshold does not guarantee full market maturation. Achieving an adoption rate of 25% remains a significant challenge, particularly in less developed economies [12]. This tipping point marks the onset of a self-sustaining diffusion process [13].

Estimating this threshold requires a robust quantitative framework. Rogers' diffusion model assumes a known and fixed population of potential adopters; however, this assumption does not fully apply to the automotive market. Individuals may own more than one vehicle, and empirical evidence indicates that EVs are often purchased as second or third vehicles rather than as primary replacements [14]. Additionally, the Portuguese automotive market has experienced substantial growth, with annual vehicle acquisitions increasing by approximately 300% between 2011 and 2024, rising from 239,380 to 979,696 vehicles. Consequently, the relevant unit of analysis is not the number of individuals but rather consumers' annual purchase decisions between EVs and ICVs.

Given the pronounced fluctuations observed in annual sales growth, it is necessary to adopt a method capable of identifying the overall behaviour of the dataset, thereby making the underlying patterns clearer and more visually interpretable. To this end, the estimation of a trend line is required to smooth short-term variability and reveal the long-term diffusion dynamics.

Although Rogers' diffusion framework does not provide a formal mathematical specification suitable for trend estimation, the literature commonly addresses this limitation through the use of logistic diffusion models characterized by S-shaped curves [14]. Logistic diffusion models have been widely applied in empirical research on electric vehicle adoption and offer a well-established methodological foundation for operationalizing the diffusion process and estimating adoption trajectories over time. As such, these models provide an appropriate analytical framework for capturing both the inherently non-linear nature of EV diffusion and the heterogeneous adoption patterns observed across municipalities.

The literature reveals that poorly targeted financial incentives may hinder EV adoption and delay necessary CO_2 emission reductions. As a member of the EU, Portugal is required to meet the Climate Law targets embedded in the European Green Deal, established by the European Parliament, notably the "Fit for 55 by 2030" initiative, which aims for a 55% reduction in emissions by 2030. However, in 2024, Portugal's national EV adoption rate reached only 13%, with the new vehicle market already achieving a 46% preference for EVs, while the used vehicle market remains at 7%. When considering only 100% electric vehicles, the figures at both the national and used-vehicle levels are considerably more concerning, standing at 7% and 4%, respectively. By contrast, the new-vehicle market has already reached a state of self-sustainability, with fully electric vehicles accounting for 26% of new acquisitions (based on data from the database employed in this work). Despite this, Portugal continues to open applications for national subsidies exclusively for new 100% electric passenger vehicles. The limited understanding of municipal-level dynamics in both new and used EV markets risks leading to public policies that do not broadly stimulate the market but instead disproportionately benefit regions already operating in a self-sustaining manner without subsidies. This work evaluates Portuguese municipalities based on key EV adoption tipping points in new and used markets, classifying them into early (5%), critical mass (25%), and advanced (>50%) stages, with this latter milestone being achievable primarily in more developed areas needing support from more advanced ones. We also emphasize the secondary market's vital role in diffusion and argue that such detailed, local analyses are crucial for effective policy design to accelerate EV adoption and reduce greenhouse gas emissions.

The remaining of this paper is organized as follows. Section 2 reviews the existing literature on the key tipping points relevant for understanding the evolution of EVs adoption, the structure of the vehicle market, and the impact of financial incentives on EV market dynamics. Section 3 describes the data sources and their composition. Section 4 introduces the methodology used to estimate EV adoption levels for the year 2024. Section 5 presents and discusses the results on the evolution of the new and used EV markets, as well as their combined effect, and discusses the implications of these findings for policy decision-making. Finally, Section 6 summarizes the main conclusions and outlines policy recommendations to support EV adoption in Portugal.

2 Literature review

This section presents a literature review to contextualize the work, including the different tipping points associated with innovation diffusion, the role of market shares of new and used vehicles, as well as subsidies and their implications for the used vehicle market.

2.1 Tipping Points

Everett Rogers' Diffusion of Innovations theory [11] identifies five adopter categories that describe how new technologies spread within a population – Innovators (2.5%), Early Adopters (13.5%), Early Majority (34%), Late Majority (34%), and Laggards (16%).

The transition from the Early Adopters to the Early Majority, which occurs around 16% adoption [15], is often regarded as a pivotal phase in diffusion studies and is commonly referred to as the chasm, as it separates the early market (new product) from the main market (established product) (Figure 1).

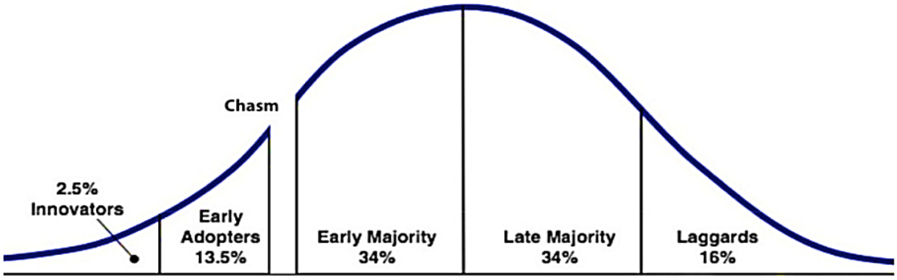

Fig. 1. Everett Rogers' Diffusion of Innovations model and the chasm phase [15]

The take-off stage in the diffusion of an innovation occurs at approximately 5% adoption and is commonly identified in the literature as an early tipping point [12]. We use this threshold as a baseline, whereby municipalities below this level are considered not yet to have effectively adopted electric vehicles.

Achieving an adoption rate of approximately 25%, commonly referred to as the critical mass, remains a substantial challenge [12]. This threshold is described as the point at which adoption shifts from being driven primarily by innovators and early adopters to being sustained by the broader market [11]. We use this tipping point to define the moment at which EV adoption within a municipality becomes self-sustaining — that is, when growth continues independently of Early Adopters or external incentives.

Additionally, a 50% adoption threshold is also identified in the literature and is observed to be rarely achieved in developing economies [12]. We use this level to assess whether certain municipalities have already surpassed this stage and may therefore have the potential to act as catalysts for the advancement of other areas.

2.2 Market share

Vehicle lifespan significantly influences demand dynamics and the pace of technological transition in road transport, with passenger cars typically used for around 15 years. Thus, changes in new vehicle sales gradually affect fleet composition [3]. In this context, the diffusion of EVs depends not only on new sales growth but also on the expansion of robust secondary markets that increase access over time.

As earlier EV generations complete their initial ownership, more used EVs enter the market, fostering secondary market development [6]. Used EVs, defined as vehicles still operational and economically viable before end-of-life [8], are crucial for mass adoption, especially given the relatively high cost of new EVs. Evidence from ICV markets shows that used vehicles constitute the primary acquisition method in both developed and developing economies — estimated at 80% in the EU and up to 90% in lower-income regions. For instance, in the US, used vehicles accounted for about 70% of transactions in 2022 [7]. In Portugal, this value averages approximately 85%[3].

The literature indicates that as markets mature, the ratio of new to used vehicles stabilizes at an equilibrium influenced by income, financing access, and institutional factors. Developed economies generally show higher new vehicle registration rates, while less developed ones rely more on imported used vehicles. Overall, it is accepted that during the first decade after introduction, most EV registrations are new vehicles [7]. Therefore, a healthy used EV market is recognized as a marker of a mature electric mobility ecosystem, reflecting active participants, adequate infrastructure, supportive regulation, and its critical role in transport sector decarbonization [5].

2.3 Subsidies

Government incentives play a crucial role in shaping the dynamics of both new and used EV markets. Subsidies such as tax credits and discounts lower the upfront cost of new vehicles, thereby increasing demand [5]. However, financial support for new EVs can accelerate depreciation in the used vehicle market by widening the price gap between new and used vehicles. In other words, vehicle owners must offer prices lower than those of subsidized new vehicles, which can discourage resale and consequently reduce the supply in the secondary market [5, 7]. Conversely, subsidies specifically targeted at used EV purchases reduce acquisition costs, improve affordability across income groups, and stimulate demand in the secondary market [5, 7].

Research also shows that region-specific subsidy policies outperform uniform federal programs by addressing local market conditions and consumer behaviour more effectively [4]. This complex interaction between new and used EV incentives underscores the importance of comprehensive policy design that considers both segments to foster a healthy EV ecosystem.

3 Data

The Automobile Association of Portugal (ACAP) provides annual vehicle registration data for the 308 municipalities corresponding to mainland Portugal and the archipelagos of the Azores and Madeira. However, this work presents results exclusively for mainland Portugal. The dataset covers the period from 2011 to 2024.

This database includes detailed information on the energy type of light passenger vehicles, specifically Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles

[3] Based on data from the database employed in this work and covering the period 2011-2024.

with diesel engines (PHEV/Diesel), Plug-in Hybrid Electric Vehicles with gasoline engines (PHEV/Gasoline), diesel, and gasoline vehicles. It also distinguishes vehicle status by category: new, imported used, nationally used, and initial registration — the latter referring to acquisitions by dealerships and excluded here as it does not reflect final consumer ownership.

4 Applicability of diffusion theory

Due to observed annual fluctuations in sales growth over time, the methodology used prioritizes establishing a trend line for each municipality before extracting the corresponding sales rate for the most recent year available (2024). Although Rogers' diffusion model lacks a formal mathematical function to define such trend lines, the literature commonly addresses this limitation by employing logistic diffusion models characterized by S-shaped curves [14] (Figure 2).

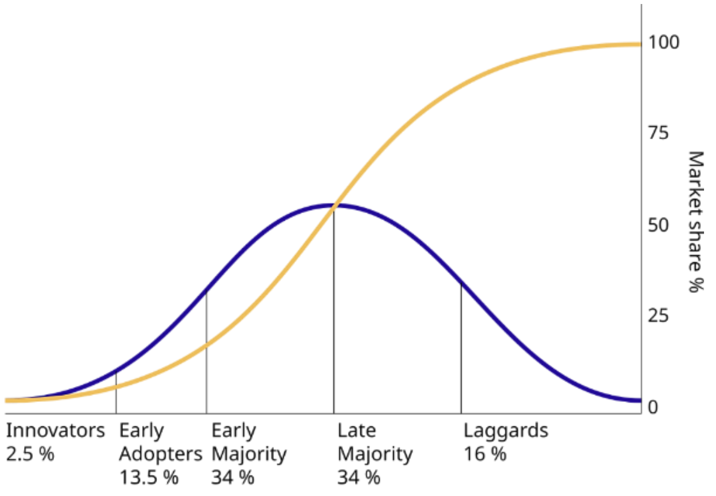

Fig. 2. S-shaped diffusion curve and Everett Rogers' Diffusion of Innovations model [15]

The S-shaped curve effectively represents the typical lifecycle of many economic phenomena. Despite their simplicity, logistic models are well-suited to describe technological diffusion processes, and numerous studies support their use as accurate representations of adoption patterns [14].

Several mathematical formulations are available to describe these diffusion trends and forecast future trajectories [3, 14] (Figure 3):

• Logistic function: symmetric around the 50% adoption threshold, computationally simple, with a pronounced growth phase, making it better aligned with Everett Rogers' diffusion model;

• Gompertz curve: asymmetric, easy to compute, with slower initial growth and a more gradual increase;

• Bass curve: asymmetric, intermediate in shape between the logistic and Gompertz functions, and which differentiates between two consumer groups: innovators and imitators;

• Richards curve: asymmetric and more complex, generalizing the previous models through a shape parameter that ranges from 0 (Gompertz) to 1 (logistic).

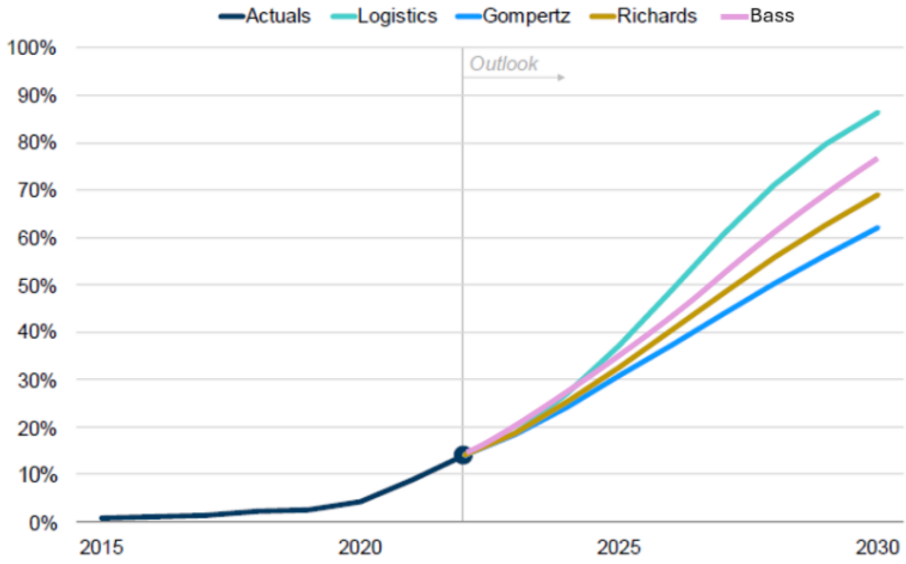

Fig. 3. S-curve models for EV market share (%) [3], with the Bass curve added manually for visual representation

The Gompertz curve (characterized by rapid growth) and the logistic curve (characterized by even faster growth) serve as benchmarks for modelling fast-growing technologies such as EVs [3]. Rather than forecasting future values, we employ these two mathematical models to extract the trend line that best fits the available data, thereby compensating for fluctuations and enhancing the clarity and visual interpretability of underlying patterns. Specifically, for each municipality, we determine the curve that maximizes the coefficient of determination (R^2), thus identifying the optimal trend representation.

Logistic Function: $$f(t) = \frac{K}{1+e^{-r(t-t_0)}} \quad (1)$$

Gompertz Function: $$f(t) = K.e^{-ae^{-r(t-t_0)}} \quad (2)$$

Let K represent the maximum adoption level, which we set at 100%, reflecting the policy objective of completely phasing out the purchase of ICVs. Under this assumption, the long-term adoption level of EVs corresponds to the entirety of new vehicle sales. Time (t) is measured in years. The parameter t_0 denotes the inflection point, i.e., the moment at which the growth rate is maximized; for Equation (1), this corresponds to 50% of K. The parameters displacement (a), growth rate (r), which must be non-negative, and t_0, which must be greater than or equal to 2011 (the earliest year in the dataset), are estimated automatically using Excel's Solver. This tool minimizes the Residual Sum of Squares to identify the trend curve that best fits the empirical data.

5 Results and discussion

This section presents the results obtained by applying the best-fitting trend line between the logistic and Gompertz functions. We report the findings for the new EV market, then show the evolution of the used EV market, and finally combine the two and compare with a situation in which the relative weight of each market is not taken into account.

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5.1 New EVs Sales Share in 2024

Trend lines were estimated for each municipality using both the logistic function and the Gompertz function. Nineteen of the 278 municipalities in Mainland Portugal achieve a higher R^2 with the Gompertz function, but for the remaining 259 municipalities the logistic function yields the best R^2.

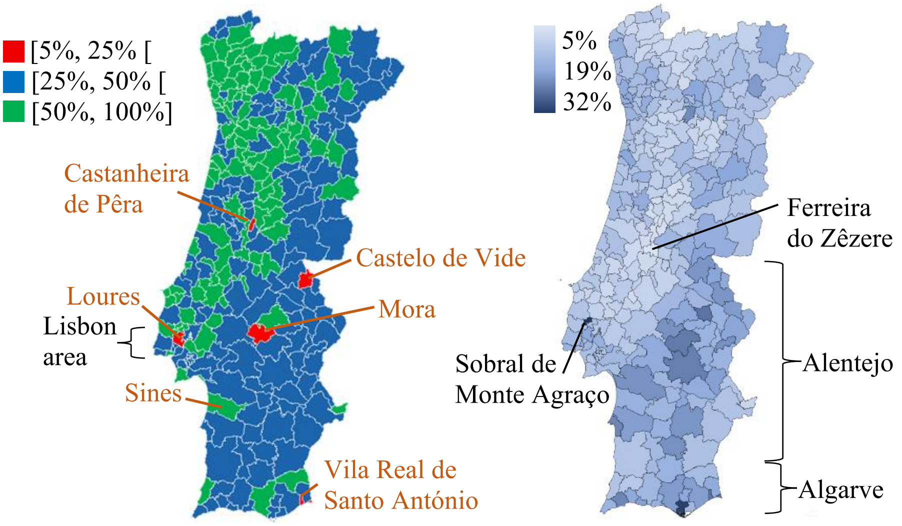

Fig. 4. (left): New EVs share sales for the year 2024; (right): Average rate of new vehicle purchases

The only municipality (Figure 4, left) that has not yet crossed the chasm (16%) is Castanheira de Pêra, located in the district of Leiria, where electric vehicles account for only 11% of new vehicle acquisitions. In addition to this case, four other municipalities have not yet reached the critical mass threshold of 25%: Castelo de Vide (Portalegre), Vila Real de Santo António (Faro), Loures (Lisbon), and Mora (Évora). Some municipalities have already reached the 50% tipping point, which is commonly used as a reference threshold to distinguish between developed and developing areas. This evidence reveals a lack of territorial cohesion in Portugal. Municipalities exhibiting higher levels of development are predominantly located in coastal areas north of Lisbon, as well as in Sines — a major industrial hub — and in the Algarve region. This spatial heterogeneity helps identify municipalities that require greater policy attention to foster development, as well as those that are better positioned to contribute to this process.

Figure 4 (right) presents the proportion of new-car acquisitions relative to the total number of vehicles purchased. This indicator was computed as the average share of new-vehicle purchases over the period 2011–2024. The municipality with the highest average share of new-car purchases is Sobral de Monte Agraço, in the Lisbon district, where new vehicles represent 32% of acquisitions, implying a second-hand market share of 68%. In contrast, the municipality with the strongest preference for used vehicles is Ferreira do Zêzere, in the Santarém district, where new vehicles account for only 5% of purchases, corresponding to a used-vehicle share of 95%. Despite these contrasting preferences between new and used vehicle markets, both municipalities have already surpassed the EV tipping point of 50%. More specifically, in 2024, Sobral de Monte Agraço acquired 58% new electric vehicles (35 units), while Ferreira do Zêzere purchased 73% new electric vehicles (26 units). Given that the new-vehicle market supplies the national second-hand market — which represents a larger share of total vehicle transactions — policy efforts should prioritize municipalities with higher absolute numbers of vehicle acquisitions to accelerate diffusion throughout the broader market.

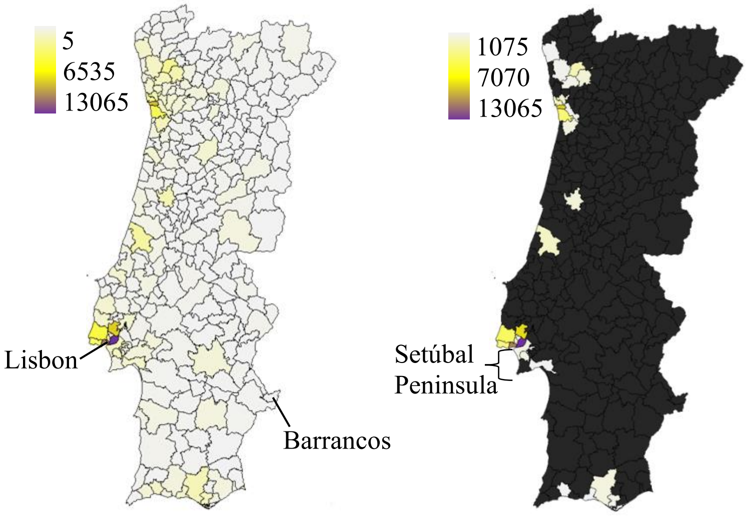

Fig. 5. For the year 2024 - (left): New vehicle purchases (electric and conventional); (right): New vehicle purchases, excluding municipalities with acquisitions below 1,000 units

The municipality with the lowest number of new vehicle purchases, in 2024, is Barrancos, with only 5 units acquired, while Lisbon records the highest value with 13,065 units (Figure 5, left). Due to this wide range of values, municipalities with fewer than 1,000 new vehicle acquisitions — which together account for a total of 46,539 units out of 131,044 new vehicles sold in 2024 — were excluded to better highlight those municipalities that can significantly contribute to the national second-hand market. Figure 4 (right) shows that Alentejo is one of the regions in Portugal with a relatively high share of new vehicle acquisitions; however, no municipality in this region exceeds 1,000 units annually (Figure 5, right). In contrast, the Algarve also exhibits a high preference for new vehicles, with some municipalities having already surpassed the 50% tipping point. Nonetheless, there remain several municipalities with substantial annual purchase volumes that could be further stimulated to increase their share of new electric vehicle acquisitions. This is particularly important in the Greater Lisbon area and the Setúbal Peninsula, where the share of new electric vehicle purchases has an especially significant impact in terms of absolute vehicle numbers.

Between 2011 and 2024, a total of 201,310 new EVs were purchased in mainland Portugal. In contrast, in 2024 alone, 43,854 nationally used vehicles were acquired, representing approximately 22% of the number of new EVs purchased. Assuming that all owners take ten years to sell their new vehicles into the secondary market, and disregarding vehicle retirements or losses, the national used vehicle market would contain only around 184 EVs available for resale, derived from new EV acquisitions between 2011 and 2014. This stark discrepancy underscores the urgent need for effective policy measures that incentivize not only the purchase of new EVs but also their resale within a shorter timeframe than ten years. Additionally, promoting the acquisition of imported used EVs could further support the growth and increased share of the secondary market, which is vital for the overall development of sustainable vehicle adoption.

5.2 Used EVs Sales Share in 2024

To estimate the values for 2024, trend lines based on both the logistic and Gompertz models were applied to the datasets of nationally used and imported used EVs. Since the objective is to understand the evolution of the secondary market, we consider both sources that feed into it. For the pre-owned market, the logistic function provided the best fit across all municipalities. As shown in Figure 6 (left), 62% of municipalities have not yet reached the first tipping point of 5%. Figure 6 (right) provides a more detailed analysis of municipalities that fall between the 5% and 25% tipping points.

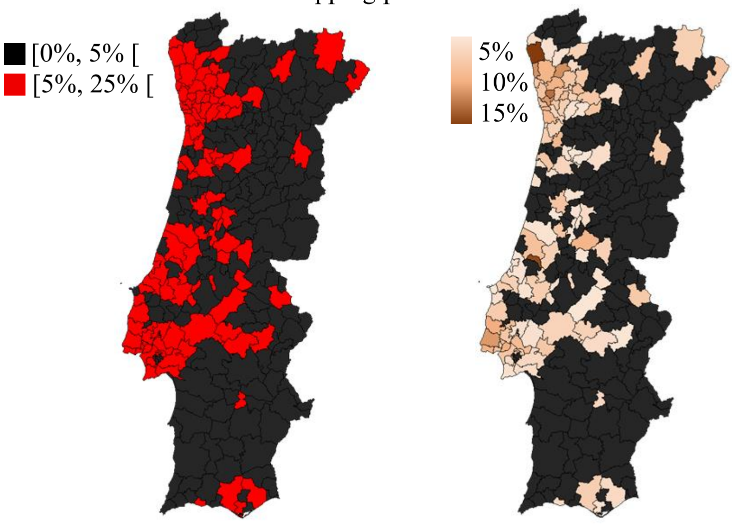

Fig. 6. For the year 2024 - (left): Used EVs share sales; (right): Used EVs share sales with details for values above 5%

In the used vehicle market, we observe an even more pronounced cluster than in the primary market. A greater number of municipalities in the coastal area north of Lisbon demonstrate significant engagement with used EVs, while the northern part of Alentejo also shows a notable presence in this market. As expected, the Algarve region, particularly around Faro, exhibits strong interest in pre-owned EVs as well.

The secondary market has not yet reached the critical mass threshold of 25%, which represents the point of self-sustainability without the need for supportive policies.

5.3 EVs (1st and 2nd market) Sales Share in 2024

To further highlight the importance of the secondary market, Figure 7 (left) presents the results for $\%EV_{Total}$= x%.New+y%.Used, where x% and y% represent the average shares of new and used vehicle purchases, respectively, for each municipality from 2011 to 2024. The values of New and Used correspond to the percentage of acquisitions in 2024 estimated using the S-curve. On the other hand, Figure 7 (right) shows the extraction of the 2024 values by applying trend lines to $\%EV_{Total}$=(EV_{Total} / Total vehicle sales).100%. In this case, the logistic function provided the best fit across all municipalities, yielding a mean coefficient of determination (R^2) of 93.65%.

Overall, accounting for the relative share of each market yields more robust results. Under this approach, only four municipalities have not yet reached the first tipping point of 5%. In contrast, when applying the alternative approach — where new EV acquisitions in the primary market gradually feed into the secondary market, which initially consists exclusively of ICVs — 18 municipalities remain below the 5% threshold. Additionally, overall EV adoption rates increase under the weighted-market approach, with the minimum rising from 3% to 4% and the maximum increasing from 19.8% to 22%.

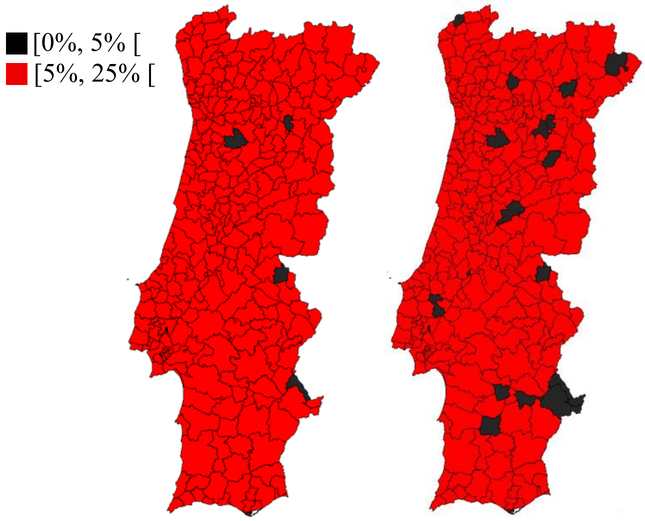

Fig. 7. For the year 2024 - (left): Total EVs considering the relative importance of each market; (right): Total EV share obtained from S-curve fitting

These findings reinforce the importance of understanding the dynamics of innovations that operate across two interdependent markets, where the secondary market depends on the primary one at both national and international levels. In particular, the primary market plays a critical role in releasing innovations to low- and middle-income populations through the secondary market. This underscores the need for accurate and comprehensive data to ensure that policy decisions are effective and well-targeted.

6 Conclusion

The diffusion of innovation unfolds through several stages, which, in addition to enabling the classification of adopters, provide valuable information about the maturity of a given technology. These stages include the initial visibility phase (5% tipping point), the achievement of critical mass (25% tipping point), which marks the onset of self-sustained adoption without the need for subsidies, and the 50% tipping point, typically attainable in more developed areas but often unreachable in less developed ones. These thresholds are of crucial importance for policy decision-making.

However, if the dynamics of the markets in which an innovation is deployed are not properly understood, policy interventions may be based on misleading signals. As a result, such decisions may fail to achieve their intended outcomes or, in the worst case, negatively affect existing adoption levels and lead to market regression. This work demonstrates that, in the case of EVs, adoption is driven by two interdependent markets: the primary (new vehicles) and the secondary (used vehicles). The latter is structurally dependent on the former, whether its supply originates from domestic or international sources.

In the primary market, only 4 out of 278 municipalities have not yet reached the critical mass threshold for new EV purchases. Among these, Loures is the only municipality with a significant acquisition volume, exceeding 1,000 new vehicles in 2024. This indicates that, in nearly all municipalities, the primary EV market has already entered a self-sustaining phase and no longer requires purchase subsidies. Furthermore, municipalities that have not yet reached the 50% tipping point but exhibit high annual volumes of new vehicle acquisitions are predominantly located in the most developed regions of the country — namely, coastal areas north of Lisbon and the Algarve. In these cases, the failure to reach the 50% threshold by 2024 likely reflects the need for additional time rather than structural barriers to adoption.

However, acquisition can be encouraged through non-subsidy measures, such as offering free parking in designated areas, allowing access to bus lanes, providing discounts on vehicle parts and maintenance services, or facilitating vehicle cleaning. These incentives can effectively promote electric vehicle adoption without relying on direct purchase subsidies.

The primary market accounts for approximately 15% of the total light-duty vehicle market and, in most municipalities, does not appear to require continued subsidy support. Persisting with purchase subsidies for private vehicles may, in fact, generate unintended consequences by discouraging owners from reselling their vehicles. To compete with subsidized new vehicles, sellers would need to significantly reduce resale prices, increasing financial losses relative to their initial investment and thereby constraining the supply of used EVs.

In contrast, the secondary market has not yet reached critical mass, with the majority of municipalities remaining below the 5% tipping point. This clearly identifies the secondary market as the segment most in need of policy support. Accelerating the transfer of EVs from the primary to the secondary market is therefore essential. Policy instruments such as incentives for fleet electrification, particularly targeting corporate fleets with replacement cycles of two to three years, could substantially increase the availability of affordable used EVs. Where domestic supply remains insufficient, incentives for the acquisition of imported used EVs should also be considered. However, the expansion of the secondary EV market must also address demand-side barriers. The used electric vehicle market is particularly vulnerable to adverse selection due to information asymmetries between sellers and buyers, especially regarding battery condition and future performance. This uncertainty can undermine consumer confidence and hinder market development, making clear government regulations on quality standards, battery health certification, and minimum warranty requirements essential to support a well-functioning secondary EV market.

Finally, this work highlights that each market segment and municipality exhibits distinct dynamics and contributes differently to overall EV adoption. Ignoring these differences risks inefficient or counterproductive policy outcomes. A nuanced, data-driven approach that explicitly accounts for the interaction between primary and secondary markets, as well as for municipal heterogeneity, is therefore essential to support effective and equitable EV transition policies.

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