Effects of Informed Consumers on the Adoption of Electric Vehicles

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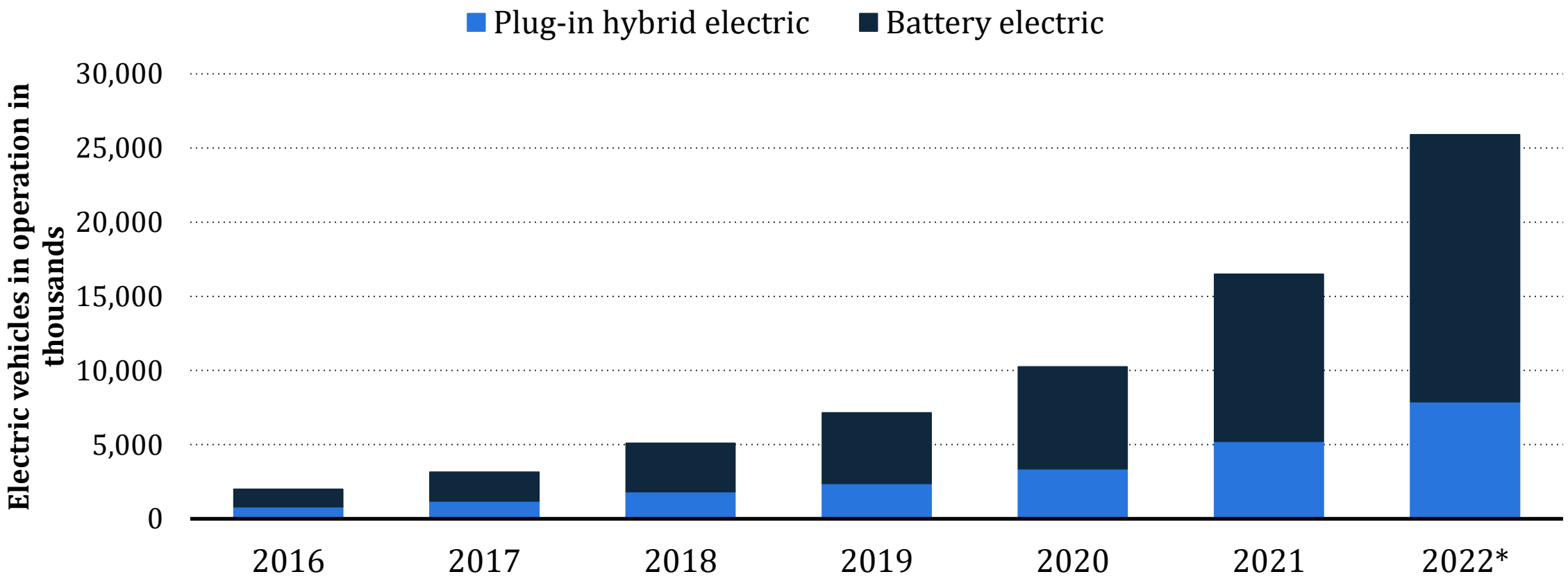
Estimated number of electric vehicles in use worldwide between 2016 and 2022, by type (in 1,000s)

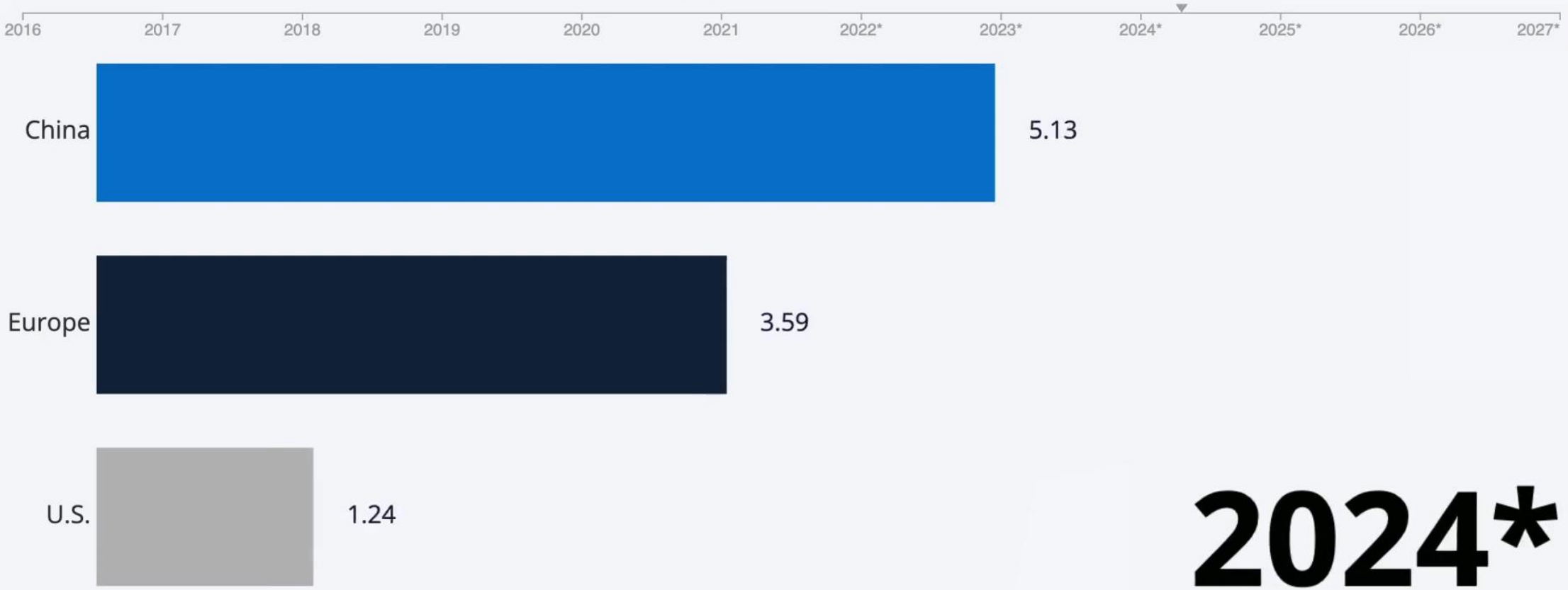
Number of electric vehicles in use by type 2016-2022



Description: There were about 25.9 million electric vehicles in operation worldwide in 2022. That year, all-electric vehicles accounted for about 69.5 percent of plug-in electric vehicles. Read more
Note(s): Worldwide; 2016 to 2022; * The source changed its rounding method for the 2023 edition of its Global EV Outlook report. Data prior to 2022 comes from the Global EV Outlook 2022 report and data release. Read more
Source(s): IEA

The Global EV Race

Estimated electric vehicle sales incl. plug-in hybrids (in million vehicles)



* forecast from 2022; Data shown reflects market impacts of the Russia-Ukraine war

Source: Statista Mobility Market Outlook

statista

Motivation and Contributions

- Significant **misconceptions** about range, charging infrastructure, and battery longevity
- Informed consumers, influenced by social factors and increased public knowledge (Krause et al., 2016)
  - EV driving experience & skills
  - EV battery knowledge; EV related policies knowledge
  - Social influence (Social media & social networking)
  - Traditional & multiple media
- This is the first meta-study to evaluate the information-EV adoption nexus

Research questions

- How does consumer knowledge about electric vehicle (EV) influence EV adoption?
- How does the relationship between consumer knowledge and EV adoption vary across regions globally (Asia, Europe, North America, and others)?

Empirical literature: Information and EV adoption

- **Personal experience**, charging options, and comfort with electric ranges influence EV buyers (Axsen et al., 2016).
- **Social media influencers** had minimal impact on EV adoption (Stork, 2022).
- **Media ads** negatively impacted purchase intentions, but knowledge of charging stations and policies positively affected adoption (Lan et al., 2020).
- Interest in EVs declined after buyers learned about **actual costs and specifications** (Munshi et al., 2022).
- No significant link between **information sources and EV adoption** (Ackaah et al., 2022).

Empirical literature: Regional Differences

- In North America, consumer knowledge is driven by **marketing**, major EV manufacturers like Tesla, environmental awareness, and **government incentives**.
- In Europe, **stringent regulations**, **emission targets**, and **government incentives** have led to high awareness and EV adoption.
- In Asia-Pacific, EV adoption varies, with China seeing rapid growth due to **infrastructure investment** or **status symbol,** while other regions face challenges due to economic development and infrastructure readiness.

Procedure of literature search

- Searched literature through **Google Scholar**, **Econ-Lit** and **Web of Science** databases
- 13 studies (56 estimates) focused on **EV driving experience** and **skills** as the primary information source for EVs;
- 9 studies (42 estimates) emphasized **EV infrastructure**, including **battery knowledge;**
- 27 studies (119 estimates) considered **EV knowledge and awareness**,;
- 7 studies (26 estimates) addressed **EV-related policies;**
- 27 studies (100 estimates) integrated **social influence** (social media and social networking).
- The remaining 7 studies (50 estimates) analyzed **traditional and multiple media sources**, such as TV, radio, and newspapers, using these as explanatory variables.

Data and Methodology of Meta-Analysis

- 393 estimates from 52 studies published between 2010 and 2024
- 3 Panel data studies; 49 cross-sectional
- Partial correlation coefficients
- Publication selection bias**:** funnel graph; FAT-PET-PEESE; non-linear measures
- MRA: Frequentist Model Averaging; Weighted Average Least Squares; Cluster-robust WLS [N]; Multilevel mixed-effects RM; Cluster-robust random-effects panel GLS

Table 2. Synthesis of Collected Estimates

		(a) Traditional synthesis		(b) Heterogeneity test and measures		
Study type	Number of estimates (K)	Fixed-effect model (z value) [a]	Random-effects model (z value) [a]	Cochran Q test of homogeneity (p value) [b]	I^2 statistic [c]	H statistic [d]
All studies	393	0.05 ***	0.057 ***	1337.974 ***	70.7	1.847
		33.221	18.708	0.000		
(a) By Regions						
Studies of Asia-Pacific	162	0.068 ***	0.079 ***	646.597 ***	75.1	2.004
		24.649	12.483	0.000		
Studies of Western Europe	64	0.049 ***	0.06 ***	178.696 ***	64.7	1.684
		10.609	7.232	0.000		
Studies of North America	150	0.038 ***	0.037 ***	350.668 ***	57.5	1.534
		19.352	11.799	0.000		
Studies of Rest of the World	17	0.101 ***	0.102 ***	49.616	67.8	1.761
		11.019	6.251	0.000		
(b) By Sources of Knowledge						
EV driving experience & skills	56	0.042 ***	0.048 ***	136.356 ***	59.7	1.575
		13.254	8.589	0.000		
EV infrastructure including battery knowledge	42	0.049 ***	0.044 ***	133.681 ***	69.3	1.806
		9.878	4.486	0.000		
EV knowledge & awareness	119	0.052 ***	0.058 ***	417.509 ***	71.7	1.881
		16.638	8.855	0.000		
EV related policies knowledge	26	0.078 ***	0.089 ***	51.687 ***	51.6	1.438
		11.501	7.972	0.000		
Social influence (social media & social networking	100	0.053 ***	0.064 ***	386.461 ***	74.4	1.976
		18.212	10.478	0.000		
Traditional & multiple media	50	0.043 ***	0.046 ***	185.164 ***	73.5	1.944
		10.804	5.813	0.000		

Notes: See Table A1 for further details about the description of above regions and sources of knowledge concerning EV.

[a] Null hypothesis: The synthesized effect size is zero.

[b] Null hypothesis: Studies are homogeneous.

[c] Range is between 0% and 100%; larger scores indicating heterogeneity.

[d] Takes zero in the case of homogeneity

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels respectively.

Synthesis of the collected estimates

- EV-related information has a significantly positive but small impact on EV adoption (PCC= 0.057)
- The strongest effect observed in rest of the world (PCC= 0.102), followed by Asia-Pacific (PCC= 0.079), Western Europe (PCC= 0.06), and North America (PCC= 0.037).

Publication Selection Bias

All Studies (K = 393)

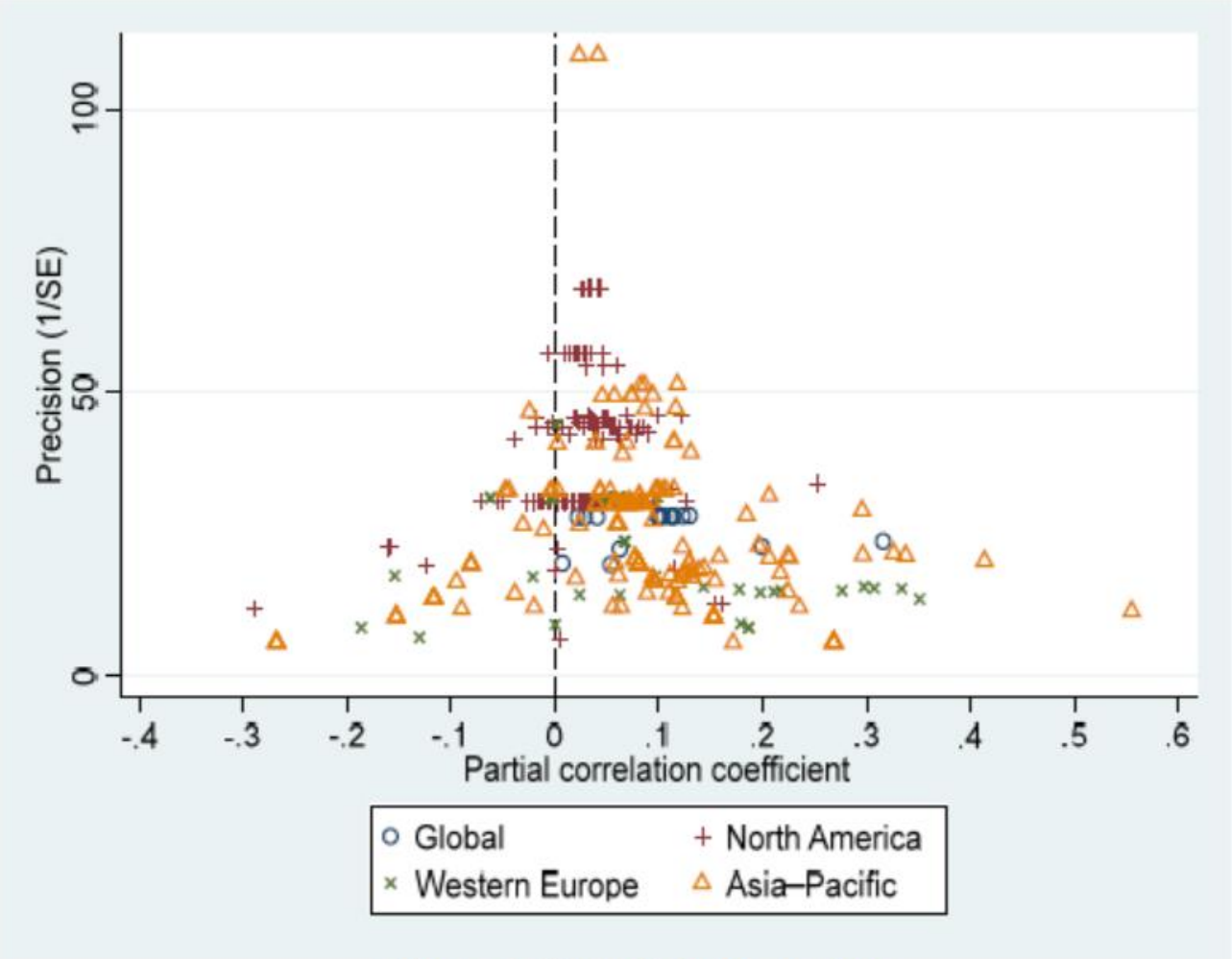


Figure 2. Funnel plot by regions

Note : Precision is the inverse of the standard error of the partial correlation coefficient (PCC)

Source: Authors' illustration

Publication Selection Bias: Linear techniques

(a) FAT-PET test (Equation: $t = \beta_0 + \beta_1(1/SE) + v$)

Estimator	WLS, robust	WLS, cluster	Cluster-robust fixed-effects panel LSDV	Mixed-effects REML	IV
Model	[1]	[2]	[3][a]	[4]	[5]
Publication bias: (FAT: $H_0: \beta_0 = 0$)	0.259	0.259***	1.796***	1.970***	0.461
	(0.306)	(0.037)	(0.018)	(0.473)	(0.425)
True effect: $1/SE$ (PET: $H_0: \beta_1 = 0$)	0.052***	0.052***	-0.004	0.012	0.040***
	(0.011)	(0.013)	(0.033)	(0.013)	(0.013)
Observations	393	393	393	393	393

(b) PEESE approach (Equation: $t = \beta_0 SE + \beta_1(1/SE) + v$)

Estimator	WLS, robust	WLS, cluster	Population-averaged panel GEE	Mixed-effects REML	IV
Model	[6]	[7]	[8]	[9]	[10]
SE	0.216	0.216	8.123**	8.123**	3.050
	(2.069)	(1.488)	(3.363)	(3.217)	(3.207)
Non-zero effect: $1/SE$ ($H_0: \beta_1 = 0$)	0.062***	0.062***	0.055***	0.055***	0.051***
	(0.005)	(0.009)	(0.008)	(0.008)	(0.007)
Observations	393	393	393	393	393

Publication Selection Bias: Non-linear techniques

(c) Advanced

Estimator	WAAP [b]	Selection model [c]	p-uniform* [d]	Stem model [e]	Kink model [f]
Model	[11]	[12]	[13]	[14]	[15]
Mean beyond bias	0.081***	0.091***	0.049***	0.041***	0.028***
	(0.008)	(0.022)	(0.002)	(0.008)	(0.006)
Observations	113	393	393	393	393

Publication Selection Bias

- The FAT test results **confirm the presence of publication bias** in the examined literature
- The PET test confirms the **existence of a genuine** or underlying effect in the collected estimates
- The PEESE test reveals a **non-zero publication bias-adjusted effect** ranges between **0.051 and 0.062** in terms of PCC.
- **Advanced tests** affirm these findings, indicating a positive influence of EV-related information on EV adoption, albeit with mostly modest impacts ranging from **0.028 to 0.091**.

Results: Meta-regression analysis

- **Regional differences**: North America shows a smaller impact on EV adoption whereas the rest of the world demonstrates a significantly greater impact.
- **Role of information factors**: Information about EV-related policies obtained from government institutions and auto dealers play a significant role in EV adoption
- **Estimation techniques**: The consumer knowledge-EV adoption nexus does not vary by estimation techniques

Results: Meta-regression analysis

- **Control variables**: Control variables like age, income, education, EV mileage, infrastructure, and EV price have a weaker impact on EV adoption
- **Quality of studies**: The quality of studies included in the meta-analysis does not significantly impact the relationship
- Capturing PSB: A higher likelihood of PSB in the EV information and adoption literature, thus confirming our earlier findings.

Questions and Answers

Table 1. List of selected studies for the knowledge-EV adoption nexus

Sr No.	Author (s) (publication year)	Number of collected estimates	Country	Data type	Type of EV[a]	Knowledge Measure (Explanatory Variable)[b]
1	Ackaah et al. (2022)	2	Ghana	Cross-section	EV	C
2	Ado-Gyamfi et al. (2024)	3	Ghana	Cross-section	EV	C, F
3	Bhat et al. (2022)	1	India	Cross-section	EV	E
4	Bohrmann and Criado (2023)	1	Spain	Cross-section	EV	C
5	Carley et al. (2013)	5	USA	Cross-section	PEV	A, B, C, F
6	Carley et al. (2019)	36	USA	Cross-section	BEV, PHEV	A, B, E, F
7	Chakraborty and Chakravarty (2023)	5	India	Cross-section	EV	D, E
8	Engels (2022)	4	Germany	Cross-section	EV	B, E
9	Globisch et al. (2018)	3	Germany	Cross-section	EV	C, E
10	Habich-sobiegalla et al. (2018)	36	Brazil, China, Russia	Cross-section	EV	A, C, E
11	Habich-sobiegalla et al. (2019)	3	China	Cross-section	EV	E
12	He et al. (2022)	1	China	Cross-section	EV	A
13	Hoogland et al. (2024)	14	USA	Cross-section	BEV, PHEV	A, C, D, E, F
14	Ingusaen et al. (2023)	11	USA	Panel	AFV, BEV, PHEV	A, E
15	Jain et al. (2022)	9	India	Cross-section	EV	C, E
16	Khurana et al. (2020)	4	India	Panel	EV	C, E
17	Kim et al. (2022)	2	South Korea	Cross-section	EV	C
18	Koth and Shamma (2022)	1	Egypt	Cross-section	EV	E
19	Krause et al. (2013)	6	USA	Cross-section	BEV, PHEV	A, B, C
20	Krause et al. (2016)	6	USA	Cross-section	BEV, HEV, PHEV	A
21	Krishnan and Sreekumar (2023)	1	India	Cross-section	EV	E
22	Lane et al. (2018)	60	USA	Cross-section	BEV, HEV, PHEV	A, B, E, F
23	Li et al. (2022)	2	China	Cross-section	BEV	B, E
24	Li et al. (2023)	2	China	Cross-section	EV	C
25	Lin and Tan (2017)	4	China	Cross-section	BEV	C
26	Manuteworakit and Choochartukul (202	3	Thailand	Cross-section	BEV	C, E
27	Moons and De Pelsmacker (2015)	39	Belgian	Cross-section	EV	C, E, F
28	Munshi et al. (2022)	8	India	Cross-section	EV	D
29	Martiningrum et al. (2022)	2	Indonesia	Cross-section	EV	C, E
30	Nie et al. (2018)	1	China	Cross-section	EV	D
31	Oliver and Lee (2010)	4	South Korea, USA	Cross-section	HEV	E, F
32	Pattnaju et al. (2021)	48	India	Cross-section	EV	A, B, C, D
33	Philip et al. (2023)	2	Australia	Cross-section	BEV	A, C
34	Planavska and Gamma (2022)	4	Switzerland	Cross-section	EV	C
35	Renaud-Blondeau et al. (2022)	4	Canada	Cross-section	EV	A, E
36	Roemer and Hanseder (2022)	3	Germany	Panel	EV	C
37	Rye and Sintov (2020)	5	USA	Cross-section	EV	B
38	Sang and Bekhet (2015)	2	Malaysia	Cross-section	EV	C
39	Schmalfuß et al. (2017)	2	Germany	Cross-section	BEV	A
40	Shi et al. (2023)	5	China	Cross-section	EV	C
41	Singh et al. (2023)	9	India	Cross-section	EV	C, E
42	Stork (2022)	2	Austria	Cross-section	EV	E
43	Thøgersen and Ebsen (2019)	6	Denmark	Cross-section	EV	C
44	Tu and Yang (2019)	2	China	Cross-section	EV	C, E
45	Vergis and Chen (2015)	1	USA	Cross-section	BEV	E
46	Wang et al. (2016)	2	China	Cross-section	HEV	E
47	Wang et al. (2017a)	3	China	Cross-section	EV	B
48	Wang et al. (2017b)	1	China	Cross-section	EV	C
49	Xia et al. (2022)	1	China	Cross-section	EV	C
50	Zhang et al. (2013)	2	China	Cross-section	EV	D
51	Zhang et al. (2022a)	4	China	Cross-section	EV	D, E
52	Zhao et al. (2022)	6	China	Cross-section	EV	E

Note: [a] AFV - Alternative Fuel Vehicles (capable of operating on electricity, ethanol, propane, hydrogen and natural gas), BEV - Battery Electric Vehicles (more frequently called EVs, also called pure electric vehicles, only-electric vehicles, fully electric vehicles or all-electric vehicles; powered solely by an electric battery, with no gas engine parts), HEV - Hybrid Electric Vehicles (run on a combination of electricity and conventional fuel - not considered pure or all-electric vehicles), PEV - Plug-in Electric Vehicles (do not have the ability to be propelled by gasoline), PHEV - Plug-in Hybrid Electric Vehicles (use both gasoline and electricity as fuel sources)

[b] A - EV driving experience & Skills, B - EV infrastructure including Battery knowledge, C - EV knowledge & awareness, D - EV related policies knowledge, E - Social influence (Social Media & Social Networking), F - Traditional & Multiple media. See Table A1 for the description of these measures.

Table 4. Meta-regression analysis of the knowledge-EV adoption nexus for all studies

Estimator (Analytical weight in parentheses)	Cluster-robust WLS [*N*]	Multilevel mixed-effects RML	Cluster-robust random-effects panel GLS
Meta-independent variable (Default)/Model	[1]	[2]	[3]*
Region (Reference: Asia-Pacific)			
North America	-0.0208	-0.0649**	-0.0716***
	(0.0158)	(0.0253)	(0.0249)
Europe	-0.0314	-0.0251	-0.0309
	(0.0249)	(0.0443)	(0.0442)
Rest of the world	0.0349**	0.0375***	0.0404***
	(0.0133)	(0.0118)	(0.0082)
Sources of EV knowledge (Reference: EV knowledge & awareness)			
EV driving experience & Skills	0.0103	0.0316***	0.0327***
	(0.0123)	(0.0114)	(0.0112)
EV infrastructure including battery knowledge	0.0271	0.0289**	0.0325**
	(0.0165)	(0.0142)	(0.0130)
Information about EV related policies	0.0289	0.0515**	0.0539**
	(0.0202)	(0.0216)	(0.0219)
Social influence (Social Media & Social Networking)	0.0148	0.0270**	0.0272**
	(0.0126)	(0.0126)	(0.0125)
Traditional & Multiple media	0.0192	0.0229**	0.0224**
	(0.0136)	(0.0108)	(0.0106)
Estimator (Reference: OLS)			
Non-OLS	0.0128	0.0079	0.0046
	(0.0176)	(0.0287)	(0.0283)
Selection of Controls			
Age of respondent	-0.0196	-0.0183	-0.0184
	(0.0199)	(0.0373)	(0.0391)
Income	0.0133	0.0285	0.0314
	(0.0109)	(0.0279)	(0.0301)
Education of respondent	-0.0202*	-0.0297	-0.0284
	(0.0105)	(0.0228)	(0.0255)
EV mileage coverage	-0.0032	-0.0194	-0.0158
	(0.0128)	(0.0211)	(0.0221)
Infrastructure	0.0031	-0.0047	-0.0034
	(0.0142)	(0.0169)	(0.0136)
Price of EV	-0.0101	-0.0095	-0.0056
	(0.0186)	(0.0204)	(0.0161)
Publication characteristics			
H-index (log)	0.0025	-0.0072	-0.0093
	(0.0046)	(0.0115)	(0.0135)
SE^2 of PCC	4.0689	-0.0101	0.0979
	(3.4448)	(0.8319)	(0.7842)
Intercept	0.0509	0.1374*	0.1463*
	(0.0327)	(0.0741)	(0.0865)
R-squared	0.145		
Number of observations	393	393	393

Response variable: PCC	Frequentist Model Averaging			Weighted Average Least Squares		
	Coeff.	S.E.	*p*-value	Coeff.	S.E.	*p*-value
Region (Reference: Asia-Pacific)						
North America	-0.0543	0.0215	0.0120	-0.041	0.0201	0.042
Europe	-0.0243	0.0231	0.2930	-0.017	0.0203	0.403
Rest of the world	0.0098	0.0260	0.7060	0.010	0.0216	0.643
Source: of EV knowledge (Reference: EV knowledge & awareness)						
EV driving experience & Skills	0.0232	0.0169	0.1700	0.015	0.0142	0.293
EV infrastructure including Battery knowledge	0.0155	0.0187	0.4070	0.008	0.0165	0.628
Information about EV related policies	0.0516	0.0219	0.0180	0.032	0.0182	0.079
Social influence (Social Media & Social Networking)	0.0240	0.0136	0.0780	0.017	0.0115	0.141
Traditional & Multiple media	0.0259	0.0181	0.1520	0.016	0.0157	0.309
Estimator (Reference: OLS)						
Non-OLS	0.0275	0.0209	0.1880	0.020	0.0183	0.274
Selection of Control:						
Age of respondent	-0.0320	0.0226	0.1570	-0.024	0.0205	0.244
Income	0.0644	0.0250	0.0100	0.044	0.0232	0.059
Education of respondent	-0.0490	0.0197	0.0130	-0.033	0.0174	0.059
EV mileage coverage	-0.0013	0.0188	0.9450	-0.0010	0.0526	0.985
Infrastructure	-0.0093	0.0153	0.5430	-0.008	0.0125	0.522
Price of EV	-0.0234	0.0174	0.1790	-0.018	0.0153	0.239
Publication characteristics						
H-index (log)	-0.0059	0.0044	0.1800	-0.004	0.0040	0.314
SE^2 of PCC	0.0000	0.1090	1.0000	-0.137	0.9580	0.886
Intercept	0.1075	0.0314	0.0010	0.098	0.0276	0.000
Number of observations		393			393	
Number of studies		52			52	

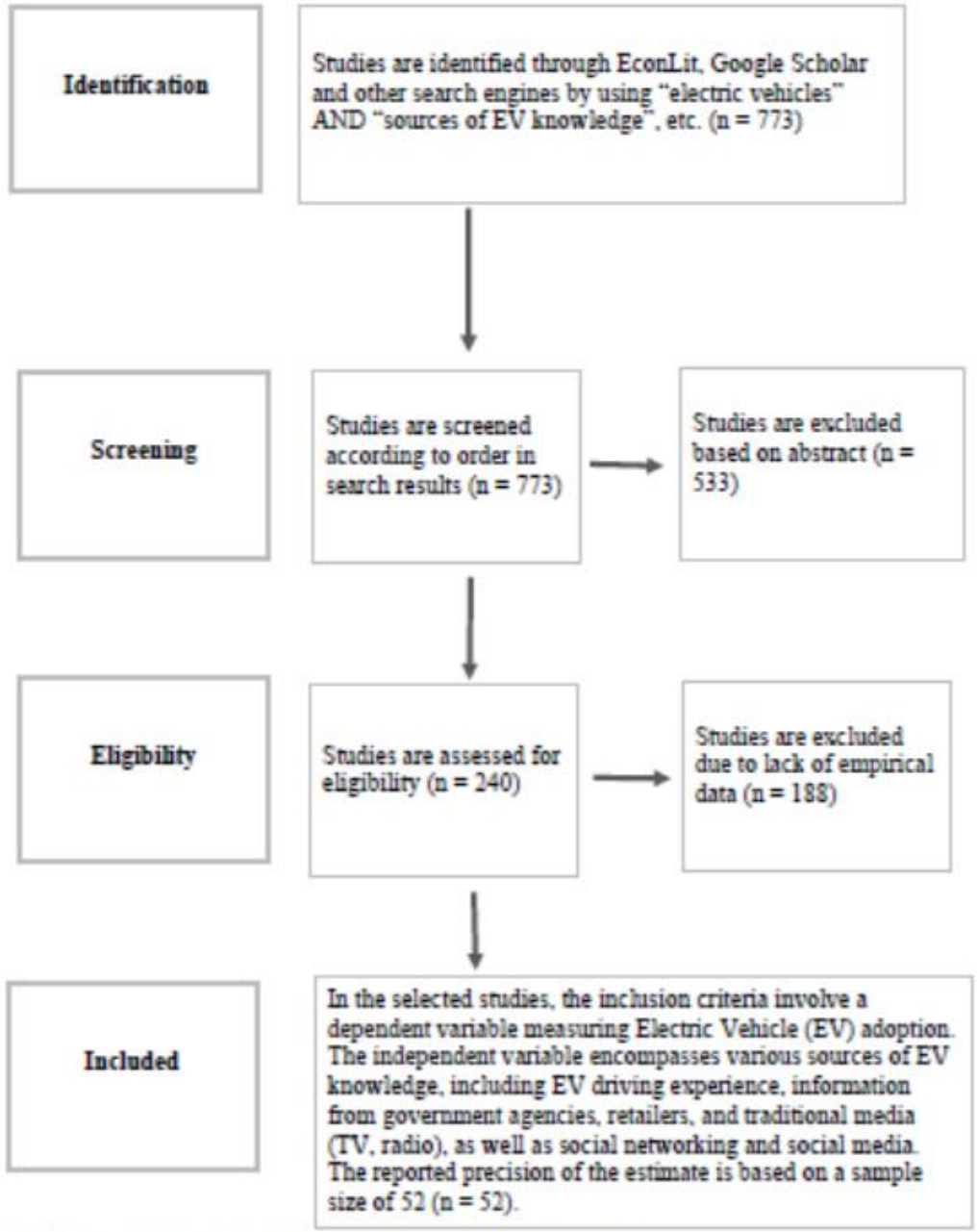


Figure A1. PRISMA Diagram of the Literature Search and Study Selection

Note: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is used for reporting search methods in meta-analyses. A discussion of PRISMA and reporting standards in meta-analysis is provided by Havranek et al. (2020).