

The Role of Residential Chargers in the EV Transition in the USA: A Quantitative Analysis of a Charging Infrastructure

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ABSTRACT

Whereas electric vehicles have a 91% retention rate, produce less air and noise pollution, and are potentially safer than gasoline cars with embedded AI solutions, their adoption rate in the USA slowed, contrary to global trends. When making a purchase decision, customers of gasoline and electric vehicles use incompatible metrics, with the EV privately owned and publicly accessed charging infrastructure being a key parameter. Even though public stations are a necessity for long journeys, up to 80% of charging in the USA is attributed to residential ports. Level 2 charging could solve the “charging anxiety” and create a competitive advantage for EVs. By applying a quantitative analysis of 48,053 ports in metro areas where 30 million people reside, it was determined that 58% of chargers are installed in parking spaces of single-family houses and multi-unit apartments, with the former constituting 96% of a residential charging network. A direct correlation between the public charging stations and the type of housing was determined. The EV adoption rate in the USA is rather proportionate to the installed residential chargers and not the publicly accessible charging infrastructure.

Keywords: transportation sector; Electric Vehicle (EV); road transportation; EV charging; charging infrastructure; sustainability.

I. INTRODUCTION

The market share of battery electric vehicles (EVs) is growing at a 20% rate per year [1]. Having a lower negative environmental impact than cars with internal combustion engine (ICE), which account for 28% of all carbon dioxide emissions globally, EVs reduce air pollution and noise in cities [2,3]. Moreover, EVs might be safer than gasoline cars with an installed autopilot technology, which could decrease the accident rate by 7.5 times, as in the case with Tesla cars [4]. Finally, EVs dominate customer choice when 91% of EV owners do not plan to return to ICE cars [5]. In the USA, however, EV sales in 2024-2025 experienced a comparatively negative trend and averaged about 10% [1,6].

The EV adoption depends on various factors such as the EV price, “range anxiety”, charging network, government incentives, etc. [3,7,8]. From a customer perspective, key obstacles [5], which affect a purchase funnel, are the cost of an EV (35% of respondents) and charging-related issues: driving

range (43%), availability of chargers (29%), and charging speed (24%). These are distinctive from ICE cars when buyers have the following priorities: safety, performance, price, and design [9]. With the charging infrastructure perceived by car owners as inseparable from EVs, a direct correlation of the growth of the fleet and charging infrastructure in general was proved [7,10,11].

The article aims to determine a type of charging that defines the EV adoption rate in the USA under the present circumstances. Following a literature review of public and private charging infrastructure, Section 2 makes a presumption that a Level 2 residential charger could be the solution and represents the most preferred charging behavior pattern. To support or reject the theory, Section 3 applies a quantitative analysis of a statistical dataset of 48,053 charging ports in various US metro areas with a total population of 30 million people. Section 4 discusses the findings and draws a conclusion in Section 5 that residential charging is the key element for the EV transition in the USA due to the unique specifics of the housing market.

II. LITERATURE REVIEW

A. Overview

The two concepts that prioritize the growth of publicly accessible and shared chargers in densely populated areas were evaluated. Negative consequences of relying solely on public charging include changing customer behavior, investments in consumer education, a protracted compared to gasoline cars refueling experience, and additional battery degradation [10,11,12,13,14,15,16]. Another solution is based on “sharing of residential infrastructure within multi-vehicle households” [14] or a “concept of community charging hubs for shared charger use” [17], which is similar to a public charging EV operation behavior pattern with reduced customer reach.

The academic literature on residential chargers predominantly relies either on public surveys or statistical analysis with few input data. The surveys overwhelmingly support the installation of residential chargers in the USA, underlying the importance of single-family houses in the EV adoption [14,18]. The works which assess cases with few statistical data, ranging from 97 to 260 private charging points in Norway and the UK [19-21], might require a larger sampling for the industry generalization and tailored to the USA specifics of type of residence and car parking options. To bridge the identified gap, secondary statistical data on 48,053

charging ports in multiple areas in the USA are used for a quantitative analysis [22].

B. Public and residential chargers

Even though EV adoption relies on a charging infrastructure [7,10,11], the contribution of its publicly accessible segment in the USA, especially in densely populated areas, has not been contrasted against privately owned chargers, which could be installed in residences, particularly in single-family houses (SFH). Table 1 highlights this relationship.

TABLE I.

State	Registered EVs	Public EVCS	EV/public EVCS	EV adoption rate, %	SFH share, %
California	1,533,900	64,260	24	4.09	64
Florida	334,800	14,477	23	1.78	62
Texas	294,700	11,993	25	1.12	67
Washington	191,400	8,362	23	2.79	65
New Jersey	173,800	5,983	29	2.32	62
New York	168,100	19,379	9	1.48	46
Colorado	127,000	7,323	17	2.31	69
Illinois	125,500	5,505	23	1.23	65
Georgia	120,000	7,383	16	1.23	71
Arizona	111,200	4,563	24	1.69	70

Fig. 1. Publicly accessible EVCSs and EVs in 2024.

As reported in Table 1 [23,24], states with the highest number of EVs overwhelmingly maintain one EVCS per 16-29 vehicles, with the EV adoption rate ranging from 1.12% to 4.09% and the median of 1.74%. While maintaining an EV share of 1.48%, New York state has from 1.8 to 3.2 times more public chargers per EV than any other assessed state. Whereas local incentives, taxation policies, geography, and other aspects affect the market share of EVs [8], the neighboring states of New Jersey and New York were comparable in 2024 in many instances, including similar EV rebates [25]. Even though no interdependency of the availability of public charging ports and the EV adoption rate was revealed, Fig. 2 identified a direct correlation of single-family houses and public charging infrastructure. This leads to a hypothesis that a correlation of EV share and privately accessed EVCSs, especially residential chargers, might exist.

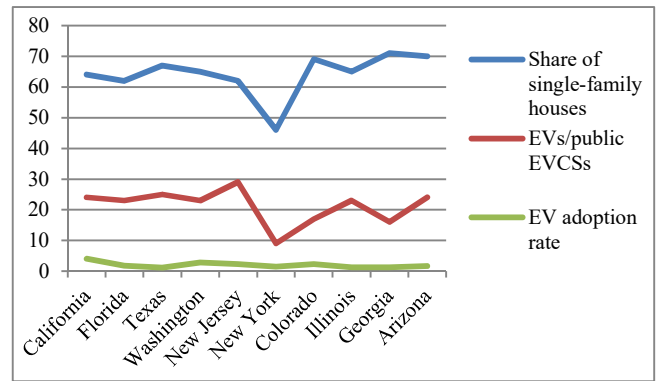


Fig. 2. Correlation of single-family houses and public charging infrastructure.

Residential chargers currently account for up to 80% of charging in the USA [14,17]. Moreover, 96% of residential chargers are installed in single-family houses [16], which constitute 62% of all American households [26]. 77% of single-family houses have the capacity to accommodate private chargers [18]. Therefore, approximately 50% of American households have the technological means to install chargers.

Current estimates of the US charging network predict installation by 2030 of 26-27 million home chargers and only 1.2 million public chargers [11,16], thus supposedly making residential chargers the key infrastructure element.

C. Level 2 residential charging

According to the US Department of Transportation [27], two types of residential chargers are approved in the USA. AC Level 1 equipment can charge an EV to 80% in 40-50+ hours, and AC Level 2 equipment – in 4-10 hours.

To determine the most suitable home charging option, a comparative assessment of the behavior patterns of refueling gasoline cars' usage and charging at public EVCSs was taken into consideration. In particular, in 70% of cases, American customers opt for a full tank, with 24% of responders constrained by financial means to act so [28]. The pattern could be described as a "maximum range per refueling". At the same time, key concerns of public EVCS users [13] are speed (42% of respondents), charging costs (36%), safety (21%), reliability (21%), and free spots (18%). The Level 2 charging thus addresses these concerns, since it allows a vehicle to fully charge in one session, if an overnight cycle is applied [27].

Residential charging varies based on a parking venue [18]: indoor and outdoor private assigned parking lots (personal garage, driveway/carport, parking garage/lot) at single- and multi-unit housing and unassigned parking places (on-street).

The analysis of a national survey on access to home charging by region and income, depending on the type of housing, tenure, and parking options, proves that residential charging is the most preferred pattern of EV users and that a parking venue correlates with the EV adoption rate [18]. Another statewide survey supports the perception that personal garages and, to some extent, carports, which are common for single-family houses (SFH), are EVCS-ready; however, residents of multi-unit housing (MUH) with parking garages and on-street parking have no or low access to EVCSs [14]. Residential EVCSs are overwhelmingly available to single-

family house residents and have a low penetration rate with multiunit dwellers [14].

III. MATERIALS AND METHODS

A. Ontology, epistemology, logic of inquiry, project design, methods

To quantifiably trace a correlation of public and residential chargers in relation to a parking venue and to generalize factual information through measurement, a single large sample set of data, which is characterized by objectivity and reduced bias due to standardized collection methods of information, is selected. The objective knowledge represented by a set of records “Evwatts.public” of the National Renewable Energy Laboratory of the US Department of Energy Office of Energy Efficiency and Renewable Energy [22] is assessed. The data were collected, recorded, and anonymized for public use from both on-board electric vehicle telematics and electric vehicle supply equipment in a longitudinal study from 2019 to 2022. The large and multi-state sampling size, which contains information about 48,053 charging ports and adheres to the common Open Charge Point Interface (OCPI) protocol, ensured the validity, reliability, consistency, and generalizability of the dataset [22].

A quantitative method of descriptive and correlational designs is employed to identify characteristics and relationships between residential and publicly accessed charging infrastructure and the type of parking on a metro area basis. A hypothesis that residential chargers represent the majority of EVCSs by customer choice and thus are most impactful for EV adoption – a theory which is specific to the USA and narrows previous findings about the correlation of EV adoption and charging infrastructure in global terms [7,10,11]. To determine patterns and reveal appropriate relationships depending on a parking type and EV adoption rate, systematically collected data are processed using statistical techniques to form a discrete data representation and create cross-tabulations to showcase the frequency distribution of selected variables [22].

The research refrains from a perspective of radically changing customer behavior to increase the EV adoption rate and proclaims financial justification and regulatory perspective of integration and cohesion of practices and solutions of the stakeholders to satisfy, in measurable terms, the needs of both EV owners and transitioning to EVs gasoline car users.

If the hypothesis were supported and the explanatory study of the dataset con-firmed the statistical significance of the relationships, the research would continue with the evaluative study of the processes and stakeholders. In case patterns of residential chargers and the type of housing are established, the research would use this information for customer segmentation and narrow cost-benefit economic analysis.

B. Assumptions

Since the data in the set are secondary, the assumptions are adopted based on the dictionary in Table 2 [22].

Dataset Data Dictionary		Notes
metro_area	A metropolitan area of an EVCS.	
region	A region based on US Census mapping.	
num_ports	A number of ports capable of simultaneous charging.	Counted as EVCSs to more accurately describe infrastructure’s capacity [7].
charge_level	L2, DCFC	
venue	Venue types include public places (Leisure Destination, Business Office, Municipal Building, Retail, Fleet, Medical or Educational Campus, Hotel, Transit Facility, corridor), residential spots (Single Family Residential, Multi-Unit Dwelling, Multi-use Parking Garage/Lot), and Undesignated lots.	Statistics on multi-use parking is included into multiunit houses.
pricing	Can be Paid, Free, or Undesignated.	‘Paid’ implies public EVCSs for profit generation. ‘Free’ means residential access only. ‘Undesignated’ is included in the Total chargers.

Fig. 3. Dataset description.

Other assumptions for the model assessment include:

- (a) undesignated type of pricing is counted in the Total chargers, since otherwise the objective of this research to find patterns between publicly and privately accessed EVCSs is undermined;
- (b) areas which do not contain information about single-family houses or contain statistically insignificant data of less than 1% are excluded;
- (c) unassigned metro areas are excluded from the analysis because other metrics specific to a particular area are required.

C. Limitations, Integrity and Responsibility

The dataset used for this research was obtained at the official website and is the proprietary information of the US Department of Energy and its contractors, with permission for public access and usage [22]. The dataset is available for download and interactive reading.

The research promotes the accuracy of data supported by referencing practices. Concerns of data misrepresentation and impartiality are addressed either by large sampling or contextual explanation.

The primary challenge of the work lies with the data being limited to 16 states that lack national coverage. Moreover, the dataset does not contain information on social, demographic, and income factors that might affect customers’ decisions on EV procurement beyond the cost and charging infrastructure paradigm [7].

From the axiology standpoint, even though the research supports the transition to electric vehicles, the work is framed by a comparative literature review, impartiality of the analysis of numerical data with reliability and neutrality ensured by a

TABLE II.

single large sample set to minimize bias, and refrains from the possible subjectivism of surveys.

D. Findings

With metro areas excluded due to the methodology assumptions, metro areas that cumulatively account for 30 million people in 16 states, with the share of single-family housing ranging from 58% to 76% [24], are assessed. The sampling varies considerably from 297 to 3,356 EVCSs.

TABLE III.

Metro area	SFH share in an area, %	EVCSs in SFH	EVCSs in MUH and MUP	Total residential EVCSs	Total EVCSs
Ann Arbor	65	277	33	398	539
Baltimore-Columbia-Towson	73	1,356	42	1,758	2,338
Burlington South Burlington	67	1,051	4	1,084	1,234
Des Moines West Des Moines	73	128	17	204	297
Detroit Warren Dearborn	76	1,392	66	1,684	2,149
Grand Rapids Kentwood	74	402	16	494	656
Kansas City	74	215	15	353	1,220
Las Vegas Henderson Paradise	66	662	30	924	1,302
Philadelphia Camden Wilmington	72	957	46	1,319	2,091
Pittsburgh	76	369	26	619	898
Portland Vancouver Hillsboro	66	2,280	62	2,633	3,356
Providence Warwick	58	309	17	567	1,110
Reno	66	150	16	229	338
Salem	63	251	1	271	361
Washington Arlington Alexandria	64	1,638	46	1,927	2,523
Total	n/a	11,437	437	14,464	20,412

Fig. 4. Publicly accessible EVCSs and EVs in 2024.

With the key data retrieved from the set in Table 3 [22,24], patterns are derived by applying ratios and additional relevant state information in Table 4 [22,23,24].

TABLE IV.

Metro area	State	EV adoption rate in a state, %	SFH share in an area, %	SFH, MUH, MUP EVCSs to all EVCSs %	SFH EVCSs to MUH, and MUP EVCSs %	SFH, MUH, MUP EVCSs to all EVCSs %
Des Moines West Des Moines	IA	0.34	73	49	88	69
Kansas City	MO	0.59	74	19	93	29
Ann Arbor	MI	0.87	65	58	89	74
Detroit Warren Dearborn	MI	0.87	76	68	95	78
Grand Rapids Kentwood	MI	0.87	74	64	96	75
Pittsburgh	PA	0.88	76	64	93	69
Burlington South Burlington	VT	1.70	67	85	100	88
Baltimore Columbia Towson	MD	1.88	73	60	97	75
Salem	OR	2.03	63	70	100	75
Las Vegas Henderson Paradise	NV	2.51	66	53	96	71
Reno	NV	2.51	66	49	90	68
Philadelphia Camden Wilmington	PAN J DEM D	-	72	48	95	63
Portland Vancouver Hillsboro	ORW A	-	66	89	97	78
Providence Warwick	RI MA	-	58	29	95	51
Washington Arlington Alexandria	DCV AMD WV	-	64	67	97	76
Total	-	-	-	58	96	71

Fig. 5. Type of EVCSs and housing.

E. Results

Privately accessed chargers represent 71% of all ports. The residential charging infrastructure constitutes 58% of all chargers. The findings statistically support other assessments [11,16,17] that such a type of charging could be the most preferred EV operation pattern in comparison to other private parking options. Single-family house EVCSs with 56% share are the dominant type of the charging network.

Even though the EV adoption depends on multiple factors [8,25], the research determined that the EV adoption rate cumulatively correlates with the installation of residential chargers. Fig. 6 highlights that for states with the adoption rate ranging from 0.34% to 0.88%, the ratio of residential to all EVCS is 53.7. When the EV share is between 1.70% and 2.51%, the ratio is 63.4.

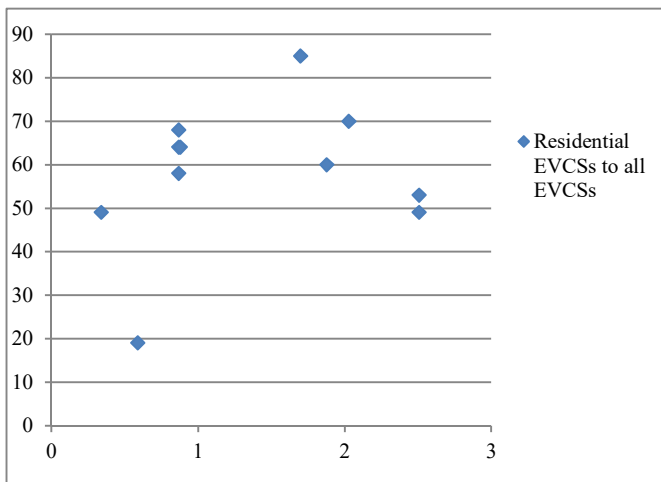


Fig. 6. Residential EVCSs to all EVCSs.

The share of chargers in single-family houses to multi-unit houses and multi-use parking ranges from 88% to 100%, with the average share of 96%.

Overall, the analysis confirmed that Level 2 residential chargers represent the majority of chargers and thus have the most impact on the EV adoption. The higher EV adoption rate, the higher is the share of residential chargers.

IV. DISCUSSION AND FUTURE DIRECTIONS

Whereas the availability of public chargers in the USA is not aligned with the EV adoption rate (Fig. 2), if other considerations primarily related to commute behaviors are not taken into account [29], the quantitative analysis (Fig. 6) proved that residential chargers define that trend and shape the EV usage behavior pattern in the USA [10, 11]. The outcome supports other research [11,16] which predicts that by 2030 the ratio of chargers in single-family houses to multi-unit houses and multi-use parking ranges will be 98%.

An economic analysis of residential chargers for consumers in the USA, when assessing all involved stakeholders, including EV and EVCS manufacturers, permitting authorities, and electricity generation companies, could contribute to this research in determining market trends and solutions to increase the installation of Level 2 residential chargers, which define the EV market share.

Future directions might include research on developing a charging pattern of residential and destination chargers in the USA and installation of public Level 2 chargers in residential areas, in particular:

a) determining a preferred charging pattern at public EVCSs, contrasting densely populated areas and highways for EV owners with residential EVCSs.

b) calculating the economy for a street per street residential charging installations targeting “one EV – one overnight charging” customer behavior pattern applicable primarily to the UK and EU markets.

V. CONCLUSIONS

Residential Level 2 chargers represent the critical part of the charging infrastructure and the most preferred customer behavior pattern in the USA. Overnight Level 2 charging could solve the “charging anxiety” and create a competitive advantage for EVs. While no correlation of public chargers and the EV adoption rate was identified, a direct interdependence of the number of public charging stations and the type of housing in a state was determined. The EV adoption rate increase proportionally to the share of residential chargers in the mix of a charging infrastructure.

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REFERENCES

- [1] Executive summary - Global EV Outlook, IEA, 2025. Available online: <https://www.iea.org/reports/global-ev-outlook-2025/executive-summary>.
- [2] J.P. Arenas, “On the impact of electric vehicle transition on urban noise pollution”, *Current Opinion in Environmental Science & Health*, 2025, 45.
- [3] N.B. Samarakoon, D. Herath, C. Sankalpa, S. Sampath, and M. Wickramasingha, “A Comprehensive Review of Electric Vehicles”, *Journal of Research Technology and Engineering*, 2024, 5(3), pp. 111-142.
- [4] “The Bigger Picture on Autopilot Safety”, Tesla. Available online: <https://www.tesla.com/blog/bigger-picture-autopilot-safety>.
- [5] P. Hertzke, P. Schaufuss, P. Kampshoff, T. Möller, A. Smith, F. Rupalla, “New twists in the electric-vehicle transition: A consumer perspective. McKinsey & Company, Tech. Rep., 2025.
- [6] “Hybrid vehicle sales continue to rise as electric and plug-in vehicle shares remain flat”, EIA. Available online: <https://www.eia.gov/todayinenergy/detail.php?id=65384>.
- [7] F.S. Alrasheedi, H.H. Ali, “A Graph Theoretic Approach for Exploring the Relationship between EV Adoption and Charging Infrastructure Growth”, *Vehicles*, 2025, 7(2).
- [8] S. Wee, M. Coffman, S. La Croix, “Do electric vehicle incentives matter? Evidence from the 50 U.S. states”, *Research Policy*, 2018, 47(9), pp. 1601-1610.
- [9] D. Byun, “The AHP approach for selecting an automobile purchase model”, *Information & Management*, 2001, 38(5), pp. 289-297.
- [10] J. Dijk, N. Delacrétaz, B. Lanz, “Technology Adoption and Early Network Infrastructure Provision in the Market for Electric Vehicles”, *Environmental and Resource Economics*, 2022, 83, pp. 631–679.
- [11] P. Frode, M. Lee, S. Sahdev, “Can public EV fast-charging stations be profitable in the United States?” McKinsey & Company, 2023.
- [12] N. Andrenacci, M.P. Valentini, “A Literature Review on the Charging Behaviour of Private Electric Vehicles”, *Applied Sciences*, 2023, 13(23).
- [13] L. Fischer, F. Rupalla, S. Sahdev, A. Tanweer, “Exploring consumer sentiment on electric-vehicle charging”. McKinsey & Company, 2024.
- [14] Y. Ge, C. Simeone, A. Duvall, E. Wood, “There’s No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure”, *National Renewable Energy Laboratory*, 2021.
- [15] J. Leijon, “Charging strategies and battery ageing for electric vehicles: A review”, *Energy Strategy Reviews*, 2025, 57.
- [16] E. Wood, B. Borlaug, M. Moniot, D.Y.D. Lee, Y. Ge, F. Yang, Z. Liu, “The 2030 National Charging Network: Estimating U.S. Light-Duty

- Demand for Electric Vehicle Charging Infrastructure, National Renewable Energy Laboratory, 2023.
- [17] R. Zhang, N. Horesh, E. Kontou, Y. Zhou, "Electric vehicle community charging hubs in multi-unit dwellings: Scheduling and techno-economic assessment", *Transportation Research Part D: Transport and Environment*, 2023, 120.
- [18] D. Lee, M.H. McDermott, B.K. Sovacool, R. Isaac, "Toward just and equitable mobility: Socioeconomic and perceptual barriers for electric vehicles and charging infrastructure in the United States", *Energy and Climate Change*, 2024, 5.
- [19] A.L. Sørensen, K.B. Lindberg, I. Sartori, I. Andresen, "Residential electric vehicle charging datasets from apartment buildings", *Data in Brief*, 2021, 36.
- [20] J. Quirós, L.F. Ochoa, B. Lees, "A statistical analysis of EV charging behavior in the UK", *IEEE/PES Innovative Smart Grid Technologies Latin America (ISGT LATAM)*, Montevideo, Uruguay, 05-07 October 2015.
- [21] M. Neaimeh, R. Wardle, A. Jenkins, J. Yi, G. Hill, P. Lyons, Y. Hübner, P. Blythe, P. Taylor, "A probabilistic approach to combining smart meter and electric vehicle charging data to investigate distribution network impacts", *Applied Energy*, 2015, 157, pp. 688-698.
- [22] "EV Watts Public Database", *Livewire Data Platform*, U.S. Department of Energy's Vehicle Technologies Office, 2025. Available online: <https://doi.org/10.15483/1970735>.
- [23] "State Information", *Alternative Fuels Data Center of the U.S. Department of Energy's Vehicle Technologies Office*. Available online: <https://afdc.energy.gov/states>
- [24] "Profile", *Census Reporter*. Available online: <https://censusreporter.org>.
- [25] "State Laws and Incentives", *Alternative Fuels Data Center of the U.S. Department of Energy's Vehicle Technologies Office*. Available online: <https://afdc.energy.gov/laws/state>
- [26] "Table HC2.1 Structural and geographic characteristics of U.S. homes, by housing unit type, 2020", *EIA*. Available online: <https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%202021.pdf>.
- [27] "Charger Types and Speeds", *US Department of Transportation*, 2025. Available online: <https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds>.
- [28] J. Lenard, "High Five", *NACS Magazine*, 2019.
- [29] H.L. Vo, "What drives electric vehicle adoption? Perspectives from a geospatial and longitudinal study", *Transportation Research Part A: Policy and Practice*, 2026, 203.