LOCAL ELECTRIC VEHICLE INCENTIVE PROGRAMS: WHAT WORKS?

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INTRODUCTION

There is great excitement about electric vehicles (EVs)[1] and the role they can play in addressing critical environmental, economic, and social problems. Because of the potential benefits, there are a variety of U.S. federal and state incentive programs designed to encourage EV adoption and use. Perhaps the best-known example is the federal tax credit of up to $7,500 per EV purchase. There is also a federal tax credit of up to $1,000 for installation of a home EV charger or electric vehicle supply equipment (EVSE).

Although it is less widely known, many local entities have their own incentive programs in addition to what is available at the state or federal level. By local, we refer to jurisdictions that are typically smaller than a state such as a service territory or city. These entities include public and private utilities, air quality management districts, community choice aggregators, among others.

Despite the prevalence, costs, and potential benefits of these local programs, little attention has been paid to analytical or empirical evidence regarding their impacts. The purpose of this article is to summarize what is known rigorously about the effectiveness of these programs, with a focus on programs in California.

LOCAL PROGRAMS

Most local EV incentive programs can be organized into four categories:

- **Direct investment in EVs and EVSEs.** The local entity acquires EVs for its own fleet or installs public EVSEs on property it owns or controls. On the EV front, Exelon recently announced plans to electrify 50% of its own fleet by 2030.[2] On the EVSE front, a consortium of more than a dozen utilities is actively planning a West Coast Clean Transit Corridor with utility-owned electric truck charging stations up and down Interstate 5.[3]
- **Up-Front Cost Subsidies for EV Purchases and EVSE Installations.** The local entity offers financial incentives that reduce the capital cost of EVs and EVSEs. Current programs span a very wide spectrum from broad to focused and small to large. The Clean Vehicle Rebate project lists roughly 50 such programs in California with subsidies ranging from a few hundred to many thousands of dollars.[4]
- **Operating Cost Subsidies that Reduce the Effective EV Operating Cost.** For power suppliers, the most obvious example is offering a special reduced EV charging electricity rate. In a 2018 survey, approximately 10% of U.S. utilities had such a special EV rate.[5] For others, these programs include free access to convenient parking or similar "perks."[6]
- **Promotional Activities Designed to Improve and Disseminate EV and EVSE Knowledge, through Research and Communication.** For example, many local entities participate in

[1] In this paper, we use the term EV to refer to the full range of on-road electric vehicles – light duty cars and trucks, medium duty trucks, heavy duty trucks, motorcycles, and buses.

[2] Chris Galford, *Exelon unveils utility fleet electrification plan*, Daily Energy Insider, June 4, 2020.

[3] Bengt Halvorson, *Utilities aim to make I-5 a West Coast electric highway for commercial trucks*, Green Car Reports, June 22, 2020.

[4] https://cleanvehiclerebate.org/eng/ev/incentives/local-rebates, accessed July 18, 2020.

[5] Smart Electric Power Alliance, Utilities and Electric Vehicles: Evolving to Unlock Grid Value, March 2018.

[6] Nic Lutsey, Stephanie Searle, Sarah Chambliss and Anup Bandivadekar, *Assessment of leading electric vehicle promotion activities in United States cities*, International Council on Clean Transportation, July 2015.

"Ride and Drive" events where potential customers can experience (pre-COVID-19 at least) EVs in person.7

It seems intuitive that these programs, particularly those that offer an up-front cost or operating cost subsidy, would have a positive impact on EV acquisition and use. However, for both policy and business reasons, it is important to understand the magnitude of those impacts. The next sections briefly summarize readily available published information on this topic.

DIRECT INVESTMENT

The impact of direct EV investments by local entities is straightforward; it increases the number of EVs. Although the local entity fleet typically represents only a fraction of the vehicles in a given jurisdiction, the electrification of the entire fleet can have a sizable impact, even where electric vehicles are already popular.

Consider two examples from California. Both the City of Alameda and the City of Palo Alto have roughly 70,000 people, 50,000 registered vehicles, and a municipal fleet of 500 vehicles. Alameda currently has several hundred private EVs whereas Palo Alto – sometimes referred to as America's electric car capital – has several thousand. In Alameda, converting the municipal fleet to EVs would represent more than a 50% increase in EV adoption. Even in Palo Alto, it would represent a nearly 10% increase in EV adoption. Of course, in both cases, 500 vehicles still represent only 1% of the estimated 50,000 vehicles in each city.

The impact of direct EVSE investments on EV acquisition and use is less straightforward. "Range anxiety" is widely mentioned as a barrier to EV adoption, but there are relatively few quantitative studies on the role that charging infrastructure plays in the EV purchase decision-making process. This may be due to the complexity of the EV-EVSE relationship. More available EVSEs likely means more consumers are willing to buy EVs. But at the same time, more EVs likely mean more organizations are willing to install EVSEs. In assessing the impact of local programs, it is important to focus only on the former phenomenon since we are interested in influencing rather than simply understanding the EV market.

Researchers at Tufts and the National Renewable Energy Laboratory (NREL) recently conducted one of the more comprehensive studies on this topic.[8] Their analysis indicated that the addition of one public EVSE site (not plug) per million drivers resulted in a 3% to 6% increase in EV adoption. For a typical locale with a driving population of 100,000 and five public EVSE sites, this means that adding one EVSE site (or 10 per million) would increase EV sales by a considerable 30% to 60%. Of course, the effect would be much smaller if there were already say 25 public EVSE sites.

An earlier 2015 International Council on Clean Transportation (ICCT) study of 25 cities across the United States reached a similar conclusion. This study indicated that an increase of roughly 0.5 EVSE sites per million increased the EV share by 1%.[9] For a typical locale, this means that

[7] Sierra Club and Plug in America, AchiEVe: Model State & Local Policies to Accelerate Electric Vehicle Adoption, Version 2.0, June 2018.

[8] Easwaran Narassimhan and Caley Johnson, *The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: Analysis of US states*, 2018 Environ. Res. Lett. 13 074032.

[9] Nic Lutsey, Stephanie Searle, Sarah Chambliss, and Anup Bandivadekar, *Assessment of Leading Electric Vehicle Promotion Activities in United States Cities*, International Council on Clean Transportation, July 2015.

adding one EVSE site would increase EV sales by 20%. Again, the strength of this effect presumably declines as the pre-existing number of EVSE sites increases.

A study focusing only on California showed a much more modest effect.[10] In that study, each percentage increase in the number of public EVSE sites resulted in an increase in EV sales of somewhat less than 0.1%. For the typical locale noted above with five EVSE sites, this means that an increase of one EVSE site or 20% from current levels would increase EV sales by only 2%. Perhaps this reflects the higher level of pre-existing EVSE sites in California.

Overall, there is some empirical evidence that increased public EVSE installations lead to increased EV sales. Logically, this effect should be stronger where the current density of EVSEs is lower. The magnitude of these effects is uncertain.

UP-FRONT COST SUBSIDIES

The impact of up-front EV cost subsidies on EV adoption has been widely discussed, although typically in the context of large federal or state tax credits.

Most available studies indicate an EV price elasticity of around 2. The Tufts/NREL study noted above indicated an EV price elasticity of 1 to 3. A 2015 UCLA study reported similar results.[11] A recent study on the effect of removing the roughly $7,000 average federal EV subsidy estimated that it would decrease sales by roughly 30%. Given the average EV price, this represents an increase in price of around 15% and again an elasticity of around 2.

Most of these studies are based on price changes on the order of $5,000 or $10,000, and there have been few studies on the effect of price changes in the $500 to $1000 range. Assuming the up-front cost subsidy phenomenon is linear, an elasticity of 2 means that a typical $1,000 rebate – assuming it is viewed as a price reduction – will increase EV sales by perhaps 4%.

Importantly, several observers have noted that these subsidies tend to accrue primarily to the wealthy, and that – in part for that reason – as much as 70% of the subsidy may be "wasted" on consumers who would have purchased an EV anyway.[12] A recent study focused on low and middle income customers showed a stronger price effect. It indicated that a $1,000 rebate will increase sales to such customers by as much as 15-20%.[13]

Up-front EVSE cost subsidies are less well studied. While there are studies on the effect of incentives on EV sales and studies on the effect of (public) EVSEs on EV sales, there are no readily available studies of the impact of incentives on either public or private EVSE installations and ultimately on EV acquisition and use.

Overall, there is good empirical evidence that up-front EV cost subsidies, particularly larger ones aimed at lower-income consumers, have a sizable impact on EV sales. Unfortunately,

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[10] Viraj Singh, *How can California Best Promote Electric Vehicle Adoption? The Effect of Public Charging Station Availability on EV Adoption*, Pomona Senior Thesis, 2019.

[11] UCLA Luskin School of Public Affairs, Factors Affecting Plug-in Electric Vehicle Sales in California, 2015.

[12] Jianwei Xing, Benjamin Leard, and Shanjun Li, *What does an Electric Vehicle Replace?,* Resources for the Future Working Paper 19-05, February 2019.

[13] Erich Muehlegger and David S. Rapson, *Subsidizing Mass Adoption of Electric Vehicles: Quasi-Experimental Evidence from California*, University of California - Davis, December 6, 2018.

there is little evidence on the impact of up-front EVSE cost subsidies on EVSE installations and ultimately on EV sales.

OPERATING COST SUBSIDIES

As noted above, considerable analysis has been conducted on the impact of up-front cost subsidies on EV adoption and use. However, there are far fewer available quantitative studies of the impact of operating cost subsidies.

The few studies that have looked directly at operating cost subsidies – other than EV charging rates – have found a range of impacts. For example, an NREL study was unable to find any impact of the HOV lane access perk on EV sales.[14] A more recent UCLA study found a "strong association" between this perk and EV sales in locations near HOV lanes, but did not provide a specific quantitative estimate.[15]

Other analyses estimate the lump sum monetary value of operating cost subsidies, and then treat them as the equivalent of an up-front cost subsidy. For example, an estimated $100/year discount in use of express lanes can be treated as a $1,000 discount in the EV purchase price. Based on the up-front cost subsidy analysis above, this operating cost subsidy then would have a 4% impact on EV sales.

Interestingly, there are no readily available studies on the direct impact of special EV charging rates on EV sales. The literature is all about the impact of EVs on electricity prices rather than the reverse. Based on fundamental economic principles however, lower EV operating costs should increase EV sales. Some studies have attempted to quantify this relationship indirectly.

One approach is to look at the impact of conventional vehicle operating costs – particularly gasoline price – on vehicle sales. The effects of course can vary dramatically in different market segments. One extensive study looked at the impact of an increase in gasoline prices on the relative demand for inefficient and efficient vehicles.[16] This study indicated that a $400 increase in relative annual operating cost for inefficient vehicles reduced sales by nearly 20%. Great care must be taken in extrapolating from this work, but it suggests that a $100 annual rate subsidy for EVs could increase sales by perhaps 5%.

Another approach is to look at the impact of operational costs (or savings) on another electricity-related capital investment – rooftop solar. One recent study reported an operating savings elasticity of 1.5 to 2.0 for rooftop solar, meaning that a 10% increase in operating savings leads to a 15% to 20% change in rooftop solar installations.[17] The equivalent for EVs is lower since operating costs play a smaller role in EV than solar. Consequently, a 10% reduction in operating costs or roughly $50/year might increase EV sales by perhaps 5%.

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[14] Bentley Clinton, Austin Brown, Carolyn Davidson and Daniel Steinberg, Impact of Direct Financial Incentives in the Emerging Battery Electric Vehicle Market: A Preliminary Analysis, National Renewable Energy Laboratory, February 2015.

[15] University of California - Los Angeles, Factors Affecting Plug-in Electric Vehicle Sales in California, May 23, 2017.

[16] Meghan Busse, Christopher Knittel, and Florian Zettelmeyer, Pain at the Pump: How Gasoline Prices Affect Automobile Purchasing in New and Used Markets, National Bureau of Economic Research, February 2009.

[17] H. Ron Chan, Takahiko Kiso and Yosuke Arino, *The Effect of Electricity Prices on Residential Solar Photovoltaic Panel Adoption*, SSRN Electronic Journal, July 2017.

Overall, there is only limited evidence, driven mostly by principle and analogy, that operating cost subsidies influence EV sales.

PROMOTIONAL ACTIVITIES

In general, it is notoriously difficult to quantify the impact of promotional activities on sales. As Jon Wanamaker famously said, *"Half the money I spend on advertising is wasted; the trouble is I don't know which half."* EVs are no exception. Perhaps as a result, there are only a few efforts to quantify the impact of promotion on EV sales.

The July 2015 ICCT study is one of the few on this topic, but it was unable to find a statistically-significant relationship between promotional activities and EV sales.[18] An October 2016 study by Plug In America for the California Electric Transportation Coalition focused on sales intention rather than sales. It describes survey data that connects higher awareness due to promotional activities with a higher stated propensity to buy an electric vehicle.[19] However, no information was provided directly regarding sales.

Therefore, we are effectively limited to anecdotal information regarding the impact of promotional activities on EV sales.

STATISTICAL ANALYSIS

Although there is considerable qualitative and some quantitative information relevant to the impact of local EV incentive programs, the published literature provides relatively little guidance. There is support for some programs, particularly larger up-front EV cost subsidies, but little support for others, such as promotional activities. Furthermore, the available data is often inconsistent with projected impacts for some programs varying by well over an order of magnitude. Perhaps most importantly, there is very little direct evidence regarding the impacts of the smaller targeted programs that may be most appropriate for local entities.

Given this situation, one natural question is whether more clarity and certainty regarding the impacts of local programs can be obtained using real data from local EV programs and sales. We attempted to answer this question with the statistical analysis below.

Background

California is home to more than 100 local entities that supply electric power and/or are promoting EVs. These include air quality management districts, community choice aggregators (CCAs), investor-owned utilities (IOUs) and publicly owned utilities (POUs), and one rural electric cooperative. There is great diversity among these entities, their programs, and the jurisdictions they serve. Consequently, care is required for apples to apples comparison. We reviewed available information on these entities and identified 39 CCAs and municipal utilities (munis) where relevant reliable and comparable data is available. Based on these 39 entities, we attempted to answer a simple question. *What can we say about the impact of EV programs on EV sales?* Note that all entities face the same federal and state rules, so differences should be the result of local programs and conditions.

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[18] See footnote 8.

[19] Plug in America for CalETC, Evaluating Methods to Encourage Plug-in Electric Vehicle Adoption, October 2016.

Analysis

Each program for the 39 entities was characterized using five independent variables:

- **Direct Investment**: Number of public EVSEs per capita. We used the total number of public EVSEs, with the assumption that the local entity can increase that amount.
- **Up-Front EV Cost Subsidy**: EV up-front cost subsidy in $ per EV. These subsidies can vary by market segment and vehicle type; we used the most commonly reported value.
- **Up-Front EVSE Cost Subsidy**: EVSE (home) up-front cost subsidy in $ per EVSE. A few entities offer subsidies for commercial or public EVSEs; we did not look directly at those.
- **Operating Subsidy**: Special EV rate (Yes/No). We did not look directly at other perks such as parking.
- **Promotional Activities**: Dedicated EV webpage (Yes/No). We did not look directly at variations in such programs.

The impact of these programs was measured using per capita EV sales in 2018. Since our focus is directly on EV sales, this is the most "decision-relevant" measure. We considered other measures such as EV share and EV sales growth rate; these results are similar.

Table 1 below shows data inputs for the 39 entities.

Table 1. Regression Analysis Inputs

Entity				Independent Variables					Dependent Variable
Name	Type	Zip Code	Popul	Direct Invest (Public EVSE's/ capita)	EV Up-front Subsidy ($/EV)	EVSE Up-front Subsidy ($/EVSE)	Oper Subsidy (EV rate, Y/N)	Promo (EV webpage, Y/N)	2018 EV's per capita
Lancaster Choice Energy	CCA	93534	39,088	0.0006	$ 3,000	$ -	0	0	0.0005
Marin Clean Energy	CCA	94901	42,482	0.0028	$ 3,500	$ -	1	1	0.0042
Peninsula Clean Energy	CCA	94061	39,624	0.0005	$ -	$ -	1	1	0.0051
Sonoma Clean Power	CCA	95404	40,474	0.0006	$ -	$ 1,000	1	1	0.0028
Alameda Municipal Power	Muni	94501	63,843	0.0005	$ 900	$ 800	1	1	0.0040
Anaheim Public Utilities	Muni	92805	74,413	0.0008	$ -	$ 500	1	1	0.0015
Azusa Light & Water	Muni	91702	62,348	0.0005	$ -	$ 150	1	1	0.0018
Banning Public Utilities District	Muni	92220	33,014	0.0002	$ -	$ -	0	0	0.0006
Burbank Water and Power	Muni	91502	11,598	0.0077	$ -	$ 500	0	1	0.0023
Cerritos (City of) Water & Power	Muni	90703	50,963	0.0004	$ -	$ 200	0	0	0.0058
City of Industry	Muni	91744	87,240	0.0001	$ -	$ -	0	0	0.0005
Colton Electric Utility	Muni	92324	59,409	0.0004	$ -	$ 500	1	1	0.0005
Corona Department of Water & Power	Muni	92880	69,720	0.0001	$ -	$ -	0	0	0.0039
Glendale Water & Power	Muni	91206	34,386	0.0001	$ -	$ 500	0	1	0.0038
Gridley (City of)	Muni	95948	11,173	-	$ -	$ -	0	0	0.0001
Healdsburg (City of) Utility Department	Muni	95448	17,482	0.0034	$ -	$ 1,500	0	1	0.0045
Imperial Irrigation District	Muni	92251	23,388	-	$ -	$ 500	0	1	0.0004
Island Energy	Muni	94592	1,087	0.0083	$ -	$ 750	0	0	0.0055
Lassen Municipal Utility District	Muni	96130	20,553	0.0002	$ -	$ -	1	0	0.0001
Lodi Electric Utility	Muni	95242	26,235	0.0004	$ -	$ 1,000	1	1	0.0015
Lompoc (City of)	Muni	93436	56,406	0.0001	$ -	$ -	0	0	0.0004
Los Angeles DWP	Muni	90012	35,913	0.0062	$ -	$ 500	1	1	0.0032
Merced Irrigation District	Muni	95340	36,373	0.0001	0	0	0	0	0.0008
Modesto Irrigation District	Muni	95354	24,743	0.0001	$ -	$ 500	0	1	0.0008
Moreno Valley Electric Utility	Muni	92553	75,830	0.0001	0	0	0	1	0.0003
Palo Alto Utilities	Muni	94301	17,191	0.0029	$ -	$ -	0	1	0.0161
Pasadena Water & Power	Muni	91101	21,394	0.0052	$ 1,500	$ 600	0	1	0.0033
Pittsburg Power Company	Muni	94565	96,081	0.0002	$ -	$ -	0	0	0.0008
Rancho Cucamonga Municipal Utility	Muni	91730	71,422	0.0004	$ -	$ -	1	0	0.0013
Redding Electric Utility	Muni	96003	44,475	0.0001	$ 1,000	$ 500	0	0	0.0005
Riverside PUD	Muni	92501	21,656	0.0035	$ 500	$ -	1	1	0.0008
Roseville Electric	Muni	95747	65,335	0.0001	$ 1,000	$ 750	0	1	0.0027
Sacramento MUD	Muni	95240	48,838	0.0003	$ 600	$ 1,000	1	1	0.0003
San Francisco Public Utilities Commission	Muni	94102	31,067	0.0023	$ -	$ -	1	0	0.0015
Silicon Valley Power	Muni	95050	39,452	0.0008	$ -	$ 750	0	1	0.0051
Trinity Public Utilities District	Muni	96093	3,955	-	$ -	$ 500	0	1	0.0006
Truckee Donner Public Utilities District	Muni	96161	18,333	0.0029	$ -	$ 500	0	1	0.0014
Turlock Irrigation District	Muni	95380	42,672	0.0009	$ 1,000	$ 400	0	1	0.0003
Ukiah (City of) Electric Utility Department	Muni	95482	31,847	0.0007	$ -	$ 500	0	0	0.0007

Results

We conducted a linear regression to estimate the connection between the five elements of EV programs and per capita EV sales. We recognize that this is a rather crude analysis. The model is missing several variables, especially demographics, that may have considerable explanatory power. Further, the relationships in the model can be complex and subtle. A positive correlation between subsidies and sales, for example, can reflect causation in the subsidies to sales direction. Higher local subsidies motivate higher EV sales. A negative correlation can reflect causation in the sales to subsidies direction. Lower EV sales motivate higher EV subsidies. A zero correlation may mean that there is no relationship between sales and subsidies, or that both causation phenomena are at work. Care in interpreting the results is required.

Table 2 shows the regression results using the 2018 EV sales metric. As noted above, results for other metrics such as EV share (verses sales) are similar.

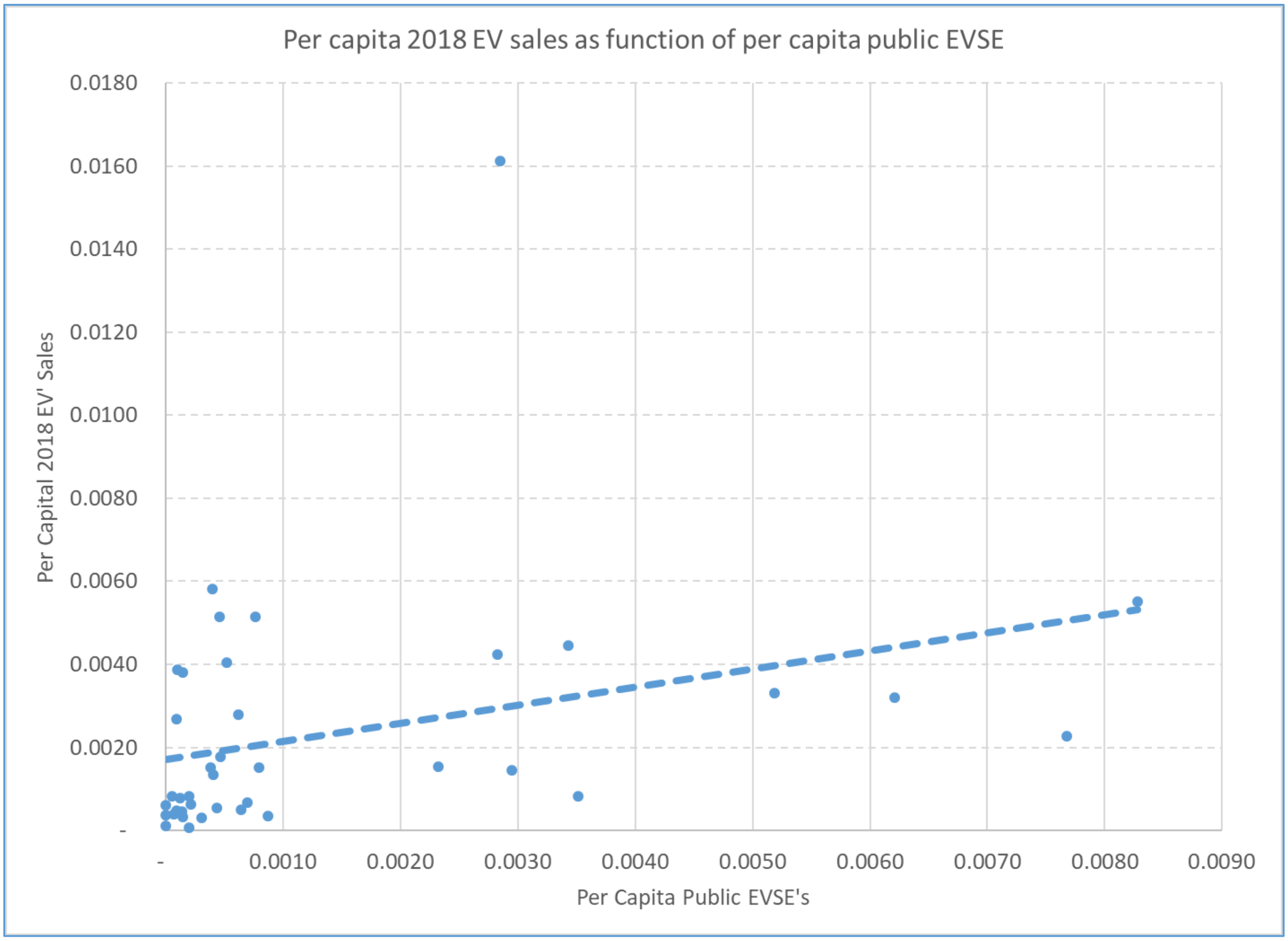
Table 2. Regression Analysis Outputs

	Direct Invest (Pub EVSE/ capita)	EV Up-front Subsidy ($/EV)	EVSE Up-front Subsidy ($/EVSE)	Oper Subsidy (EV rate, Y/N)	Promo (EV webpage, Y/N)
Coefficient	0.4161932	-0.0000002	-0.0000011	-0.0007729	0.0016004
pValue	0.07	0.71	0.45	0.44	0.16

As the table shows, two program elements had a moderately significant positive impact – public EVSE and promotional activities. No variable provided a very strong explanatory signal. These results are discussed in more detail below.

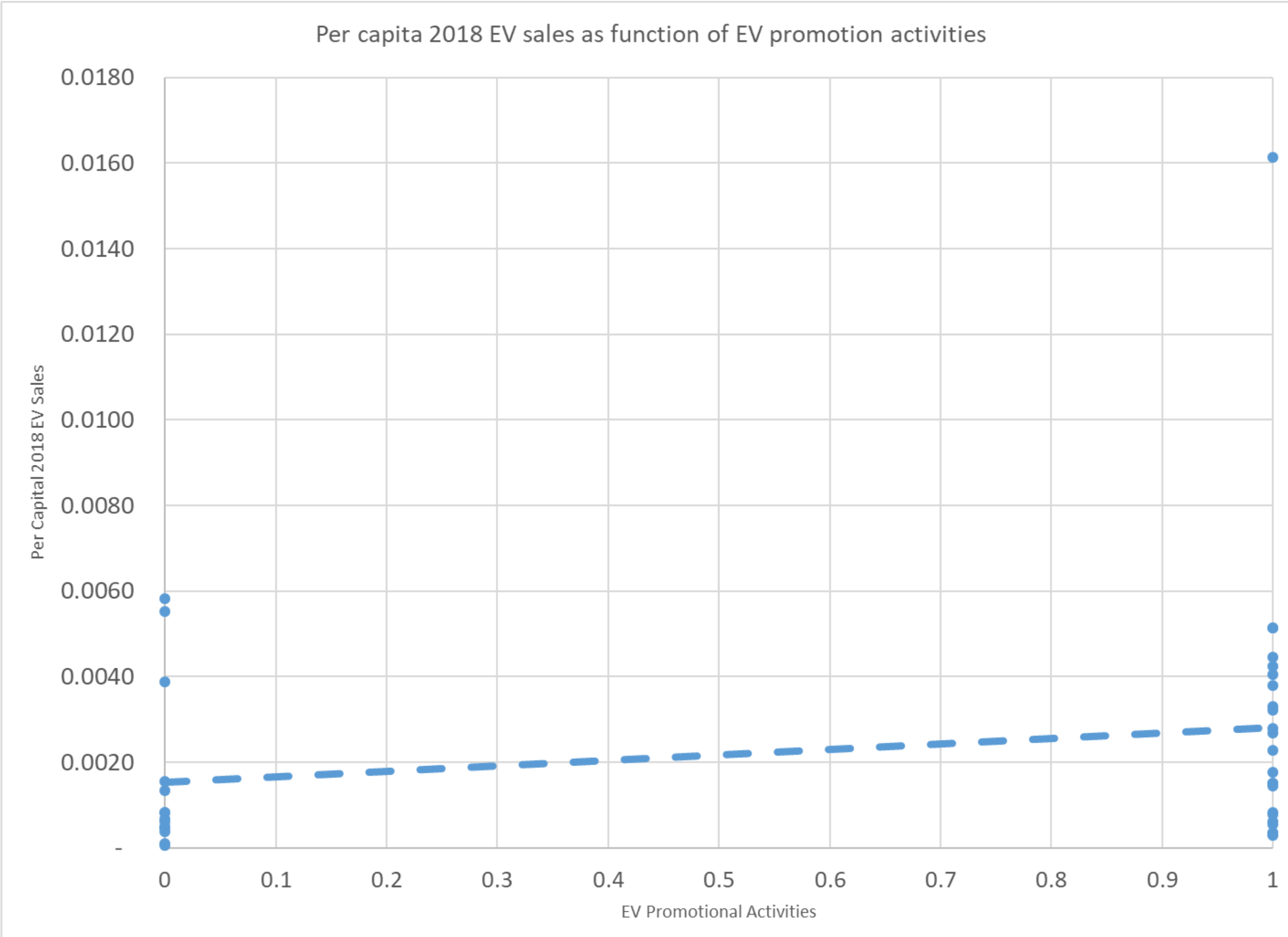
As Figure 2 below indicates, each percent increase in per capita public EVSE is associated with roughly a 0.40% increase in per capital EV sales. A typical locale of 100,000 drivers and five EVSE sites can be expected to have pre-program 2018 EV sales of around 300 vehicles. Based on this analysis, adding an additional five EVSE sites (a 100% increase) should increase EV sales by 40% or 120 vehicles.

Figure 2. Impact of Public EVSE



As Figure 3 below shows, the presence of a dedicated promotional program is associated with a 0.001 per capita increase in EV sales. This suggests, for the typical community noted above, adding a promotional program could raise 2018 EV sales from 300 (0.003 per capita) to 400 (0.004 per capita).

Figure 3. Impact of Promotional Activities



Interestingly, and perhaps surprisingly, none of the up-front cost or operating cost incentives had a significant impact in this analysis. Correlations were statistically insignificant and even negative. This could be due to the weakness of the explanatory signal. It could also reflect the crudeness of the analysis, or as noted above, the balancing effects of causation operating in both directions.

OBSERVATIONS AND CONCLUSIONS

In our judgment, the mix of our review of the published literature and our statistical analysis warrants the following conclusions.

- **Direct Investment.** **[Positive]** The available published literature on the impact of public EVSE installations suggests a positive impact of uncertain magnitude on EV sales. Our statistical analysis further suggests that public EVSE installation programs are associated with increased EV sales. Customized on-the-ground research may be helpful to target installations most effectively, but our judgment is that local entities can increase EV sales measurably by increasing the number of public EVSEs. This is particularly true in jurisdictions with relatively few EVSEs.

- **Promotional Activities. [Positive]** The published literature suggests an association of uncertain magnitude between promotional activities and EV sales. Our rather crude webpage-based analysis on this topic suggests the same. Promotional activities then appear to be a relatively low cost and low risk means of increasing EV sales. Further on-the-ground research may be helpful to identify the most effective activities.
- **Up-Front Cost Subsidies. [Uncertain]** Economic principles and the published literature clearly indicate that large up-front EV cost subsidies increase EV sales. However, our analysis was unable to detect this effect for the smaller local subsidies, and there are concerns about the wisdom and effectiveness of large programs that may waste resources and profit the already wealthy. There is also very little evidence regarding EVSE subsidies. Consequently, further analysis is likely required to determine if smaller and/or targeted upfront local subsidies are advisable either for EVs or EVSEs.
- **Operating Cost Subsidies [Uncertain]** Economic principles indicate that operating cost subsidies should increase EV sales. However, there is only minimal evidence from the published literature on this front. In addition, our rather-crude EV rate based analysis was unable to detect any effect. As with upfront cost subsidies, further analysis is likely required to determine if local operating cost subsidies, particularly targeted ones, are advisable. Whatever the impact on EV sales, EV rate design is important for incentivizing economic charging behavior and improving grid operations.

There is an evident gap between the enthusiasm for local EV incentive programs and the understanding of the impacts of those programs. This paper is a modest contribution to closing that gap. We look forward to further progress in deepening this understanding and in fully realizing the important benefits of EVs.