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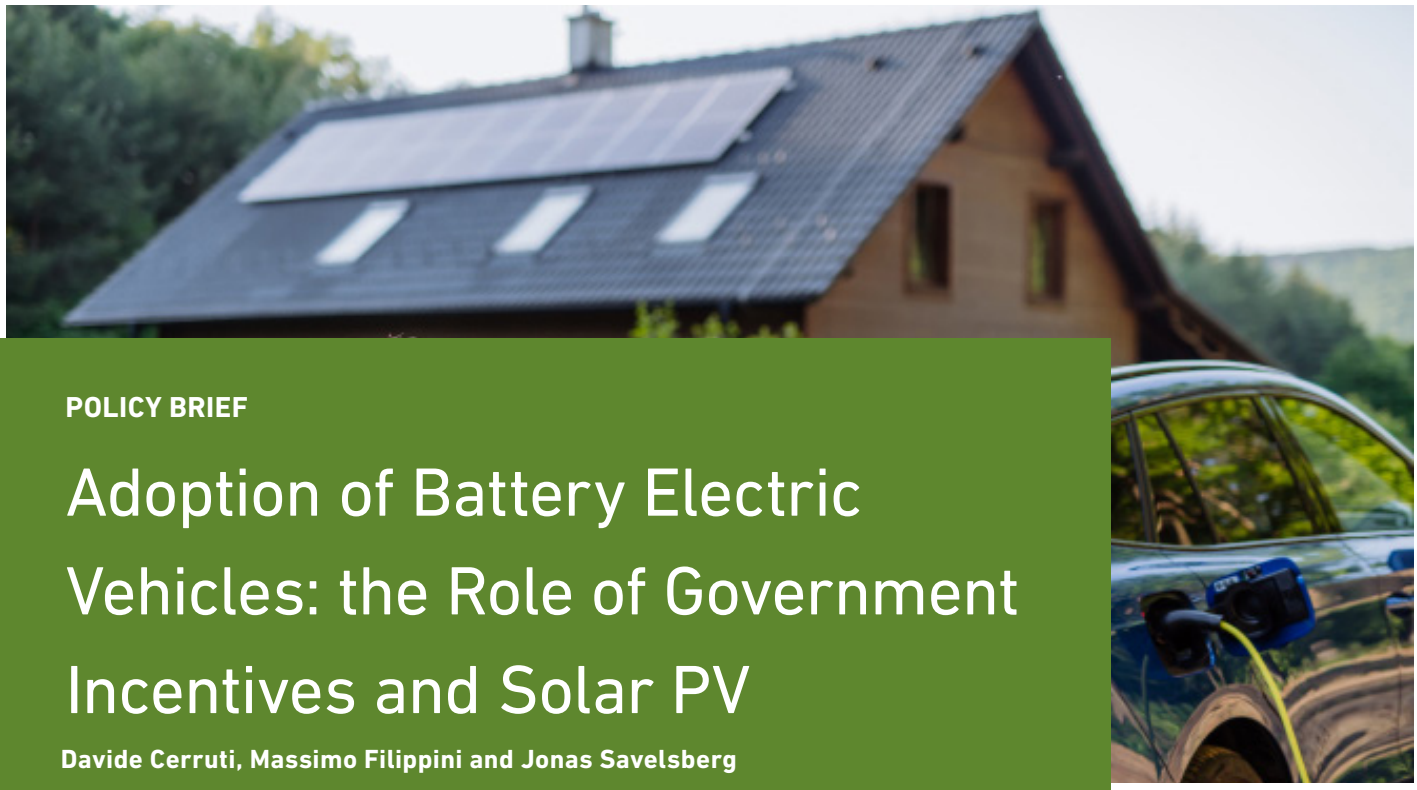

POLICY BRIEF

Adoption of Battery Electric Vehicles: the Role of Government Incentives and Solar PV

Davide Cerruti, Massimo Filippini and Jonas Savelsberg

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Executive Summary

• Electrification of private passenger transport is crucial to lower carbon emissions and air pollution from the transport sector.
• To reach this goal, battery electric vehicles (BEVs) are an essential technology.
• Several cantons adopted monetary incentives to promote the adoption of BEVs.
• One common type of incentive is a discount on the annual cantonal circulation tax for BEVs. The other type is a subsidy on the purchase of a BEV.
• The present study investigates: 1) if the incentives in place are effective in promoting BEV adoption; 2) which of the two measures to promote BEVs is more effective; 3) whether the increased diffusion of rooftop solar PV induces households to buy a BEV.
• The empirical evidence shows that purchase subsidies subsidies help promoting BEVs while circulation tax discounts are not so effective. A possible explanation for that is, as shown in Cerruti et al. (2023), the lower visibility and low awareness of tax discounts at the moment of purchasing a car. Therefore, to increase the effectiveness of tax discounts, it is important to introduce information campaigns about this policy measure.
• When the market share of new BEVs is already a few percentage points high, purchase subsidies become less cost-effective in promoting the adoption of BEVs..
• The diffusion of solar PV encourages BEV adoption. This might be because people plan to charge the vehicle with self-produced electricity.

Outline

Electrification of private passenger transport represents a crucial milestone to reduce carbon emissions and air pollution from the transport sector. To accelerate this process, several central and local governments around the world introduced a series of monetary incentives for the purchase of battery electric vehicles (BEVs). The share of new BEVs increased significantly in the last few years: for instance, in 2016 the average share of new BEVs per municipality was 1.1%, while in 2021 it was 14.2%.

In many European countries, including Switzerland, two of the most common incentives are purchase subsidies and discounts on the annual vehicle circulation tax. The first policy is a lump sum transfer that reduces the purchase cost of a BEV. The second policy is a reduction of the annual tax every car owner

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must pay to use the vehicle: this discount can be a percentage reduction on the base rate or a fixed amount reduction. In some cases such reduction is limited to the first few years after the purchase.

In Switzerland, these two types of incentives are typically adopted at the cantonal level and both involve the commitment from public institutions to invest public funds, either in terms of budgetary expenditures (purchase subsidies) or in terms of forgone tax revenues (tax discounts). In this study we aim to answer the following two questions: 1) are these measures effective? 2) which of the two measures is more effective, i.e. which type of incentive will increase the market share of BEVs the most for a given amount of money spent? In particular, the presence of free riders, i.e. individuals who would have bought a BEV even in the absence of incentives, implies that ineffective policies can have significant costs.

Another factor of interest is the diffusion of rooftop solar PV, which went from a total capacity of 1906 MW in 2017 to 3655 MW in 2021. One hypothesis is that the diffusion of solar PV might incentivize the adoption of BEVs, as households would charge their vehicle with self-produced electricity. As can be seen from Figure 1, the adoption of BEVs and solar PV increased dramatically between 2014 and 2021.

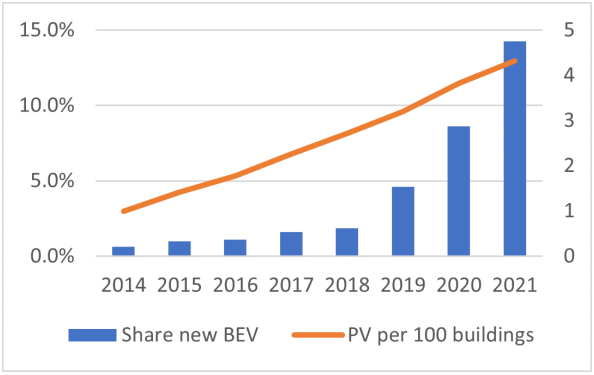

Figure 1: Comparison of share of new BEV and solar PV per 100 buildings between 2014 and 2021

Cantonal incentives for battery electric vehicles

The 26 cantons of Switzerland have considerable autonomy in setting up their own vehicle circulation tax and purchase subsidies for BEVs. We looked at cantonal legislation from 2014 to 2021 to understand which cantons adopted monetary incentives for battery electric vehicles.

The circulation tax is due every year and depends on one or more characteristics of the vehicle such as engine size, engine power, and weight. This baseline amount can be reduced (or increased) depending on the characteristics of the car, such as the presence of an electric engine.

We distinguish between four types of four monetary incentives to promote BEVs:

- Tax discounts (or increases) based on the vehicle energy label and/or CO_2 emissions per km.
- Tax discounts for hybrid vehicles and battery electric vehicles.
- Tax discounts for battery electric vehicles only.
- Purchase subsidies for battery electric vehicles.

A canton can have one or more of these incentives. Tax discounts on energy labels and/or CO_2 emissions are applicable to all cars, while the other three measures are limited to hybrid and battery electric cars. In our analysis, we consider only incentives that apply specifically to BEVs.

During the period 2014-2021, 18 cantons had a tax discount in place for BEVs, and 4 cantons had a BEV purchase subsidy.

The role of cantonal incentives in promoting BEV adoption

To analyze the level of effectiveness of the policy measures introduced by the cantons we perform an empirical analysis based on the estimation of a regression model. For this purpose, we used yearly data from 2014 to 2021 at the municipality level on the share of new registrations of BEVs. Moreover, we have collected information on the amount and timing of the adoption of tax discounts and purchase subsidies for BEV in the various cantons. For circulation tax discounts, we also compute the amount of monetary savings for the lifecycle of a representative BEV. Figure 2 illustrates the average purchase subsidy and the average tax discount applied in the Swiss cantons that introduced these measures.

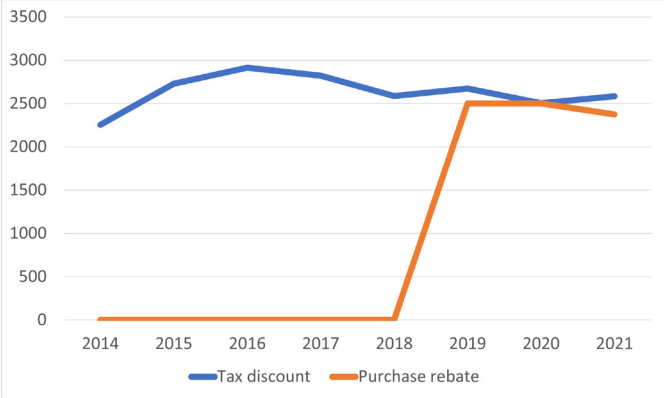

Figure 2: Average size of monetary incentives, CHF

In our regression analysis, we compare BEV market share in municipalities with and without the policy measures. In the analysis, we also consider other factors that can influence the adoption

of BEVs, such as population, sociodemographic characteristics, consumer electricity price and share of single-family houses.

Our main findings are the following:

- The introduction of a purchase subsidy for BEVs increased the municipality share of new BEVs by 2.6 percentage points. Given that in the 2014-2021 period the average municipality share of BEVs for municipalities that never adopted one of the two policies examined was around 4.2%, the introduction of the purchase subsidy would increase this share to 6.8%.
- The effect of the introduction of a tax discount for BEVs is not statistically significant.

This difference in the impact may be due to a lower level of awareness of the circulation tax discount in comparison to the upfront subsidy that is more salient to the buyers of cars, as found out in the study by Cerruti et. al. (2023).

Given these results, we can perform a very rough back-on-the-envelope calculation. For example, in 2021 an increase in the purchase subsidy of 2500 CHF (corresponding to the average amount of the subsidy) will increase the number of new BEVs of approximately 2-3 units. Considering that the average number of newly registered BEVs in a representative municipality is already 15 units without subsidy, it would increase to 17-18 with a subsidy. In this situation, the total amount of subsidies in this municipality will be around 44,000 CHF. Therefore, the cost of increasing the number of BEVs by one unit would be around 16'000 CHF. The very high value is due to the fact that the upfront subsidy would be also paid to consumers that would have bought a BEV anyway.
If a representative gasoline car emits for 10 years (the average lifetime of a car in Switzerland) 13 tons of CO_2, the subsidy will decrease the emissions only by this amount (extra BEV due to the subsidy). Therefore, the reduction cost per ton of CO_2 is around 1200 CHF, which is a very high number. Because we do not observe an effect statistically significant from zero from the tax discounts, the costs related to such a policy would be even higher.

Of course, in this simple calculation, that are based on some assumptions, we are not considering all benefits such as the reduction of air pollution. Nevertheless, we show that the costs of these programs can be high when BEV adoption starts to rise, due to the presence of individuals who would buy a BEV in any case but still receive the incentive.
When interpreting these results, one should keep in mind that the empirical analysis refers to a period of early stage of adoption of BEVs and with a limited number of cantons that introduced the tax discounts and the purchase subsidies. Our results are thus to be interpreted within this context. For instance, we cannot exclude that in the future the evaluation of these two policies might change with the evolution of the BEV market, the diffusion of public charging station and an increase of the cantons adopting these incentives.

Synergies between solar PV and BEV adoption

To analyze the relationship between BEV adoption and pre-existing solar PV capacity we perform an empirical analysis based on the estimation of a regression model. For this purpose, we use yearly data from 2014 to 2021 at the municipality level of the share of new registrations of BEVs and of the diffusion of solar PV, indicated either as number of solar PV every 100 buildings or as kW of installed solar PV every 100 buildings.

In our regression analysis, we compare BEV market share in municipalities with different levels of solar PV penetration. As for the analysis of cantonal incentives, we consider also other factors that can influence the adoption of BEVs, such as population, sociodemographic characteristics, consumer electricity price, and share of single-family houses.

Our main findings are the following:

- Adding 1 solar PV every 100 buildings would increase the municipality market share of new BEVs by 0.76 percentage points.
- Adding 10 kW of additional solar PV capacity to every 100 buildings would increase the municipality's share of new BEVs by 0.57 percentage points.

Policy recommendations

- The results of our study suggest that purchase subsides promote the adoption of BEVs, although the impact is relatively modest, while there is no clear impact from circulation tax discounts.
- The difference in the impact of the two policy measures may be due to the different levels of awareness among the buyers of these monetary incentives. Therefore, as shown in Cerruti et al. (2023), it is very important to introduce public campaigns to increase the level of policy awareness.
- The installation of solar PV has a positive influence on the adoption of BEVs. Therefore, subsidies that promote the adoption of solar panels may have also an impact on the adoption of BEVs.
- When the market share of new BEVs is already a few percentage points high, purchase subsidies become less cost-effective in promoting the adoption of BEVs. Conversely, when the share of BEVs is relatively low, as in the beginning of the period of our study, the policy might be cost-effective.
- Generally, there is a need to rethink the policy measures to further increase adoption rates of BEVs.

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