The Effect of Government Subsidy Program on Consumer Behaviours – A Case Study of Electric Scooters in Taiwan

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In Taiwan, pollutions from scooters, particularly gasoline-fueled ones, have become a significant environment and public health threat. Replacing gasoline scooters with electric scooters is believed to be the best way to reduce air pollutants and maintain urban mobility. As the adoption rates for electric scooters are historically low, the Taiwan government implemented several subsidy programs, incentivising consumers to purchase electric scooters. The research paper introduces policy background and previous unsuccessful programs, summarises the reasons for the low adoption rate, examines the relationship between subsidy amount and electric scooter sales, proposed some issues and limitations of the policy. The result suggests that financial incentives can stimulate early adopters' interests, but scooter performance, design, and overall infrastructure have more impacts on long-term policy success.

Introduction

Two-wheelers are important transportation instrument in urban areas for their flexibility, versatility, and low costs. In Taiwan, scooters became the most popular form of transportation because the majority of the commute distance is short; the year-round climate is suitable for riding, the parking is convenient. With 23 million occupants and nearly 14 million registered scooters, Taiwan has the highest scooter density in the world (Gruenais & Marchal, 2015). The exhausts from scooters, particular gasoline-fueled scooters, have posed a significant threat to the environment and public health.

To address the concerns on air pollution from gasoline scooter (GS), the Taiwan government has implemented a series of policies to promote electric scooter (ES). The research reviews previous subsidy programs explores the factors influencing the decisions to purchase, and analyses the effect of the subsidy on ES sales.

Policy Background

Majority of the pollutants and emissions produced by scooters, particularly gasoline or petrol scooters, come from fuel-burning processes. For example, at 60 km/hr, ES and FS produce 0.0264 and 0.055 kg of carbon per kilometre (Ministry of Economic Affairs [MOEA], 2018), respectively. Switching to ES lowers emissions, diversifies energy sources, and reduce reliance on imported fuels. For consumers, ES can help with saving money on fuel in the long run.

In 1998, the government adopted the first policy aimed at promoting electric vehicles, "Electric Motorcycle Development Action Plan". Environmental Protection Administration (EPA) provided an average NT$25,000 (US$850) for each ES to encourage adoption of ES and estimated to sell 400,000 ESs by 2006 (Environmental Protection Administration [EPA], 1998).

While the subsidy made the price of ES comparable to that of GS, the adoption rate remained low, around 1% of scooter sales. EPA eventually terminated the program and acknowledged failure in 2002 (Liu & Liao, 2004). The government spent NT$ 1.7 billion over five years for 26,000 units. According to the report published by Control Yuan[1] following the policy failure, the main barriers to adopt electric scooters were:

1) *Higher initial investment and maintenance costs* – ES on average costs NTD$15,000 (USD$500) more than gasoline one. Also, the price for gasoline has been low at around NTD$26 (USD$0.80) per litre and the savings from fuel seemed

[1] Full investigation report available in Chinese on https://cybsbox.cy.gov.tw/CYBSBoxSSL/edoc/download/19705

unworthy of the initial investment. As electric scooters were relatively new to the market, the cost for repair or battery replacement was higher.

2) *Poorer performance* – Including shorter driving distance, slower speed, and inability to climb hills: in early 2000, a fully-charged electric scooter was capable of driving around 20 to 40 kilometres (Taiji, 2001), much lower compared to 80-kilometre of a full-tanked gasoline scooter.

3) *Inconvenience of charging and using* – Long charging time and the lack of charging stations: following the previous point, electric scooters could take 6 to 8 hours to charge, while gasoline ones required around 3 minutes to refuel. Moreover, if the electricity ran out mid-trip, owners typically had trouble finding stations to recharge the battery. Small storage capacity is another concern as riders often store helmets, raincoats, face masks, and other gadgets.

A new subsidy program was launched in 2009 under the amended Air Pollution Control Act (Ministry of Justice, 2006). For the transportation sector, the goal is to ban all sales of nonelectric motorcycles and sell only fully electric ones by 2035 (MOEA, 2018).

To encourage consumers to adopt ES, two subordinate agencies started incentives program: EPA in 2009, aiming at reducing pollution and improving air quality, and Ministry of Economic Affairs (MOEA) in 2014, focusing on promoting a new industry. Both policies are designed to address market failures, in which the consumers underinvest in ES, and enable the benefits of ES to be more salient, including better energy efficiency, lower fuel costs, and fewer pollutants. Other than financial incentives, the administrative agency incorporated various approaches to attract more consumers,

such as different license plates for electric scooters and installing 3,300 roadside charging stations in five years, by making the overall infrastructure more ES friendly. Furthermore, to speed up phasing-out aged scooters, particularly two-stroke ones, which are a dominant source of air pollution in many cities (Platt, et al., 2014), Executive Yuan offered more reward for people who recycle vehicles that are more than ten years old. As a result, consumers who replaced aged GS with ES received a higher rebate than those who only purchase ES.

Altogether, eligible applicants received rebates from EPA, MOEA, and local administrative agencies. Individuals can get up to NTD$37,500 (USD$1,250) for recycling a two-stroke scooter and purchasing an ES. As shown in Figure 1, after accounting for three subsidy programs, the cost of an ES was cheaper than petrol scooter.

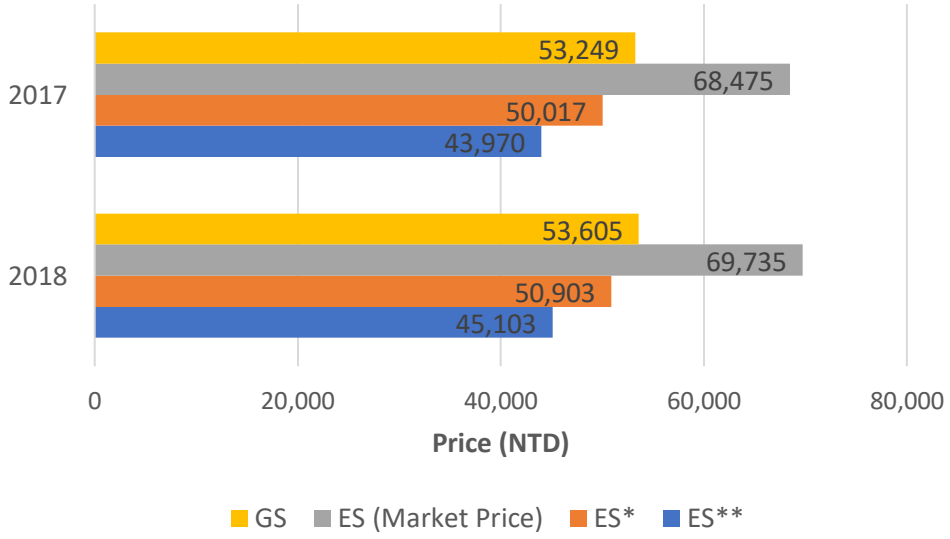


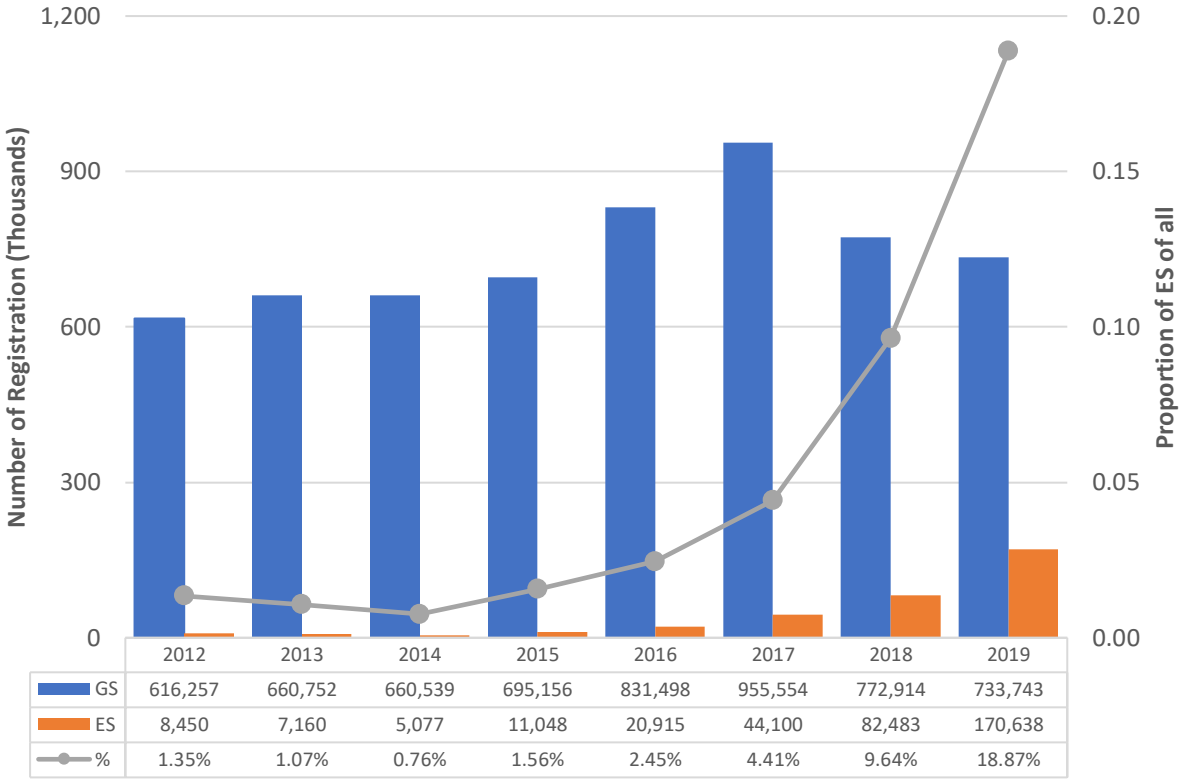
Figure 1, Scooter Price Comparison[2]

[2] ES* is the price of ES with new purchasing subsidy. ES** is the price with eliminating aged scooter and new purchasing. The unit is NTD, the exchange rate to USD is approximately USD$1 to NTD$30.

Analysis

Did Electric Scooter Sales Increase?

Figure 2 illustrates the scooter registration[3] by fuel type (ES and GS) and outlines the proportion of ES of total new scooter registration since 2012. Although EPA started providing subsidy in 2009, the data is not available. The ratio of ES consistently increased since 2015 and reached 18.87% at the end of 2019. Still, in January 2020, a substantial number of existing scooters runs on gasoline, and only less than 2% of scooters are powered by electricity (Directorate General of Highways , 2020).



	2012	2013	2014	2015	2016	2017	2018	2019
GS	616,257	660,752	660,539	695,156	831,498	955,554	772,914	733,743
ES	8,450	7,160	5,077	11,048	20,915	44,100	82,483	170,638
%	1.35%	1.07%	0.76%	1.56%	2.45%	4.41%	9.64%	18.87%

Figure 2, New Scooter Registration by Fuel Type

[3] The data is collected from the Directorate General of Highways, Ministry of Transportation and Communication statistics webpage (https://stat.thb.gov.tw/).

Did Higher Subsidy Attract More Electric Scooter Adoption?

As every purchase was eligible to apply three subsidies, MOEA, EPA, and local government bonuses and most consumers applied to three, the total amount is more important. Figure 3 shows the subsidy amount from MOEA, EPA, and local government and the number application, ranging from September 2012 to December 2012.

MOEA implemented the program the earliest and the rebatement remains constant at NT$ 10,000 (USD$ 350), and both EPA and local government started in August 2015. As shown in the graph, the subsidy from EPA gradually decreased. For local government, as each city provides a different level of bonuses, the number provided is the average subsidy amount for a given month, excluding the cities offering no additional bonuses. Out of 22 municipal governments in Taiwan, 16 to 17 provided additional incentives for adopting ES. Even though the total amount from three sources stays stable around NTD$ 20,000 (USD$ 650) from August 2015 to December 2019, monthly application [4] grew considerably from 358 to 53,221.

In addition to new purchase, another type of subsidy is provided for consumers who recycle GS more than ten years old and purchase new ES at a level higher. As shown in Figure 4, the total amount remains around NTD$ 25,000 (USD$ 830) since August 2015. Similar to the previous graph, the number of application increased significantly from 318 to 8,517.

[4] For the MOEA subsidy program, the data is collected from (https://www.lev.org.tw/subsidy/result.aspx). For EPA, the information is downloaded from (https://mobile.epa.gov.tw/LowPoll/Results.aspx). Python and Selenium were used to automate the collection process. The script is available on (https://github.com/yuenhsu/Taiwan-Scooter-Data).

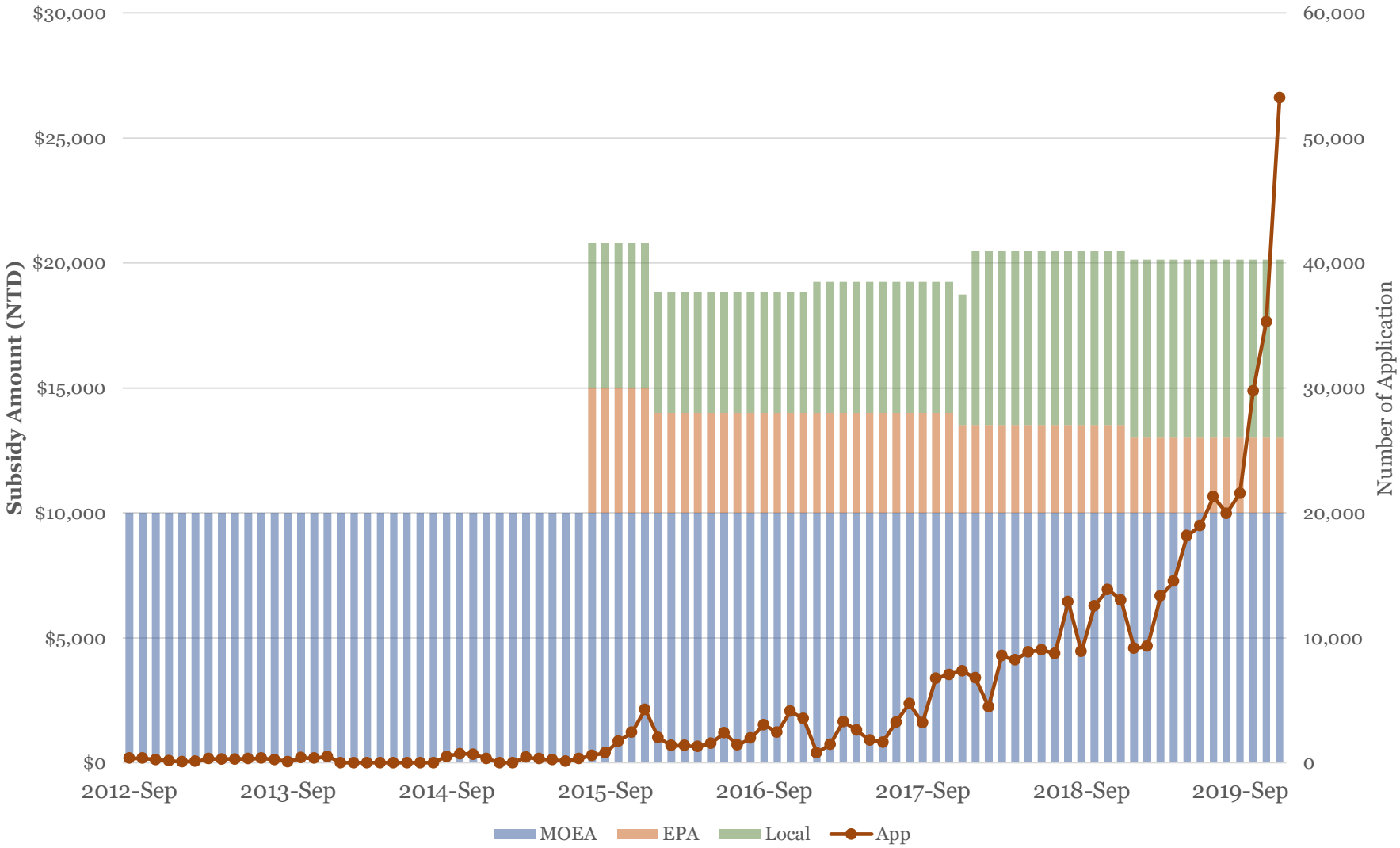


Figure 3, New Purchase Subsidy Amount and Application

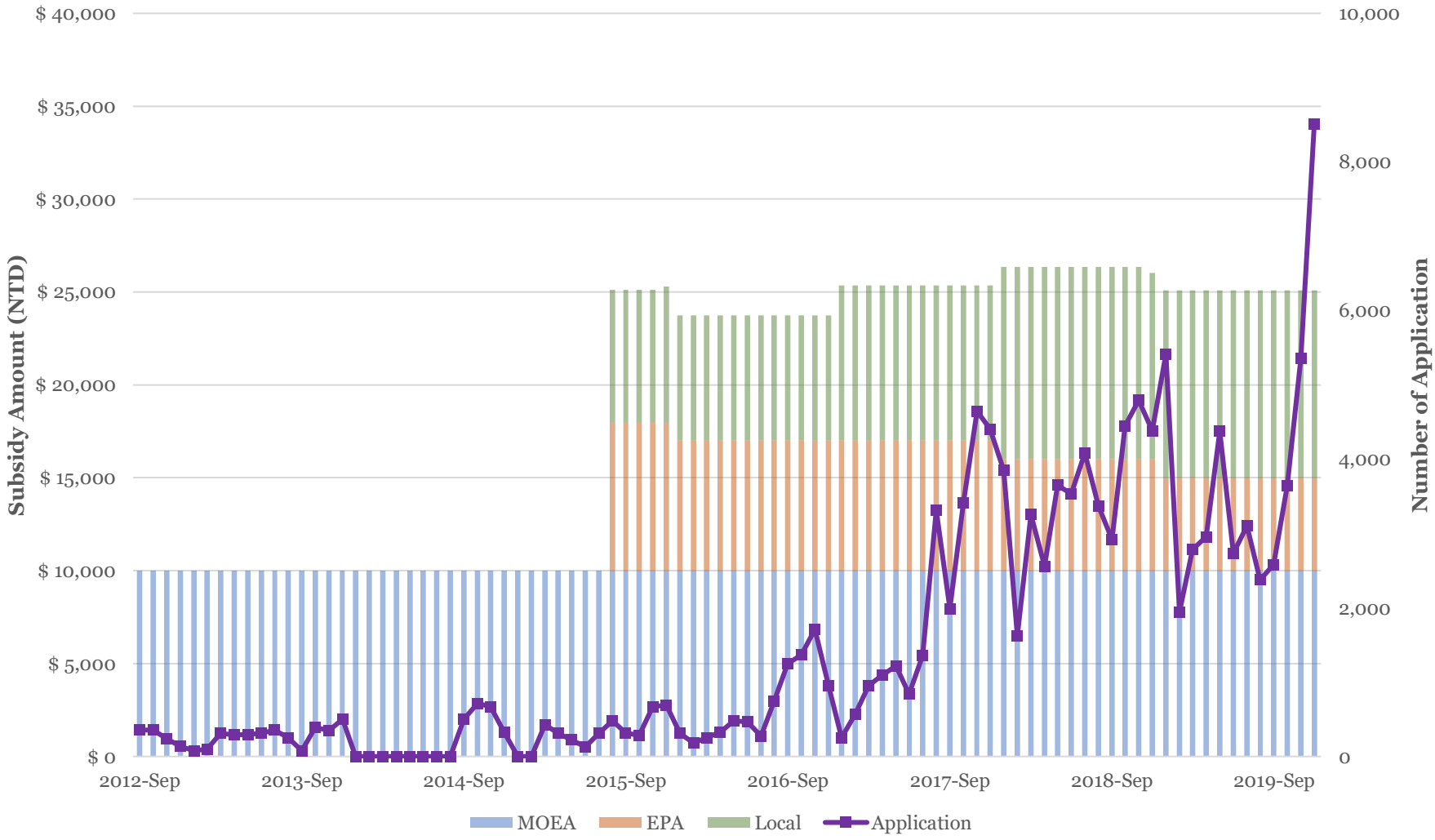


Figure 4, Eliminating Aged Scooters and Purchasing ES Subsidy Amount and Application

The sales of ES consistently grew, given that the subsidy has been stable or even decreasing since August 2015. This may be a delay in showing the change as the policy takes a gradual effect or suggest that there are other factors influencing consumers' decisions to purchase ESs. The failure of the 1998 policy and the relative success of 2009 plans also indicate that financial incentive is not the only criteria in adopting ES.

Some other reasons that may be responsible for increasing ES sales:

Innovation of "battery-swap" system

Echoing to the survey result, the majority of the concerns focus on the inconvenience of long charging time and the unavailability of road-side charging stations. Several manufacturers addressed the issue by improving battery capacity and charging speed. Several firms switched to lithium-ion battery from the more common lead-acid battery to reduce scooter weight and enhance energy efficiency. Still, it requires overnight charging.

In 2015, Gogoro introduced ES with swappable batteries, dramatically cutting the six-to-eight hour charging time to two-minute battery exchanging. While the concept is not new, Gogoro was the first firm to establish a broad network of battery stations, as shown in Figure 5. Gogoro currently has over 1,400 battery-swapping stations in major cities and claims 95% of share in the Taiwanese ES market (Jennings, 2019). However, more research needs to be conducted to understand whether the sales come from consumers switching from GS to ES or whether the brand attracts a new consumer base that would not have purchased scooters.

Learning by using

As shown in Figure 3 and Figure 4, the application for subsidy programs remained low after the implementation in August 2015. Consumers may be waiting for feedbacks from early ES adopters. With positive feedback, more and more people switched to ES.

Accessibility of maintenance and information

As technology evolves, the cost of maintenance has decreased. Moreover, more mechanics started offering services to ES. With a broader user base, the discussion on ES is more accessible, and individuals can receive more feedback and support for any questions.

Figure 5, Gogoro Battery Swap Station (Toll, 2018)

Lower price

Firstly, as product design matures, the price for ES is likely to decrease. Even if this is not the case, as income increases over time, the cost of ES becomes proportionally smaller and more affordable. Secondly, although the amount of subsidy remains constant, as the price of ES goes down, the ratio of rebatement of total price increases, therefore, while the subsidy amount appears to be stable over time, the effect on price may be different.

Salience of financial incentives

The 1998 subsidy was done by reducing the price of ES and providing rebates to the firms. In 2009, the consumers paid the full price upfront, filed applications, and received rebatements from the government. While the later sounded more troublesome, the subsidy is observable and direct.

Discussion

While the subsidy and other approaches seem effective in stimulating interests in purchasing ESs, some potential issues come with increasing ESs.

Energy demand

The goal of the Air Pollution Control Act is replacing fuel vehicles and scooters with electric ones by 2040, adding 40,110,000Kwh extra demand on daily electricity usage (Chen, 2018). Taiwan Power Company stated that existing plants have sufficient capacity for additional electricity consumption and that no new plants are required. Moreover, as more and more charging and battery-swapping stations run on solar power, the demand is expected to be lower than the estimation.

The source of additional electricity and corresponding pollution should be considered as well. In 2018, oil, coal, natural gas contributed to 48.28%, 29.38%, and 15.18% of the energy supply, respectively (Bureau of Energy, 2019). According to research published by the United Nations, aggressive electrification of passenger transportation may lead to an increase in environmental impacts and natural resource pressures (United Nations Environment Programme, 2017). The report points out that, in countries that generate over 70% of the electricity from coal burning, electrification of vehicles may worsen air

pollution. As Taiwan aims to shift energy supply to wind, solar, and renewable energy, by the time of full electrification in 2040, Taiwan will produce less than 30% of the electricity from coal; thus, electrification of transportation sector should reduce air pollution.

Pollutions

Regardless of the type of power source, charging or detachable batteries, increasing ESs can lead to higher demand in batteries, thus, metal. Moreover, as batteries have limited useful life and require replacements, metal consumption and pollution is a continuous process throughout an ES's life-cycle. The impact on the environment from mining activities and the pollution from battery production should be taken into account.

Electrification of scooters does not regulate pollution directly but relies on the assumption that ES produces fewer pollutants. However, in addition to electricity generation and battery production, the pollution generated from manufacturing, transporting, installing charging stations, and others must be considered in the evaluation.

Equity

Firstly, only ES is eligible for getting subsidy; thus, only ES firms can take advantage of the policy. While the policy provides commercial incentives for joining the market and switching production to ES, smaller firms may not have the capital or power to participate. Moreover, as the design improves and regulation tightens, major brands claimed the pollution from new GS_5 is comparable to that from ES and stated that they should be included in the subsidy programs.

[5] Starting from 2021, EPA will implement a new set of regulations, known as the Seventh. Fuel scooters on the market after 1st January 2021 must comply with the emission standards from the Seventh.

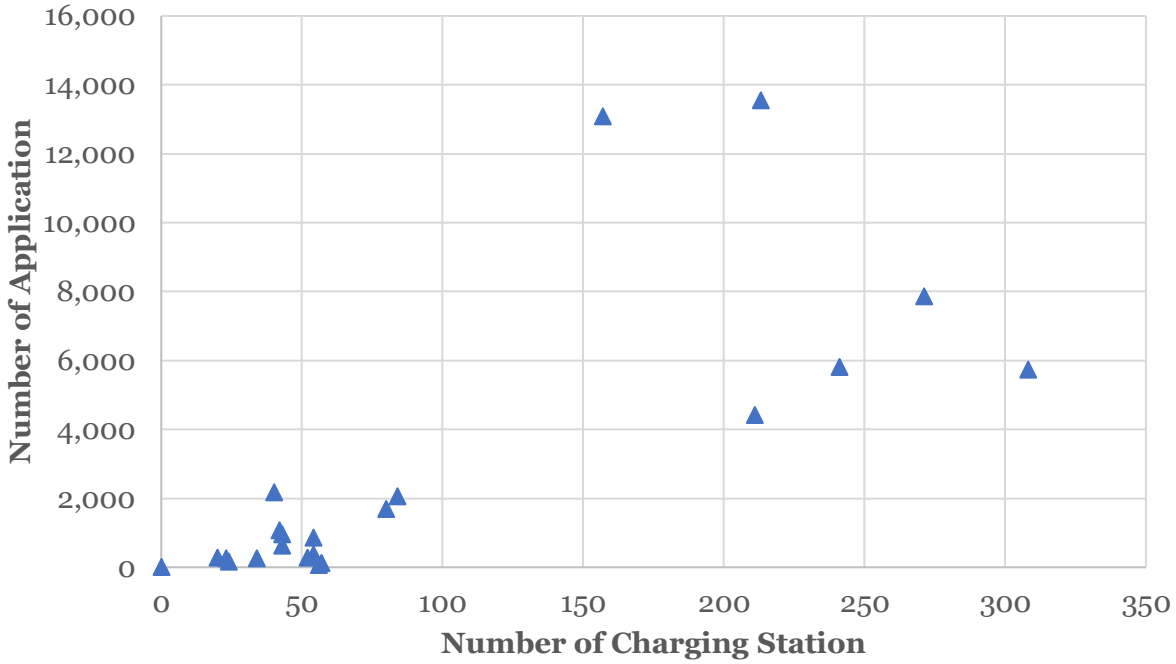


Figure 6, Scatter Plot of Charging Station and Application

Secondly, with no access to battery-swapping stations, consumers are unable to adopt ES with detachable batteries. While they can purchase ES and charge at home, the cruising range and scooter performance are usually insufficient for commuting in rural areas. Using the number of charging station available and the number of subsidy application from December 2019, Figure 6 illustrates a positive relationship between two variables. However, it is unclear whether the charging stations are installed after demands are met or before to attract more residents nearby to adopt ES.

Thirdly, compensation for non-drivers. Given the popularity of scooter, many people, particularly those in major cities, choose to utilise public transportation, including bus and metro. Without owning a two-wheeler, they are not entitled to the subsidy program, but they still suffer from air pollution and noise from the traffic.

Alternative Policies

According to the 2018 scooter usage report[6] published by the Ministry of Transportation and Communications, 79.2% of scooter users utilise other methods of transportation. Figure 7 illustrated the ratio by region. For those taking public transportation, scooters are mostly used to commute from home to bus stops or metro stations.

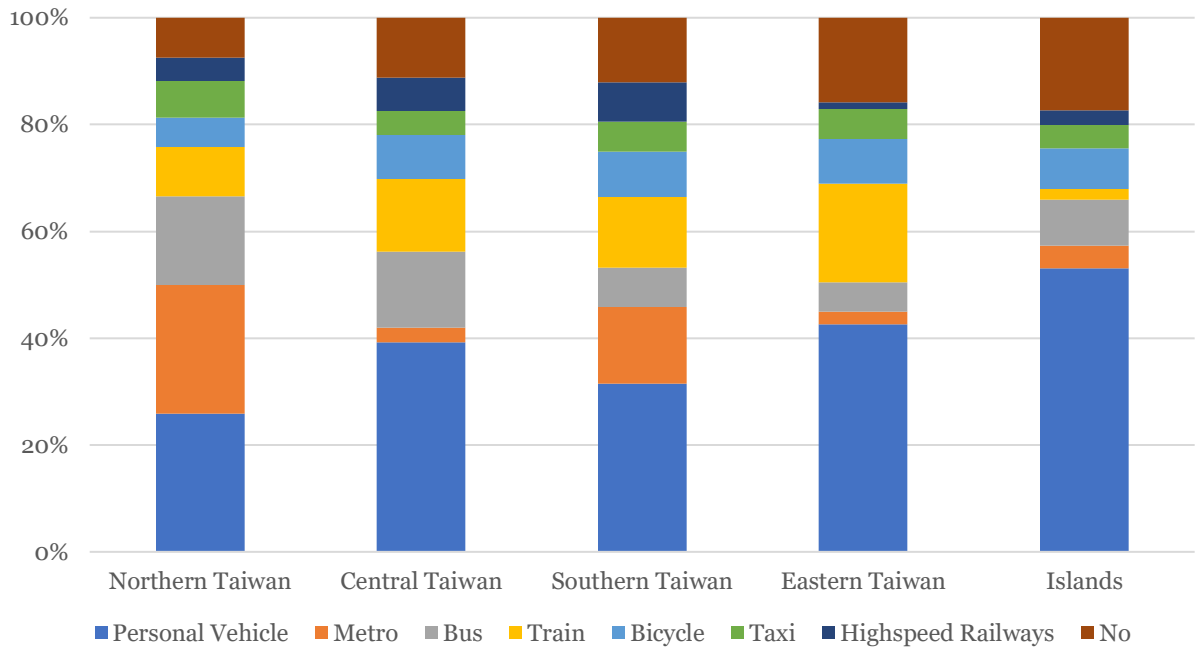


Figure 7, Other Transportation Usage

As commute time is concentrated from 7 to 9 in the morning and from 4 to 6 in the afternoon, the government should consider making shuttle service for peak-time, particularly for population-dense regions. For rural areas with fewer residents, since it would be less cost-effective to implement shuttle service, promoting scooter pooling would be a more feasible option.

[6] The report (in Chinese) is available on https://www.motc.gov.tw/uploaddowndoc?file=survey/201911011142510.pdf&filedisplay=107%E5%B9%B4%E6%A9%9F%E8%BB%8A%E4%BD%BF%E7%94%A8%E7%8B%80%E6%B3%81%E8%AA%BF%E6%9F%A5_%E5%85%A8.pdf&flag=doc

Additionally, riders over 60 years old should be targeted, either with more incentives or with different strategies, for switching to ES. 18.4% of all scooter riders and 7.8% of ES riders age 60 or above, however, they are also the most likely to own old scooters that produce more pollutants. It is unclear why the adoption rate of ES is particularly low for the group, and understanding the barriers and rationales can help to eliminate old two-wheelers with electric ones.

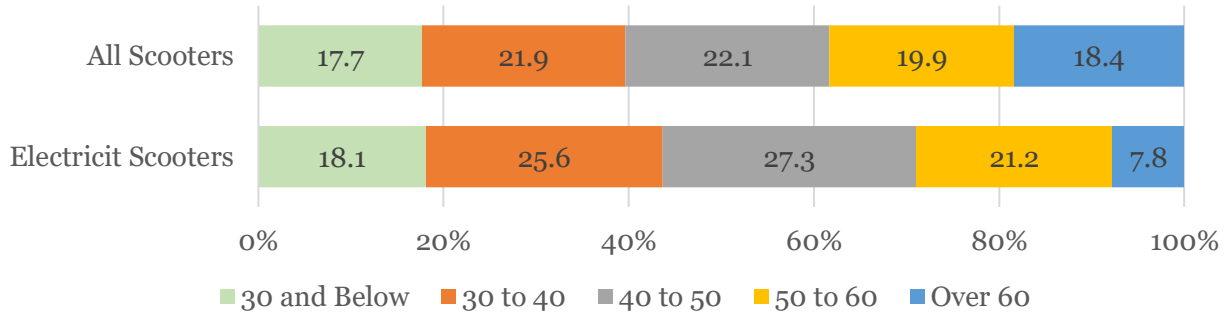


Figure 8, Scooter User Age Distribution

Conclusion

Without subsidy programs, the ES adoption rate is low. While more scooter users switch to ES after the implementation of subsidy programs, financial consideration is not the only factor. Higher living standard, raising awareness of the environment, and better ES design and performance all influence a consumer's decision on purchasing ES. However, regarding the efforts to promote ES, how to continue the trend even after subsidy is no longer available is the main challenge for the government.

The ultimate policy goal is to reduce pollutants and improve air quality, and only focusing on the electrification of scooters is insufficient to achieve the objective. Without decarbonising the source for additional electricity, the pollution shifts from the transportation sector to the energy sector. The need for batteries also increases the

pressure on metal resources. Currently, the government focuses on promoting a new industry and providing firms with assistance in research and development. However, firms should be responsible for not only improving product design and raising energy efficiency but also decreasing emissions and reducing the impact of production on the environment.

The adoption rate of ES is lower for rural area and offshore islands, even though the subsidy amount is typically higher, and the long-term cost-saving is higher. One explanation is the lack of charging or battery-swap stations. However, with fewer residents and scooter users, regional air quality is better, and the cost of installing facilities per capita becomes more expensive. On the one hand, for equity, the subsidy should be applicable for all residents. On the other hand, from the cost-effectiveness perspective, it is more efficient to prioritise urban users.

Riders over 60 years old are less likely to use ES, although they are the majority of aged scooters users that generate emissions. The government should tailor the policy for the group to expedite phasing out old scooters. Lastly, as most people use scooters for commuting to work or study, making shuttle service available during peak hours can provide incentives to give up on scooters.

Overall, financial incentives can attract early adopters to try new technology. But, making the environment more friendly to ES is more important to the long-term success on phasing out gasoline scooters. The effect on air pollution reduction is to be determined as the proportion of ES is still low.

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