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PEV Policy Study in California

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Abstract

Local governments in California have a significant impact on the dissemination of electric vehicles. These governments use instruments to increase the number of electric vehicles. The effectiveness of these instruments is determined by this quantitative study. We have found a significant and positive effect of incentives for home and workplace charging on the number of electric vehicles within a municipality. Population density has a significant negative effect. Both correlations can be explained by the need for charging infrastructure. Incentives for charging infrastructure provide more charging facilities and result in a higher proportion of electric vehicles. The negative effect of population density can be explained as follows: densely populated areas have less private driveways where charging infrastructure can be installed and used. Combined with insufficient public charging infrastructure the number of electric vehicles will be low.

Keywords: policy, electric vehicle, charging, infrastructure

1 Introduction

1.1 Context

Both California and the Netherlands are progressive when it comes to electric cars. California is the largest plug-in regional market in the United States, with over 200,000 plug-in electric cars registered by March 2016, and in the Netherlands nearly 100,000 electric cars were registered by July 2016. Despite these similarities regarding the number of electric vehicles, also some fundamental differences can be identified between the two markets:

- In the Netherlands the number of PHEVs is much higher than the number of BEVs; i.e. 11.8% are BEVs and the remaining 88.2% are PHEVs. In California this is the other way around, with BEVs having a share of 51% and PHEVs 49%.
- There is a difference regarding car ownership. In the Netherlands 50% of the households has one car, compared to 32% of the households in California. In California, however, the share of households with two or more cars is higher (60%) compared to the Netherlands (23%).
- The Netherlands has more public charging infrastructure in comparison to California, where private charging is dominant.

Both in California and the Netherlands, many local governments apply policy measures in order to stimulate the number of electric vehicles (EVs) in their municipality. These policy measures differ from municipality to municipality, often making it difficult for local governments to find the set of best practices. Examples of policy measures are, among others, the realization of public charging infrastructure, the provision of grants, or the offering of parking benefits for EV drivers.

1.2 Purpose of this paper

In 2012 and 2014, two studies have been carried out in the Netherlands to determine the effectiveness of the policy measures taken by local governments. These studies have shown that there are specific policy measures which have an impact on the number of EVs in a county or municipality. This method has proven itself successful, and therefore it is recommendable that this method is applied to California in order to find out which policy measures are effective in a different context. This paper is the result of this process, which should be seen as a pilot. The main objective of this pilot is to obtain novel insights in policy measurements and their corresponding effectiveness.

This paper is structured as follows. First of all, the context of the Dutch and Californian situation will be outlined, after which the research method will be introduced. Afterwards, the results of the Californian pilot are presented, followed by a comparison of these results to the study in the Netherlands. At the end of the paper the conclusions are presented from which relevant recommendations can be derived.

This research has been performed by APPM in cooperation with the California Plug-In Electric Vehicle Collaborative (PEVC), Coast to Coast E-Mobility (C2C) and UC Davis.

2 Method

The research method is based on the so-called regression model. In this chapter an explanation is given of this method.

2.1 Regression model

Based on a regression model, a quantitative study is performed which analyses the relation between EV policy and the proportion and increase in the number of electric vehicles in a municipality. The following steps are taken:

1. Collection of the necessary data;
2. Analysis of data in the regression model;
3. Analysis of the results;
4. Interpretation of the results in order to reach conclusions and recommendations.

The regression model analyses the relation between independent variables and a dependent variable. By using the data from as many cities as possible, the most reliable insight can be gained from the regression model on the influence of the EV policy and control variables (as independent variables) on the proportion or increase of electric vehicles in the fleet of cars (dependent variables).

Based on the available data we performed the following analysis using the regression model: determining the influence of the EV policy and the control variables on *the proportion* of EVs in a municipality.

2.2 Data collection

The following data was collected:

1. The number of electric vehicles based on the number of rebates for EVs per municipality per inhabitant;
2. Information about EV policy, including councils' policy measures;
3. Control variables with specific characteristics of municipalities.

In order to have a representative dataset, we gathered data from municipalities in three areas: Bay Area, San Joaquin Valley and San Diego. These areas were chosen because they differ in level of urbanity. Bay Area and San Diego have a denser population. San Joaquin Valley has country-side characteristics. Moreover, these areas represent Northern, Central and Southern California.

These municipalities have been approached in consultation with the PEVC. The municipalities were invited to provide the required information by completing an online survey.

2.2.1 Number of electric vehicles

In order to get an inventory of the number of EVs per municipality, we used data of the number of rebates given by the Clean Vehicle Rebate Project. This data could be filtered by ZIP code. Although not every EV user uses these rebates (estimates are that 70-80% of California PEV buyers request a rebate), it gives good information about the proportion of EVs per municipality.

2.2.2 Policy measures used by cities

A questionnaire was used to gather insights on EV policy of municipal councils. Civil servants familiar with EV policy were asked to fill in this questionnaire. The study focused on municipalities in the Bay Area, San Joaquin Valley and San Diego.

The following policy measures were studied:

1. *Public charging stations:* this is the number of charging points (up to 22 kW) within the jurisdiction;
2. *Fleet vehicles:* this involves the use of electric vehicles by the jurisdiction instead of regular vehicles. In this case the local government acts as a launching customer;
3. *Incentives for home and workplace charging:* the local government provides subsidies for charging points for private use for citizens or companies;
4. *Fast charging points*: this is the presence of fast charging points (more than 22 kW) within the jurisdiction;
5. *Parking benefits:* this includes incentives including free parking, parking with discount, priority in issuing parking permits, or parking beyond a time limit in certain areas;
6. *Information and promotion:* this relates to information the local government gives on possibilities to charge, the availability of a contact person for e-drivers, or promoting EV by taking part in specific events or among local media;
7. *Other policy measures:* other measures include the allowance to use bus- or carpool lanes or other subsidies.

2.2.3 Control variables

Control variables have been used to analyze the effectiveness of the EV policy. Control variables concern the specific characteristics of municipalities. Without using control variables, 'composition effects' could emerge. In the case of subsidy regulations, the number of electric vehicles appears to be partly defined by the average income in a municipality. Without the control variable 'average income' the results could be biased. The following control variables were included in the regression model:

1. Average income per inhabitant,
2. The population density expressed in the number of inhabitants per square kilometer.

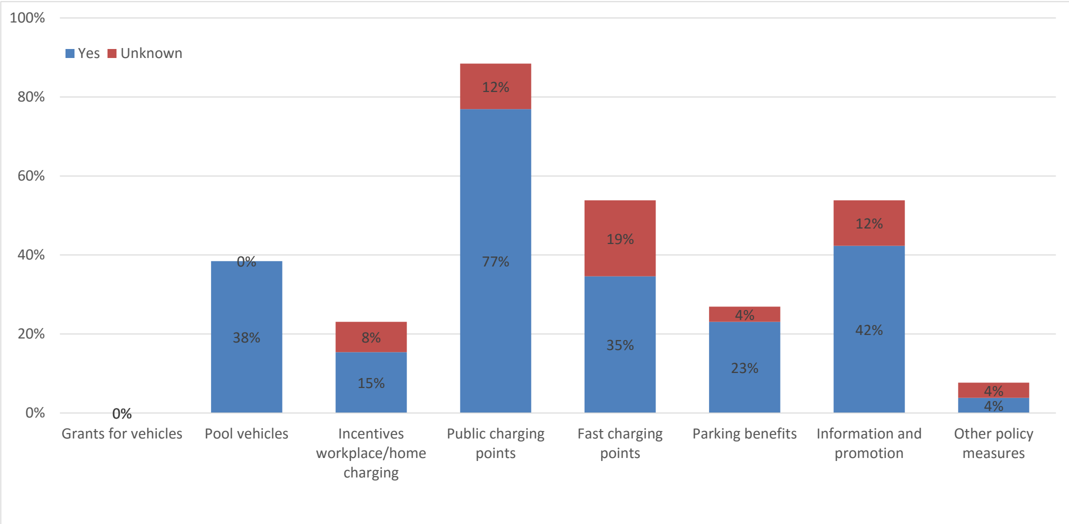
3 Results in California

3.1 Policy measures in California

A total of 77 cities have been approached for this pilot, with a response of 27 cities (35%). This is a fairly high response rate, since we approached these cities only by sending them an invitation plus a reminder by e-mail to fill in the survey. This sample of 27 provided us with some useful data. It is important to state that, in the Californian pilot, the number of cities that responded to the survey is somewhat modest, while the relative response of 35% is fairly high. Still, we have found significant results using the regression model.

Graph 1 gives an overview of the measures being taken by the questioned municipalities. All cities have taken policy measures of some kind. 77% of the respondents have public charging points. It is also interesting to see that a fair share of the cities are providing information of promoting electric vehicles, use of electric fleet vehicles and have fast charging points.

The responding municipalities seem to be quite active when it comes to policy measures in order to stimulate of the use of electric vehicles. However, there might be a bias; local governments that have implemented policy measures might tend to respond to the survey more often. A subsequent study could try to measure this bias.



Graph 1: Overview of the type of policy measures taken by cities

3.2 Results in California

The regression model provides insight in the extent to which a policy measure has an effect on the share of electric vehicles in a municipality per inhabitant. The results of the analyses, following iteration and selection of policy measures (see explanation in section 2.1), are presented in Table 1.

Table 1: Multivariate linear regression analysis of the effectiveness of EV policy measures on the proportion of PEVs per inhabitant (green shading indicates correlations with a significant effect)

Proportion PEVs / inhabitants (n=27)

	Beta	Significance (p)
Policy measures		
1. Fleet vehicles	0.243	0.162
2. Incentives for home and workplace charging	0.374	0.053
3. Fast charging points	0.111	0.540
Control variables		
4. Population density	-0.403	0.046
5. Income	0.245	0.195

The R-Square of the statistical analysis is 0.466. This R-square is a statistical measure for the coefficient of multiple determination for multiple regression. An R-square of 0.466 means that 46% of the variance is explained by the independent variables as predictors of the dependent variables. In Table 1 also the results of the analysis are presented. The results are significant as $p < 0.001$. The results which did not indicate a significant effect have not been included in Table 2, which are the following policy measures:

- Public charging stations
- Fast charging stations
- Parking benefits
- Information and promotion
- Others

3.3 Interpretation of the results

The interpretation of the results is as follows:

- An important part of the interpretation is the extent to which the effect of a measure is significant. That is, the extent to which the effect found (Beta) is based on coincidence. We set this value at a maximum of 10%. This means that we consider a statistical significance of 0.1 or less as ‘not being a coincidence’.
- If variables have a significant effect, Beta expresses the size and direction of the effect of an independent variable on the dependent variables. By interpreting Beta, it is possible to reach a conclusion on the effectiveness of a policy and on whether there is a positive or negative correlation. A positive and negative value of Beta indicates a positive and negative effect of the variable, respectively. A higher Beta generally means that the policy measure has a strong influence on, for example, the proportion of FEVs.

Government fleet vehicles

The use of fleet and pool vehicles by cities seems to have an effect, but cannot be considered significant. The variable approaches significance, which means that fleet vehicles *might have* an effect on the share of EVs in a municipality. Conducting the same analysis in a subsequent study with a larger number of jurisdictions will determine whether this effect is significant.

In short, two explanations can be given for a possible positive effect of fleet vehicles on the proportion of EVs. First, it could be that jurisdiction is setting an example, which is followed by inhabitants. Second, it could be attributed to the fact that the number of EVs within the jurisdictions is small. In this way the council’s fleet of cars carries a lot of weight in the analyses.

Incentives for home and workplace charging

We have found a clear, significant effect of this variable on the proportion of EVs. The explanation for this seems obvious: it is important to be able to charge when driving an EV. However, this only seems to be the case for home and workplace charging, but not for public and fast charging. This can be explained as follows. The absence of a positive effect of public charging points might be explained by the low number of public charging points. The number of public charging points is simply too small for an increase in the number of EVs.

Fast charging points

We have not found a significant effect of this variable, which might be explained by the following. Fast chargers are mainly used for range extension, instead of ‘every day charging’. There are two main categories of range extension, namely 1) trips in which the EV driver travels to a destination beyond its normal activity area, such as a more distant city or recreation area, and 2) a series of local trips, usually on a single day, that, when accumulated, exceed the range of the vehicle at the start of the day. Normally EV drivers charge at home or at work, and when distances exceed the range of the car, fast chargers are used. Therefore it is likely that these chargers are often used by EV drivers who live outside of the particular municipality. Therefore the policy measure might not be an effective measure to stimulate the proportion of EVs on a local level.

Population density (control variable)

Population density has a significant negative effect on the proportion of EVs. In other words, the more urban a jurisdiction is, the less EVs are used. This can be explained by the need for charging infrastructure: the denser a population, the less private driveways are available to charge at. If there is no possibility to charge, people are less likely to purchase an EV. As we have seen in the Netherlands, population density does not have an effect when the number of public charging stations increases. In the next chapter we will elaborate on this issue.

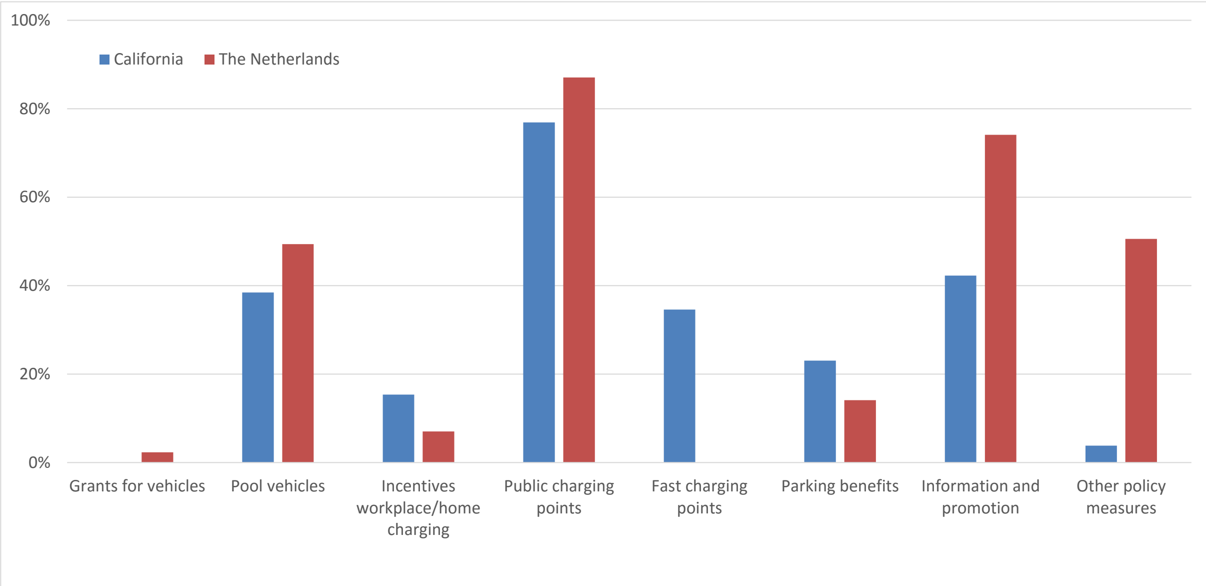
Income (control variable)

Income seems to have an effect on the number of EVs, but the effect does not seem to significant. Similar to the incentives for home and workplace charging, this variable *might* have an effect. This effect can be explained by the higher prices of electric cars in comparison to conventional cars. Electric cars are simply easier to obtain by people who have higher incomes.

4 Comparison Californian results with the Netherlands

4.1 Comparison of policy measures

Graph 2 provides an overview of the policy measures in California and the Netherlands. The policy measures of the Netherlands are taken from a study conducted in 2014. In both regions similar policy measures have been applied in a comparable way.



Graph 2: Policy measures in California and the Netherlands compared

4.2 Analyses compared: significant relations

An overview of the results of the three studies is displayed in Table 2.

Table 2: The effectiveness of policy measures in California and the Netherlands compared. Note: the green cells indicate significant correlations; grey cells lack data.

Variables	**California (2015)**	**The Netherlands (2012)**	**The Netherlands (2014)**
Policy measures			
1. Grants for vehicles		+	+
2. Fleet vehicles	Possible	+	0
3. Incentives for home and workplace charging	+		
4. Public charging points	0	+	+
5. Fast charging points	0		
6. Parking benefits	0	0	0
7. Information and promotion	0	0	0
8. Other policy measures	0		+
Control variables			
1. Population density	-	-	0
2. Income	Possible	0	+
3. Leasing company present		+	+
4. Population		-	0

Fleet vehicles

This study has shown that fleet vehicles might have a positive result in California, and therefore further study is recommended. In the Netherlands, this factor had a positive effect in 2012, but no significant effect was identified in the study of 2014. This supports the argumentation given in the previous chapter: the fact that the number of EVs within the jurisdiction is small, might give the jurisdiction's fleet a lot of weight in the analyses. The effect disappears in the Netherlands in 2014, possibly because the total number of EVs within the municipalities increased.

Public charging points

Public charging points have proven to show a positive relation with the number of EVs in each municipality. This relation was not found in California, possibly because of the small number of public charging points. In the Netherlands, there already was a significant number of public charging points in 2012.

Population density (control variable)

Both in the Netherlands in 2012, as well as in California in 2015, there was a negative relation between this variable and the number of EVs. As a being argued earlier, a possible explanation for this is that the denser a population, the less private driveways are available to charge an EV. Without a possibility to charge, people are less likely to purchase an EV. This correlation was no longer found in the Netherlands in 2014. A possible explanation for this is the increase in the rollout of public charging infrastructure. In other words, the absence of private driveways is no longer an issue.

Income (control variable)

In 2012 there was no significant relation between the average income of a municipality and the proportion of electric vehicles in the Netherlands, which might be the case in California in 2015 as well. This, however, does seem to be the case in 2014 in the Netherlands. This could also be attributed to the fact that the council's fleet of cars carried more weight in 2012 than it did in 2014. In 2012 a relatively large number of EVs was owned by the councils. The proportion of electric vehicles of the councils in 2014 is relatively small compared to the total number of electric vehicles. In other words, there are relatively more privately owned EVs. In this case, income does have a positive effect.

5 Conclusions and recommendations

5.1 Conclusions

As stated in the introduction, this pilot had the objective to obtain novel insights in policy measurements and their corresponding effectiveness. Data has been gathered by using an online survey – reaching a response rate of 35%, which included 27 cities. At first the number of respondents seemed too little for a regression analysis, but despite the small number significant results have been found. Furthermore, we have seen that the method used in the Netherlands is applicable in California in a similar way. This is promising for a study with a larger dataset.

Some useful insights were gathered. We have seen that all responding cities have a policy on electric vehicles. This result might be somewhat biased, because it is likely that cities with a policy are more inclined to respond to this survey. Still, it is striking that so many municipalities have taken policy measures.

Second, policy measures might have similar effects as in the Netherlands. This study has given insight into several aspects of California which are interesting for further exploration:

- We have found a positive effect of incentives for home and workplace charging on the proportion of EVs. In general, public involvement in charging infrastructure of any kind has an effect on the proportion of EVs. In the Netherlands – where there were relatively poor incentives on home and workplace charging – we have seen the effectiveness of public charging infrastructure. In California – where the number of public charging points is smaller – we have seen the effect of home and workplace charging.

- Population density has a negative effect on the proportion of EVs in California. This was also the case in the Netherlands in 2012. In the Netherlands, we have seen that the rollout of public charging stations has reduced the effect of population density. In others words, when public charging infrastructure is available in urban areas, the adoption of EVs is more likely. This same effect might be found in California.
- The use of fleet vehicles might have a positive effect. This is, however, unsure, so further study will be useful.

5.2 Recommendations

The possibility of gathering data in California opens up the possibility to start a study based on a larger dataset. A larger dataset would provide us with more reliable results. It is therefore *desirable* to expand this study to a larger area.

As we have seen, we have been able to gather some useful insights into the effectiveness of policy measures on EV in California. Further study is therefore *possible.* Gathering all this data also has a positive side-effect: it forces cities to give insight in their policy. This might be an incentive to apply policy measurements in an earlier stadium.

Finally, we have seen some interesting changes in the studies performed in 2012 and 2014 in the Netherlands, e.g. the increase of public charging stations and the reduced impact of high density population. Therefore, it is also recommended to repeat this study regularly in California. It provides insights into cities for evaluating and adjusting their policies.

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