Impacts of Policies and Infrastructure on the Usage of Electric Vehicles in Macao

Presentation · October 2023

DOI: 10.13140/RG.2.2.13418.08641

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Impacts of Policies and Infrastructure on Usage of Electric Vehicles in Macao

Keywords: Electric vehicles, Emission, Energy policy, Fuel switching, Macao, Public infrastructure, Renewable energy, Sustainable transportation

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Asst. Prof. **Weng Chi (Florence) Lei** 李穎芝 obtained her Ph.D. in Economics from the University of Washington, Seattle. Her main fields of research are **International Economics** and **Industrial Organization**. Since joining the USJ faculty in 2013, Lei has taught a variety of undergraduate and graduate economics courses and has supervised a number of doctoral and master theses in Business Administration, Government Studies and Community Development. Her recent research in **Green Economics** includes "Impacts of Policies and Infrastructure on the Usage of Electric Vehicles in Macao" to be presented at the 2023 Symposium on Environmental Science and Sustainable Technology and "Impact of Education on Green Fintech Adoption in a Smart City: Evidence from the Newly Developed Sub-city Center of Beijing" to be presented at the 2024 International Conference of the Academy of Global Business Research and Practice.

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INTRODUCTION

- The Macao government has implemented **policies** and invested on **infrastructure** to encourage the purchase and adoption of electric vehicles (EV).

Source: Macau Electricity Company (CEM, 2022).

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INTRODUCTION

- e.g. tax incentives for EVs in the "Environmental Protection" category

Source: Financial Services Bureau (2023)

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INTRODUCTION

- e.g. financial support and fee waivers for replacing old motorcycles with new electric motorcycles

Source: Environmental Protection Bureau (DSPA, 2023).

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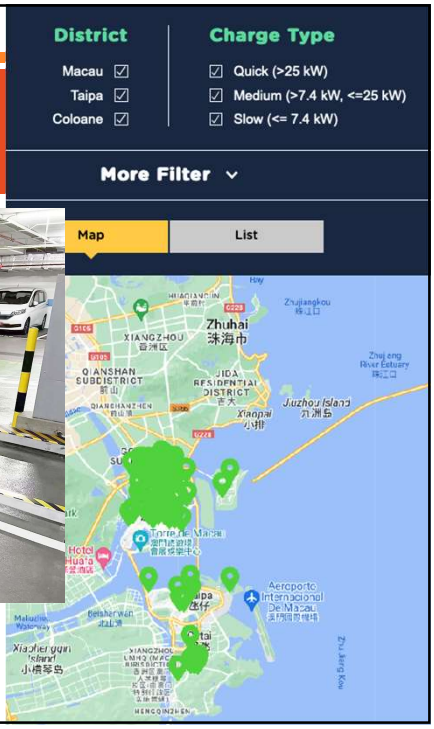
INTRODUCTION

- e.g. allocation of parking spaces for EVs, and installation of charging facilities:
  - over 2,000 charging stations for passenger cars and 590 for motorcycles



Sources: DSPA (2023) and CEM (2022).

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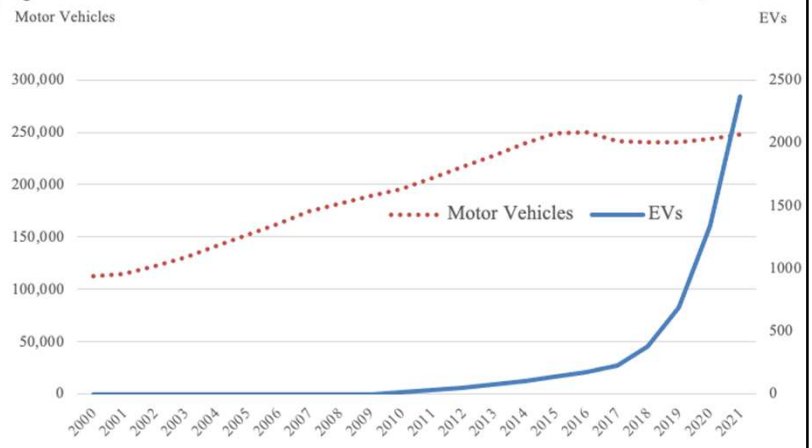
INTRODUCTION

- The number of EVs is a **small proportion** of the total number of motor vehicles in Macao,
- but it has experienced tremendous **growth** in the past decade.

Figure 1: Number of Electric Vehicles and Total Number of Motor Vehicles in Macao, 2000 - 2022



Data from Statistics and Census Service.[1]

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INTRODUCTION

- This study aims to evaluate the impacts of **public policies** and **infrastructure** on EV usage in Macao.

Source: Macau Electricity Company (CEM, 2022).

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RELATED LITERATURE

- **Impacts of public policies on EV production, purchase and usage**: Åhman (2006) (Japan), Cheng and Tong (2017) (China), He et al. (2018) (China), Sechel and Mariasiu (2021) (Romania), Tu and Yang (2019) (Mainland China), and Vidhi and Shrivastava (2018) (India).
- **Impacts of public infrastructure on EV usage**: Bernard et al. (2021) (Europe), Bhalla et al. (2018) (India), Hardman et al. (2018), He et al. (2018) (China), Lebeau et al. (2013) (Belgium), Luo and Qiu (2020) (China), Mishra et al. (2022), Sechel and Mariasiu (2021) (Romania), Vidhi and Shrivastava (2018) (India), and Wolbertus and Van den Hoed (2019) (Netherlands).
- **References for Questionnaire**: Bhalla et al. (2018), Cecere et al. (2018), Degirmenci and Breitner (2017), Fluchs (2019), Gharbaoui et al. (2013), Hardman et al. (2018), and Tu and Yang (2019).

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METHODOLOGY

- Surveyed 124 respondents by **convenience, snowball** and **self-selection sampling**. (10 non-Macao-residents were omitted from the sample.)
- **e-questionnaire** in English and Chinese to collect residents' ratings (based on a **5-point Likert scale**) of their experiences and perspectives toward aspects of public EV policy and infrastructure, their socio-demographic characteristics, and their road usage data between Feb. – May, 2023.
- Ethical consideration: Responses are *anonymous*, *untraceable*, and *confidential*.
- **Nonparametric statistical tests** for significant differences and relationships: the the Mann-Whitney U tests, Kruskal-Wallis ANOVA test, and the Spearman Correlation tests with bootstrapping wherever applicable.

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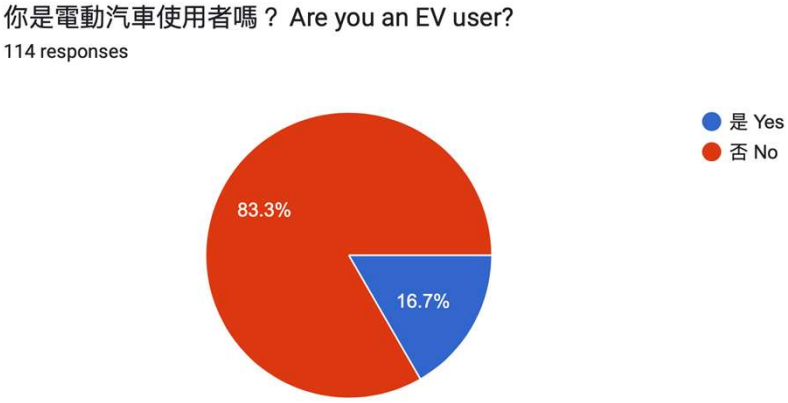
ANALYSIS
- DESCRIPTIVE STATISTICS

- Only 19 out of 114 respondents were **EV users**, who were asked questions concerning both their experiences and perspectives.
- **Non-EV users** were asked questions that concerned their perspectives and potential to use EV in the future.



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- The Mann-Whitney U tests and Kruskal-Wallis ANOVA tests indicate **no statistically significant differences** in gender, age, marriage status, education level, employment status, income level, and road usage time of the day.

Table 1: Sociodemographic Profiles of Respondents and the Population

Sociodemographic Feature	Frequency (n = 114)	Full Sample Percentage (%)
Gender		
Male	60	43.9%
Female	50	52.6%
Prefer not to say	4	3.5%
Age		
Below 15	0	0%
15-24	18	15.8%
25-34	45	39.5%
35-44	30	26.3%
45-54	15	13.2%
55-64	5	4.4%
65 or above	1	0.9%
Marital Status		
Unmarried	52	45.6%
Married	59	51.8%
Divorced/ Separated	3	2.6%
Widowed	0	0%
Highest Education Level		
Primary education or below	0	0%
Junior secondary education	4	3.5%
Senior secondary education	6	5.3%
Diploma	5	4.4%
Tertiary education	99	86.8%
Economic activity status		
Employed	99	86.8%
Unemployed	3	2.6%
Others	12	10.5%
Monthly Income		
≤MOP5999	9	7.9%
MOP6000-9999	4	3.5%
MOP10000-19999	38	33.3%
MOP20000-29999	16	14%
MOP30000-39999	21	18.4%
MOP40000-59999	19	16.7%
≥ MOP60000	7	6.1%

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DESCRIPTIVE STATISTICS – ROAD USAGE

- The **weekday peak hours** were 7:30am – 9:00am and 4:30pm – 7:00pm.
- There are no obvious "peak hours" during weekends.

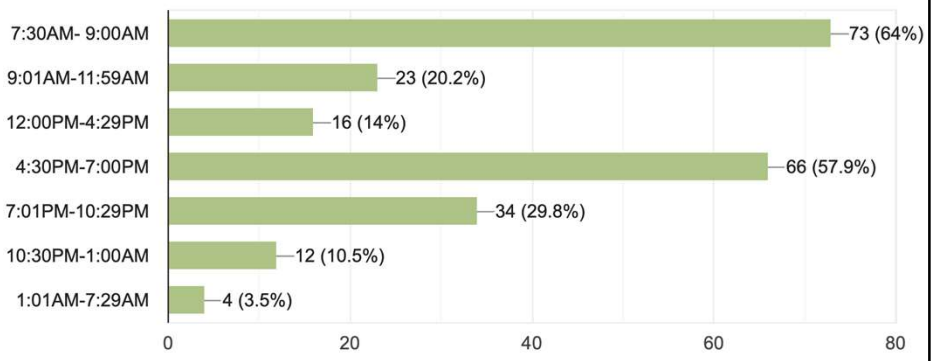

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Table 2: Summary Statistics of Experiences and Perspectives of Aspects of Public Policy and Infrastructure Toward EVs in Macao

No.	Policy and Infrastructure Aspects	Mean	Std. Dev.
	Experiences with Public Policies and Purchases of EVs: (n = 19 EV users)		
PE1	The daily cost of using an EV is cheaper than a fuel vehicle.	3.63*	1.21
PE2	Using an EV is quieter than using a fuel vehicle.	4.16**	1.50
	Perspectives on Public Policies and Purchases of EVs: (n = 114)		
PP1	People buy EVs because of the government incentives.	3.64**	1.12
PP2	Brands of EVs currently available in Macau are expensive.	3.79**	1.01
PP3	Macau should introduce more brands of EVs to the market.	3.72**	1.09
PP4	People buy EVs because of environmental protection.	3.19*	1.08
PP5	I believe EVs are safe to use.	3.39**	1.08
PP6	The promotion of public policies for EVs in Macau is sufficient.	2.72*	1.09
	Perspectives on Public Policies and Purchases of EVs: (n = 95 non-EV users)		
PP7	I am interested in buying an EV.	3.60**	1.11
PP8	EV is a new technology that I need to adapt to in the near future.	3.38**	1.10
	Experiences with Public Infrastructure and Usage of EVs: (n = 19 EV users)		
IE1	The number of EV chargers in Macau satisfies my needs.	2.42**	0.96
IE2	I am satisfied with the charging speed of the EV chargers in Macau.	2.26**	1.10
IE3	Macau has sufficient parking spaces for EVs.	2.05**	0.85
	Perspectives on Public Infrastructure and Usage of EVs: (n = 114)		
IP1	The allocation of charging facilities in Macau is reasonable.	2.68**	1.07
IP2	Macau should increase EV charging facilities in public buildings.	3.87**	0.97
IP3	Macau should increase EV charging facilities in commercial parking lots.	3.84**	1.01
IP4	Macau should increase EV charging facilities in private buildings.	3.92**	1.02
IP5	Information of public infrastructure for EVs in Macau is sufficient.	2.72**	1.10

Note: H_0: $\mu \geq 3.00$ is tested against H_A: $\mu < 3.00$ or H_0: $\mu \leq 3.00$ against $\mu > 3.00$ using Student t tests with bootstrapping, where * indicates $p < 0.05$ and ** indicates $p < 0.01$.

ANALYSIS - RESULTS

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ANALYSIS - FINDINGS

- Public policies and purchase of EVs:
  - There were **positive experiences** and willingness to **adopt EVs**.
  - **Monetary incentives**, **product variety** and **promotional work** influenced the purchases of EVs.
- Public infrastructure and usage of EVs:
  - EV users **disagree** that the availability and functionality of **charging facilities** and **parking spaces** were sufficient.
  - Better **allocation** of charging facilities in both **public and private** locations and more **information** on the infrastructure for EVs were needed.

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ANALYSIS - RESULTS

- Overall, people who agreed there was a need for more **charging facilities in public buildings** also tended to see the need in **commercial parking lots** and in **private buildings**.
- For peak-hour road users, the correlations between the need for charging facilities in **private building** and other locations were **not strong**.

Table 3: Spearman Correlation Coefficients Estimated with Bootstrapping

Correlation	Coefficient	Strength of Relationship
Sample (n = 114):		
CORR(IP2, IP3)	0.867	strong
CORR(IP2, IP4)	0.806	strong
CORR(IP3, IP4)	0.717	moderate
Peak-hour road users (n = 49):		
CORR(IP2, IP3)	0.789	moderate
Non-peak-hour road users (n = 65):		
CORR(IP2, IP4)	0.914	strong
CORR(IP2, IP4)	0.876	strong
CORR(IP3, IP4)	0.801	strong

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ANALYSIS - RESULTS

For EV users:

- The **cost saving** and **quietness** features of EVs were moderately positively correlated.
- There were moderate to strong positive associations between experiences with adequacy of **charging facilities**, **charging speed**, and sufficiency of **parking spaces** for EVs.

For non-peak-hour, non-EV users:

- Their **interest** to buy EVs was associated with how much they wanted to adapt to the **new technology** in the future.

Table 3: Spearman Correlation Coefficients Estimated with Bootstrapping

Correlation	Coefficient	Strength of Relationship
EV users (n = 19):		
CORR(PE1, PE2)	0.785	moderate
CORR(IE1, IE2)	0.812	strong
CORR(IE1, IE3)	0.764	moderate
CORR(IE2, IE3)	0.814	strong
Non-peak-hour, non-EV users (n = 53):		
CORR(PP7, PP8)	0.771	moderate

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CONCLUSION AND POLICY IMPLICATIONS

- The Macao government has implemented policies and invested on infrastructure to encourage the purchase and usage of EVs with the goal of environmental protection.
- Even though EVs take up a relatively small proportion of the total number of motor vehicles in Macao, the positive experiences of users contribute to the trend of increasing EV adoption in Macao.
- The study found that public policies (e.g. financial incentives and introduction of new brands in the EV market) could effectively impact the willingness to buy EVs.

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CONCLUSION AND POLICY IMPLICATIONS

- Allocation and functionality of charging facilities and parking spaces in public and private locations are areas to be improved.
- EV infrastructure in public locations are particularly important for weekday peak-hour commuters.
- More government promotion is necessary to help existing and potential EV users stay informed of the relevant and complementary public policies and infrastructure.

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LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

- The sample size can expand to cover more EV users to better evaluate their experiences.
- Factors that can affect EV usage (e.g. policy, infrastructure, price value, environmental awareness, road usage, etc.), controlling for socio-demographic characteristics, can be estimated using multivariate regression analysis such as structural equation modeling (SEM).

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Thank you for your attention.

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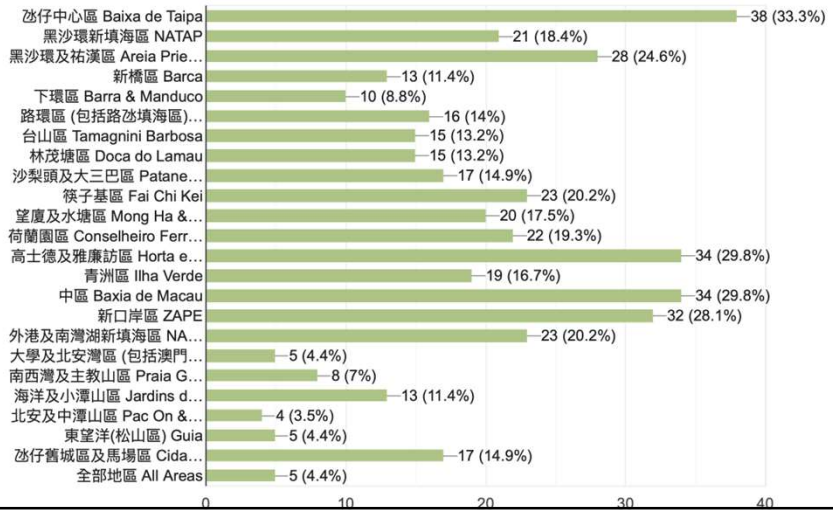
APPENDIX

- The five areas where road usage was most often were Baixa de Taipa, Horta e Costa & Ouvidor Arriaga, Ilha Verde, Baixa de Macau, ZAPE, and Areia Prieta & Iao Han.



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