CER-ETH – Center of Economic Research at ETH Zurich

Adoption of battery electric vehicles: the role of government incentives and solar PV

D. Cerruti, M. Filippini, J. Savelsberg

Working Paper 23/388
December 2023

Economics Working Paper Series

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Adoption of battery electric vehicles: the role of government incentives and solar PV

Davide Cerruti*, Massimo Filippini*†, Jonas Savelsberg*

December 20, 2023

Abstract

Electrification of the private passenger transport sector is a fundamental milestone in reducing global carbon emissions. To reach this goal, several governments introduced a series of incentive programs to encourage the adoption of battery-electric vehicles (BEVs). Two of the most widespread policies to incentivize the adoption of BEVs are discounts on the annual vehicle circulation tax and purchase rebates. This paper analyzes the causal relationship between introducing these two policies and adopting battery-electric vehicles (BEVs) in Switzerland. We also examine the effect of the diffusion of rooftop solar PV on the adoption of BEVs. We find that purchase rebates for BEVs positively affect their adoption, while the discount on the circulation tax has a minor or no effect. However, the cost-effectiveness of both policies remains low because of a free-riding problem, i.e. all buyers of a BEV are entitled to the incentives, including those who would have bought a car even in their absence. The diffusion of solar PV facilitates the adoption of BEVs.

*ETH Zürich, Center of Economic Research, 8092 Zürich, Switzerland.
†Università della Svizzera Italiana, Faculty of Economics, 6900 Lugano, Switzerland.

1 Introduction

Electrification of the private passenger transport sector is a fundamental milestone in reducing global carbon emissions. To reach this goal, several governments introduced a series of incentive programs to encourage the adoption of battery-electric vehicles (BEVs). At the same time, several countries in Europe and the rest of the world reported a substantial increase in the market share of plug-in BEV.

Two of the most widespread policies in Europe to promote the adoption of battery-electric vehicles are discounts on the annual vehicle circulation tax and purchase rebates (ACEA, 2023). However, while the two policies have the same goal, their mechanisms differ considerably. Vehicle circulation taxes are generally calculated automatically, and their saving is spread over the vehicle's life cycle. Instead, purchase rebates are applied once when the car is bought.

Given the distinct characteristics of the two policies, their effectiveness may also be different. For instance, the economics literature has underlined how automatic bill payments are less salient than regular bills and that consumers tend to underreact, and in some cases overreact, to non-salient taxes (Sexton, 2015; Morrison and Taubinsky, 2023; Taubinsky and Rees-Jones, 2018). Furthermore, while the monetary benefits from purchase rebates are relatively easy to calculate, tax discounts are often presented as percentage discounts to the baseline circulation tax, which may depend on the characteristics of the specific vehicle. Evidence that individuals are not fully informed about circulation taxes comes from Cerruti et al. (2023), who find that only 42% of the Swiss population is aware of circulation tax discounts for energy-efficient cars.

The economics literature has looked at the effect of government incentives on hybrid and plug-in vehicles (Wee et al., 2018; Münzel et al., 2019; Clinton and Steinberg, 2019; Springel, 2021; Muehlegger and Rapson, 2022). However, these studies have been performed primarily in the United States context and either focus on incentives targeted at hybrid cars and plug-in vehicles without considering the more recent policies exclusively targeted at BEVs, or they do not distinguish between discounts on vehicle registration taxes and purchase rebates.[1] Policies targeted only to BEVs and those targeted to both BEVs and hybrid electric vehicles might not have the same effect, as hybrid cars can run on gasoline and diesel. Thus, hybrid cars could look more appealing to consumers without the possibility of charging the vehicle at home.

Further, it is important to consider that the adoption of BEVs could also be influenced indirectly by policy measures that promote the installation of solar panels in the residential sector. Indeed, during the last years, in the residential sector, and especially for households living in single-family houses, we observed a diffusion of plug-in electric vehicles and solar photovoltaics (PV). Households living in single-family houses may decide to buy an electric car and eventually install solar panels to produce electricity for the utilization of the vehicle, or they may install the solar panels first and then decide to buy an electric car. In this context, a natural question is whether there are complementarities between the adoption of these two technologies and, in particular, whether the adoption of solar PV facilitates the adoption of plug-in electric vehicles or vice-versa. The analysis of the level of complementarity could also have interesting implications for policymakers, as subsidies for installing solar PV, as mentioned above, might also produce positive spillovers for adopting electric vehicles.

Some papers in the literature discuss the complementarities between solar PV and plug-in electric vehicles, without however an econometric analysis of the causal relationship between the two (Coffman et al., 2017; Kaufmann et al., 2021). For instance, Liang et al. (2022) suggests that owners of solar PV and electric vehicles adapt the charging time of their cars to charge with self-produced energy. Martin et al. (2022) show that in Switzerland, up to 56% of the energy consumption of an electric vehicle could be technically fulfilled by electricity produced by rooftop solar PV. Finally, Lyu (2022) analyzes the causal relationship between

[1] For instance, Clinton and Steinberg (2019) compare income tax credits and purchase rebates, but not discounts on registration taxes.

the diffusion of solar PV and electric vehicles in the United States, finding a mutual positive influence.

The research objectives of our paper are twofold: the first is to measure the effect of two different incentives, a purchase rebate and a circulation tax discount, on the market share of new battery electric vehicles (BEV). The second goal is to understand the relationship between the presence of rooftop solar PV and the adoption of plug-in hybrids (PHEV) and BEV.

Our paper contributes to different streams of literature. First, we provide a new empirical analysis of the impact of different types of monetary measures on the adoption of electric cars. In particular, we can show the distinct effects of an up-front subsidy and an annual circulation tax discount. Secondly, we provide new empirical evidence to the scarce literature that analyzes the impact of solar panels on the adoption of BEV.

Our results suggest that introducing the purchase rebate increased BEV adoption by 1.0 percentage points, and the circulation tax discount increased it by 0.4 percentage points. We also show that a purchase subsidy of 1000 CHF would increase BEV adoption by 0.6 percentage points and a tax discount of 1000 CHF by 0.1 percentage points, i.e., each CHF of purchase rebate has the same effect as six CHF of tax discount.

When we consider the total cost of the two policies, we find that both are pretty expensive. For instance, in 2021, on average, in a municipality, one would spend 24,000 CHF in rebates to increase the adoption of BEVs by one unit. The corresponding average cost per tonne of CO_2 saved would be 1800 CHF for the rebate. These numbers are similar in magnitude to those found in previous literature looking at the costs of rebates for plug-in electric vehicles (Sheldon, 2022). The main reason for these high costs is the presence of free riders, i.e., people who benefit from the incentives but would have bought a BEV in any case. Thus, these monetary incentives are appropriate in context with zero or very low baseline BEV adoption.

The remainder of this paper is structured as follows. The next section will provide an overview of the cantonal policies favoring BEV. Section 3 presents our empirical strategy, and section 4 describes the data. Section 5 shows the estimation results, followed by a calculation of the costs of the incentives and a concluding section.

2 Cantonal policies targeting electric vehicles

Switzerland is a federal state with 26 regional governments (cantons) that are independent in the definition of energy and transport policy measures introduced to promote the adoption of BEV. Note that the role of the central government in the car sector is limited to the implementation of emission standards and an energy label system. Therefore, the central government doesn't use fiscal incentives or subsidies to promote the adoption of BEV.

As in many other European countries, car owners in Switzerland must pay a vehicle circulation tax each year. The amount of such circulation tax is noticeable, with the average annual registration tax on a vehicle purchased in 2015 at around 435 CHF. The tax amount typically depends on baseline vehicle characteristics such as weight, engine size, and power. However, contrarily to other countries, in Switzerland, the exact amount of the tax is not defined by the central government but by each of the 26 administrative units (cantons).[2] As a result, the amount to pay varies significantly across different cantons.

In particular, some cantons allow certain types of vehicles to enjoy a discount on the baseline circulation tax if they satisfy specific requirements, typically based on energy efficiency and/or CO_2 emissions; these discounts apply to both internal combustion engine and alternative fuel vehicles. On top of that, however, certain cantons set up some specific tax discounts targeted exclusively at BEV and/or hybrid electric vehicles (HEV). These discounts typically allow a saving between 30% and 100% of the baseline circulation tax for the first 3-4 years from the first vehicle registration. The discounts can apply to all HEVs and BEVs or only to BEVs. Furthermore, some cantons have also introduced subsidy programs

[2]Switzerland is a federal state, with four different official languages and with three distinct levels of government: Federal, Cantonal (26 cantons), and Local (about 2500 municipalities). Each cantonal and local government is entitled to specific functions and considerable autonomy to impose taxes.

that cover part of the purchase cost of a BEV, typically for a maximum amount per car between 1500 and 5000 CHF.

Table 1 summarizes the purchase subsidies and tax discount cantonal policies for electric vehicles from 2005 to 2021. We can notice a wide variation in the timing and category of policies implemented: 11 cantons had a HEV and BEV tax discount, 12 had a BEV tax discount, and 4 had a BEV rebate program.[3] In particular, four cantons (Bern, Basel-Stadt, Neuchâtel, Zürich) have introduced a BEV-only tax discount between 2010 and 2021, while other four cantons (Schaffhausen, Thurgau, Ticino, Valais) have introduced a BEV purchase subsidy between 2010 and 2021. Many cantons also have Bonus/Malus policies for the vehicle registration tax. These measures offer discounts on the vehicle registration tax to cars that fulfill certain requirements, for instance, a high energy efficiency rating or a low rate of carbon emissions per km. Because these benefits do not apply exclusively to BEV or hybrid vehicles, we do not consider them in our analysis.

[3] The cantons of Neuchâtel and Basel-Stadt first introduced a circulation tax discount for BEV, then replaced it with a discount for low-emission cars in general, and then reintroduced the BEV discount again. The canton of Geneva was not considered due to the lack of information on the type of vehicles benefiting from a tax discount.

Table 1: Summary tax discounts and subsidies from 2010 to 2021

Canton	**Discount HEV+BEV**	**Discount BEV only**	**Subsidy BEV**
AG	No	No	No
AI	No	No	No
AR	2010-2017	No	No
BE	No	2013-2021	No
BL	2010-2013	No	No
BS	No	2010-2012, 2018-2021	No*
FR	2010	2010-2011	No
GL	No	2012-2021	No
GR	No	No	No
JU	2010-2021	No	No
LU	2010-2016	No	No
NE	No	2010-2013, 2016-2021	No
NW	2010-2021	No	No
OW	2010-2021	No	No
SG	No	2010-2021	No
SH	No	No	2021
SO	No	2010-2021	No
SZ	2010-2011	No	No
TG	No	2010-2021	2019-2021
TI	2009-2013	No	2019-2021
UR	No	2010-2021	No
VD	No	2010-2021	No
VS	No	No	2021
ZG	No	2010-2021	No
ZH	2010-2013	2014-2021	No

Notes: Description of main tax discounts and purchase subsidies for battery electric vehicles (BEV) in place from 2005 to 2021. The canton of Basel-Stadt introduced purchase rebates only for company cars, which was not considered in the analysis.

3 Empirical strategy

The paper's primary goal is to analyze the impact of government incentives on adopting BEVs. Moreover, we also want to explore the role of the presence of solar PV in the adoption of BEVs. From an empirical point of view, our preferred strategy is to analyze separately the effect of government incentives and the impact of solar PV diffusion on the adoption of BEVs. We hypothesize that the stock of solar PV influences the adoption of battery electric vehicles: for instance, the presence of solar PV on the roof of a household home encourages the purchase of an electric car due to the possibility of charging at home with self-produced electricity.

To understand the impact of monetary government incentives and solar PV on the adoption of electric vehicles, we use the following fixed-effect model:

$$y_{it} = \alpha + \beta_1 \text{taxHEV}_{it} + \beta_2 \text{taxBEV}_{it} + \beta_3 \text{rebateBEV}_{it} + \gamma \frac{\text{PV}_{it}}{\text{Buildings}_i} + \delta X_{it} + \eta_t + \xi_i + \epsilon_{it} \quad (1)$$

Where y_{it} is the share of newly registered vehicles of a given type for year t and municipality i. taxHEV_{it}, taxBEV_{it}, rebateBEV_{it} are respectively a dummy for the presence of a cantonal circulation tax discount for hybrid vehicles (both plug-in and non-plug-in), dummy for the presence of a cantonal circulation tax discount for BEVs, and a dummy for the presence of a rebate on the purchase of BEVs. PV_{it} corresponds to either the number of solar PV in a municipality or in a year or the related total installed power in kW, while Buildings_i is the total number of buildings in a municipality (including those without solar PV installed). The variable X_{it} is a set of time-varying controls at the municipality level: yearly electricity price, the share of women, the share of people aged 0-19, the share of people aged 65 or more, and the share of houses that are single-family houses. Municipality and year fixed effects are represented by η_t and ξ_i, respectively.

Our estimation presents two identification challenges. First, while the econometric models described above are a standard difference-in-differences model for what concerns the subsidies and the fiscal incentives for electric vehicles, the staggered adoption of the incentives by different cantons produces biased estimates in case of heterogeneous treatment effects (Sun and Abraham, 2021; De Chaisemartin and d'Haultfoeuille, 2020). For this reason, we report, along with the standard difference in difference estimates, the average treatment effect on the treated (ATT) and the treatment effects over time following the methodology proposed by Callaway and Sant'Anna (2021).

Second, using the share of installed solar PV per building as an explanatory variable presents a potential endogeneity issue related to reverse causality and omitted variable bias. For the latter reason, there might be unobservable time-varying factors at the municipality level, such as available income, environmental attitudes, or better information about new technologies, influencing both the ratio of installed solar PV per building and the adoption of electric vehicles.

To mitigate this concern, in Equation 1 we instrument the diffusion of solar PV with the 5-year moving average of the level of solar radiation in a municipality: we argue that solar radiation has no impact on the decision to buy an electric vehicle, but it directly affects the profitability of a solar PV and thus the decision to install one. The findings of Lamp (2023), which show how sunshine weather plays an important role in the decision to install a solar PV, corroborate such instrument choice.

While we have data on solar PV installation only starting from 2014, data on vehicle registrations goes back to 2010.[4] For this reason, we run our model using first data from 2014 to 2021 and then data from 2010 to 2021 while dropping the PV/building variable. By doing so, we can include more pre-treatment periods for the cantons that adopted the incentives, and we are able to include more cantons with both pre- and post-treatment observations.

[4]There were very few models of BEV available on the market before 2010 in Switzerland.

4 Data

As our outcome of interest, we calculate the share of new yearly registered battery electric vehicles in each municipality using data from the Swiss Federal Office of Statistics from 2010 to 2021.

For the diffusion of solar PV, we use data from the installation of solar PV with operating power of at least 2 kW between 2014 and 2021 from the Swiss Federal Electricity Commission. We then calculate 1) the ratio of the total number of solar PV installed in a year in a municipality over the total number of buildings in the municipality itself; 2) the ratio of the new solar PV capacity installed in a year in a municipality over the total number of buildings in the municipality itself. Similarly, we also create two variables measuring the stock of solar PV: the average number of solar PV per building in each municipality in a given year and the average total solar PV capacity per building in each municipality in a given year.

As for the other variables of interest, we obtain from cantonal legislation the years of implementation of the circulation tax discounts for both HEVs and BEVs, the circulation tax discounts only for BEV, and the purchase subsidies for BEV. From the Swiss Federal Office of Statistics, we obtain at the municipality level the share of women, the share of individuals from 0 to 19 years old, the share of individuals of 65 years old or more, and the share of single-family homes. The Federal Electricity Commission also provides information on yearly electricity tariffs in each municipality. Finally, we get annual average data on surface solar radiation downwards from the ERA5-Land dataset, using the municipality centroid to assign radiation value to each municipality.

Table 2 shows the summary statistics for the yearly adoption at the municipality level of new battery electric vehicles and solar PV in the sample period 2010-2021 (2014-2021 in the case of solar PV). We observe that the average share of battery electric vehicles is 4.7% and that in more than a quarter of the observations, likely from the earliest sample years, no new BEVs were registered. When looking at the adoption of new solar PV, we observe that, on average, a municipality has new installations of 0.47 solar PV plants for every 100 buildings and an additional installation of 9 kW for every 100 buildings. Also, in this case, we observe considerable variation across years and municipalities.

Table 3 shows summary statistics referring to the yearly stock of electric vehicles and solar PV at the municipality level. We observe an average penetration of battery electric vehicles of 0.51%, substantially lower than the share of new BEVs. Regarding solar PV, on average, in a municipality, we observe 2.6 solar PV for every 100 buildings and 60.2 kW of capacity for every 100 buildings.

Finally, in Table 4, we look at other municipality characteristics: the average yearly electricity price is around the Swiss average, with considerable variation depending on the location and the year. Another critical factor to consider is the share of single-family homes, which arguably facilitate the installation of solar PV and electric vehicle adoption (due to private parking spaces). In most municipalities, their share is between 25% and 50%.

	mean	sd	min	p25	p50	p75	max
Share BEV	0.047	0.071	0	0	0.018	0.068	1
Share PV/Build	0.0047	0.0071	0	0.0017	0.0033	0.0057	0.25
Share kW/Build	0.090	0.30	0	0.018	0.046	0.094	24.2
N	13992						

Table 2: Summary statistics for yearly new BEV and solar PV adoption

	mean	sd	min	p25	p50	p75	max
Share BEV	0.0051	0.0065	0	0.00085	0.0030	0.0071	0.14
Share PV/Build	0.026	0.033	0	0.010	0.019	0.031	1.05
Share kW/Build	0.62	0.96	0	0.19	0.40	0.74	24.8
N	16032						

Table 3: Summary statistics for stock of BEV and solar PV

	mean	sd	min	p25	p50	p75	max
elec. price	20.3	3.00	4.46	18.2	20.8	22.0	51.1
Population (1000s)	3.86	12.5	0.028	0.72	1.55	3.74	423.2
Share women	0.50	0.017	0.29	0.49	0.50	0.51	0.61
Share 0-19	0.21	0.035	0	0.19	0.21	0.23	0.44
Share 65+	0.18	0.043	0.037	0.15	0.18	0.21	0.42
Share single house	0.36	0.15	0	0.25	0.36	0.46	0.94
N	25507						

Table 4: Summary statistics for municipality characteristics

5 Results

In the following section, we first present in subsection 5.1 the results on the impact of government incentives on adopting BEV. This set of results is based on the estimation of Equation 1 using a dichotomous variable for the policy measures. We will then illustrate in sub-section 5.2 the results obtained by estimating model 1 using instead continuous variables for the amount of the incentives. Finally, in sub-section 5.3, we will discuss the results on the effect of solar PV stock on the adoption of BEV and the impact of BEV stock on the adoption of solar PV. We illustrate the econometric results obtained with and without an instrumental variable approach to address the possible endogeneity of the BEV stock and solar PV stock variables. This analysis is performed separately because, as discussed previously, due to the limited availability of information about solar PV, the data used goes only from 2014 until 2021 and not, as in the previous analysis illustrated in sub-sections 5.1 and 5.2, from 2010 until 2021.

5.1 Effect of the incentives

In Table 5, we present the OLS results of Model 1. In columns 1-3, we use data from 2014 to 2021 and include the PV/building measure as control, while in columns 4-6 we use a longer time frame from 2010 to 2021, but we do not include the PV/building measure as control, because the information to calculate this variable is available only from 2014. We use three different specifications: one with only year fixed effects, one with year and canton fixed effects, and one with year and municipality fixed effects. All specifications include a set of time-variant socioeconomic variables at the municipality level.

All the results indicate an effect of the purchase rebates on the market share of BEV, with an increase of 1.2 and 1.0 percentage points for our preferred specification with municipality fixed effects (columns 3 and 6) in periods 2014-2021 and 2010-2021. The impact of tax discounts for BEV is close to zero and insignificant when considering the 2014-2021 period, while the analysis in the 2010-2021 period shows an increase of 0.4 percentage points in BEV's market share. The broader tax discount for hybrid vehicles and BEV has no effect under the 2014-2021 and 2010-2021 samples.

Table 5: Regression results for Equation 1, baseline

	2014-2021			2010-2021		
	(1)	(2)	(3)	(4)	(5)	(6)
tax discount HEV+BEV	0.001	0.002	0.003	0.000	-0.001	-0.001
	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
tax discount BEV	0.006***	-0.006	-0.007	0.004***	0.004***	0.004***
	(0.001)	(0.008)	(0.010)	(0.001)	(0.001)	(0.001)
rebate BEV	0.008**	0.011***	0.012***	0.008*	0.010**	0.010**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
N	15462	15462	15462	24876	24876	24876
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Canton FE	No	Yes	No	No	Yes	No
Municipality FE	No	No	Yes	No	No	Yes
Municipality controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regression results from Equation 1. The dependent variable is the share of new BEVs per municipality. In columns 1-3 we consider the period 2014-2021, including the PV/building regressor; in columns 3-6 we consider the period 2010-2021, excluding the PV/building regressor. Standard errors in parenthesis, clustered at the municipality level.

As mentioned in the methodology section, results from two-way fixed effect models might be biased in the case of heterogeneous treatment effects. For this reason, we repeat our analysis using the estimator of Callaway and Sant'Anna (2021) and derive the ATT estimate, along with the effect over time.[5]

Table 6 shows the average treatment effect estimates using the methodology of Callaway and Sant'Anna (2021). Looking at the results using the 2010-2021 sample, we find an increase in BEV share of 1.6 percentage points due to the BEV rebate and a rise of 0.7 percentage points due to the BEV tax discount, both statistically significant. Both point estimates are larger than those found in Table 5, but we still observe that introducing BEV subsidies was more effective than BEV tax discounts.

In Figures 1 and 2, we also present a graphical illustration of the average treatment effects per year of introduction of the rebate and the tax discount respectively, estimated with the methodology of Callaway and Sant'Anna (2021). Figure 1 shows large positive estimates for the years post rebate introduction, although not always significant, and generally not significant effect pre-introduction, except two years. Figure 2 shows that the estimates post-introduction of the BEV discount are small and generally not statistically significant, consistently with the aggregate average treatment effects shown in Table 6.

One could be concerned that municipalities in treated and untreated cantons are not directly comparable due to unobservable time-varying characteristics linked to the introduction of the incentives and the diffusion of BEV. To address this issue, we repeat the analysis in Table 5 using only observation from municipalities at the border between a treated and an untreated canton connected by a road network and with the same language. The assumption is that these municipalities are more likely to have similar unobserved characteristics than other municipalities, thus reducing the risk of bias from omitted variables correlated to the introduction of the incentives. Results from table 7 still show a positive and significant effect from the rebate, while a minor or not significant impact from the tax credit. Of course, we should remember that the number of observations is limited.

[5] This methodological approach can be applied to the analysis of one policy measure. Therefore, we run the estimator separately for the BEV rebate and the BEV tax discount, including the other policies as dummy variables. For the cantons of Basel-Stadt, Neuchâtel, and Freiburg, where the tax discount was dismissed and, in some cases, introduced again, we consider only the second introduction and we drop the years of the first introduction. We do not run the estimator for the discount applicable for both hybrids and BEV because we only observe dismissals of the measure in the periods considered.

Table 6: Average Treatment effect on the Treated

	2014-2021	2010-2021
	(1)	(2)
	Panel A: rebate BEV	
	0.018^{***}	0.016^{**}
	(0.007)	(0.007)
N	15451	24481
	Panel B: tax discount BEV	
	0.008	0.007^{**}
	(0.009)	(0.003)
N	7613	17371

Notes: ATT estimates from the Callaway and Sant'Anna (2021) estimator. The rebate and tax discount coefficients come from two different regressions. The dependent variable is the share of new BEVs. Standard errors in parenthesis, clustered at the municipality level.

Table 7: Regression results for Equation 1, only border municipalities

	2014-2021			2010-2021		
	(1)	(2)	(3)	(4)	(5)	(6)
tax discount HEV+BEV				-0.003	-0.012^{***}	-0.012^{***}
				(0.002)	(0.004)	(0.004)
tax discount BEV	0.004	-0.021^{***}	-0.008	0.000	-0.000	-0.000
	(0.004)	(0.004)	(0.028)	(0.002)	(0.002)	(0.002)
rebate BEV	0.038^{***}	0.038^{***}	0.039^{***}	0.036^{***}	0.039^{***}	0.038^{***}
	(0.009)	(0.009)	(0.010)	(0.008)	(0.008)	(0.008)
N	937	937	937	3899	3899	3899
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Canton FE	No	Yes	No	No	Yes	No
Municipality FE	No	No	Yes	No	No	Yes

Notes: Regression results from Equation 1. The dependent variable is the share of new BEVs per municipality. Only border municipalities at the border are considered. In columns 1-3 we consider the period 2014-2021, including the PV/building regressor; in columns 3-6 we consider the period 2010-2021, excluding the PV/building regressor. In the 2014-2021 period, there was no variation in the HEV+BEV tax discount. Standard errors in parenthesis, clustered at the municipality level.

Figure 1: BEV purchase rebate, effect on BEV share by year

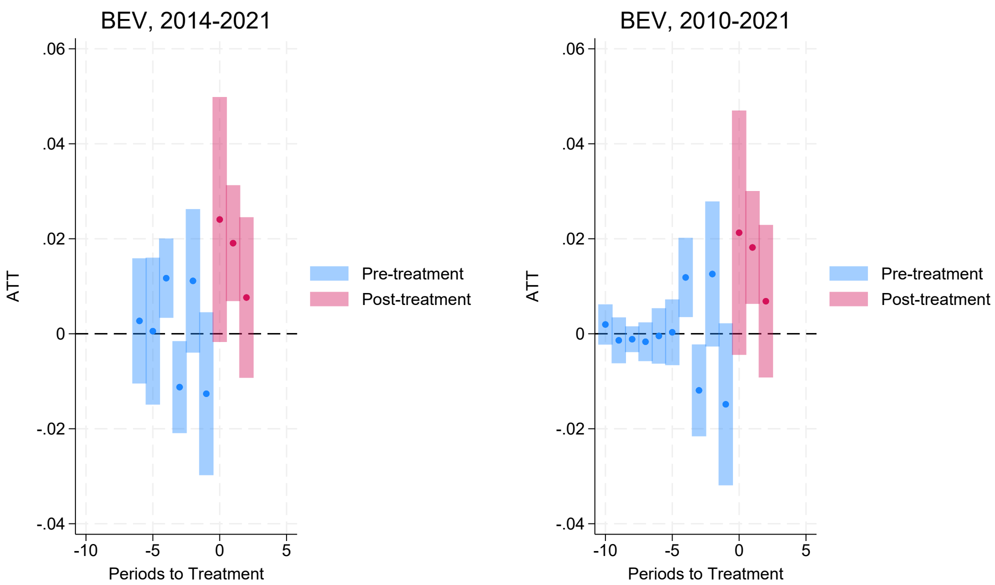
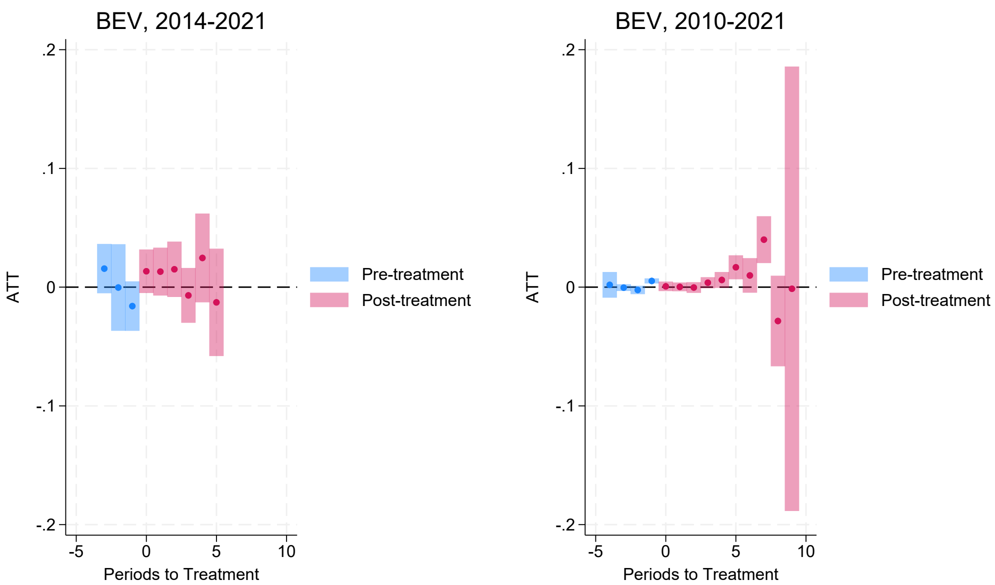


Figure 2: BEV tax discount, effect on BEV share by year



5.2 Results for effect size

So far, we have analyzed the effect of rebates and tax discounts by using dummy variables and exploiting only the variation in the adoption of the incentives over time and across cantons. However, even among cantons that adopted tax discounts and rebates, the size of the incentives varies significantly. In particular, in the case of tax discount, the actual amount saved depends on three factors: first, the percentage amount of the discount; second, the baseline tax; and third, the characteristics of the BEV vehicle.

To consider these factors, we use the database of newly registered vehicles in Switzerland to calculate and compare the incentive amount. For rebates, we use the maximum admissible incentive per vehicle. For tax discounts, we calculate for each car the average difference between the baseline tax discount and the effective tax, ignoring other bonuses and maluses based on energy labels or carbon emissions. Then, we assume a time horizon of 10 years and a 3% discount rate to calculate the expected discount's net present value, assuming no future policy change. Finally, we calculate both the unweighted average discount, based on the types of BEV available in the market in a given year, and the average discount weighted by the sales of a given vehicle model in each canton in a given year. In this case, the variation comes not only from the introduction of the discount but also from changes in the size or calculation method of the discount and the types of BEVs on sale.

In Tables 8 and 9, we present the results of the effect size both using the total sample and using only municipalities at the cantonal borders. The point estimates show that, for each 1000 CHF in tax discounts, the increase in BEV registration is between 0 and 0.3 percentage points, depending on the specification, while for each 1000 CHF in purchase rebates, we observe an increase in BEV registration of 0.6 percentage points and 1.4 percentage point in the entire sample and the border municipality sample respectively. To check the robustness of the assumptions used to calculate the amount of the tax discount for the vehicle lifetime, in Appendix A we present the results with the same model used in Table 8, but using different assumption for vehicle lifetime and discount rate. The results are remarkably similar to those obtained in Table 8.

Table 8: Regression results for Equation 1, incentive size

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.001**	0.001***	0.001	0.000***
	(0.001)	(0.000)	(0.001)	(0.000)
rebate (1000 CHF)	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
N	15462	24876	15462	24828

Notes: Regression results from Equation 1. Dependent variable is the share of new BEV per municipality. The amount for the tax credit is calculated considering 10 years of vehicle lifetime and a 3% discount rate. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

Table 9: Regression results for Equation 1, incentive size, border municipalities

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.003*	0.003**	0.002	0.001
	(0.002)	(0.001)	(0.002)	(0.001)
rebate (1000 CHF)	0.013***	0.014***	0.013***	0.014***
	(0.003)	(0.003)	(0.003)	(0.003)
N	1353	2072	1353	2060

Notes: Regression results from Equation 1. Dependent variable is the share of new BEV per municipality. Only border municipalities are considered. The amount for the tax credit is calculated considering 10 years of vehicle lifetime and a 3% discount rate. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

5.3 Effect of solar PV on the adoption of BV

In Table 10, we show the results for Equation 1 estimated using a fixed effects model (Column 1-3) and a fixed effects model combined with an instrumental variable approach using the 5-year moving average of solar radiation per municipality. In this case, we are interested in estimating the impact of the presence of solar PV on the adoption of electric BEV using data from 2014 to 2021. In the model specification, we utilize as a variable of interest the total number of solar PV divided by the number of buildings (Panel A) or the whole solar PV capacity divided by the number of edifices (Panel B).

We find a positive impact in terms of the effect of the number of solar PVs per building. Still, in most cases, it is not statistically significant when using only one of the baseline fixed effect models. The coefficient under the instrumental variable estimation is instead larger in magnitude and statistically significant, suggesting that adding one solar PV every 100 buildings would increase the share of new BEV by 0.76 percentage points and that installing 10 kW of additional capacity every 100 buildings would increase the share of new plug-in vehicles by 0.57 percentage points.

In Table 11, we show the first stage results for the instrumental variable estimation in Equations 1. Results suggest a positive and significant effect of the 5-year moving average of solar radiation on the total number and total capacity of solar PV per building. Importantly, in all equations the F-statistics of weak instruments test reject the null hypothesis of weak instruments.

Table 10: Regression results for Equation 1, effect of solar PV stock

Panel A: Number of solar PV per building

	FE	FE	FE	FE-IV
	(1)	(2)	(3)	(4)
PV/building	0.054	0.069	0.056	0.763***
	(0.043)	(0.045)	(0.080)	(0.250)
N	15462	15462	15462	15460
p-value F-test				0.0000

Panel B: Solar PV capacity per building

	FE	FE	FE	FE-IV
	(1)	(2)	(3)	(4)
kW/building	0.001*	0.002**	0.000	0.057***
	(0.001)	(0.001)	(0.002)	(0.020)
N	15462	15462	15462	15460
p-value F-test				0.0000
Year FE	Yes	Yes	Yes	Yes
Canton FE	No	Yes	No	No
Municipality FE	No	No	Yes	Yes
Municipality controls	Yes	Yes	Yes	Yes

Notes: Regression results from Equation 1. Dependent variable is the share of new BEV. Instrumental variable estimates are shown in column (4). Standard errors in parenthesis, clustered at the municipality level.

Table 11: First stage regressions for IV estimates

	PV stock	kW stock
	(1)	(2)
Solar MA-5	0.003***	0.044***
	(0.000)	(0.007)
F-Test stat	129.37	35.27
p-value	0.0000	0.0000

Notes: First stage regression results for instrumental variable estimation. Dependent variables: (1) Ratio of number of solar PV over total number of buildings; (2) Ratio of total PV capacity over total number of buildings. Solar MA-5 is the 5-year moving average for solar radiation; F-statistics and p-values for weak instrument tests are reported. Standard errors in parenthesis, clustered at the municipality level.

6 Calculation of costs of incentives

Both circulation tax discounts and rebates present a free-riding problem: all buyers of a BEV are entitled to the incentives, including those who would have bought a car even in their absence. Thus, similarly to other papers on this topic, in this section, we present an exploratory back-on-the-envelope calculation on the total incentive cost to increase newly purchased BEV by one and to reduce vehicle lifetime CO_2 emissions by one tonne. We want to simulate in a simple and straightforward way the costs for a representative municipality to increase by one unit the number of newly registered BEVs through either a purchase subsidy or a tax discount in 2021.

The representative municipality in our sample in 2021 had about 108 newly registered cars, of which about 14.27% are BEVs. Using the regression results obtained from column 2 of Table 8, the introduction of an upfront purchase subsidy of approximately 1500 CHF would increase in this representative municipality the number of newly registered BEVs by 1 unit, with the total number going from about 15 to 16 units. From a financial point of view, in this municipality the corresponding cost of increasing the number of new registered BEVs by one unit would be 24,000 CHF. This number is obtained by dividing the total cost of the subsidy given to all new BEVs by the number of additional BEVs determined by the policy. These calculations, referred to the year 2021, are reported in Table 12. The very high value is due to the fact that the upfront subsidy would also be paid to consumers who would have bought a BEV anyway.

Furthermore, the empirical results can be also used to analyze the average cost per ton of CO_2 saved. For this purpose, we assume a 10,000 km driven per year and a vehicle lifetime of 10 years. We also consider that an additional BEV would save the amount of CO_2 generated by the average new car. The cost for reducing 1 ton of CO_2 using a 1,500 CHF rebate in 2021 is thus approximately 1,800 CHF (total cost divided by overall ton of CO_2 saved), which is exceptionally high. The parameters and results of this simple calculation are illustrated in

Table 12.

We perform a similar analysis for the introduction of a yearly 925 CHF circulation tax discount per 10 years in Table 12. Introducing such a discount would increase the number of newly registered BEVs by approximately 1 unit, with the total number going from 15 to 16 units. Also in this case, the cost per additional BEV (148,000 CHF) and per ton of CO_2 saved (11,384 CHF) are exceptionally high. To note, that such high values are due to the high market penetration of BEVs in recent years (14% of new cars). The same rough calculations starting from a situation with a very low baseline share of new BEVs will provide much lower costs. Therefore, these monetary incentives can be useful to promote the purchase of BEVs at the very initial phase of market adoption, but not afterward.

While the exact amount can change depending on the econometric specification and the assumptions on the discount, these numbers are pretty similar to those found in the previous literature on the effectiveness of incentives for plug-in electric vehicles, see Sheldon (2022), and indicate that the presence of free-riders makes these policies very costly, except contexts with very low BEV penetration.

Table 12: Back on the envelope calculation of costs for 2021

	Rebate	**Tax discount**
Avg. total cars per municipality	108	108
Avg. BEV share per municipality	14%	14%
Overall subsidy per car	1500	9250
BEV increase	1	1
Estimated avg. BEVs (baseline)	15	15
Estimated avg. BEV with rebate	16	16
Avg. rebate total cost (CHF)	24,000	148,000
Avg. cost per additional BEV (CHF)	24,000	148,000
Avg. CO_2 g/km new cars	130	130
Avg. km/year	10,000	10,000
Car lifetime (years)	10	10
Avg. tonnes CO_2 per car	13	13
Avg. cost per tonne CO_2 saved (CHF)	1,800	11,384

7 Conclusion

We study the causal effect of tax discounts, purchase subsidies, and the stock of solar PV on the diffusion of battery electric vehicles (BEV). We first find that a purchase rebate increases the market share of BEV by 1.0 percentage points and by 1.6 percentage points by considering the corrected Callaway and Sant'Anna (2021) estimates. A circulation tax credit on BEV also has a positive effect, albeit smaller, of 0.4 percentage points, and by 0.7 percentage points by considering the corrected Callaway and Sant'Anna (2021) estimates. When considering the impact of the size of the incentive, we find that 1000 CHF of purchase subsidy brings a 0.6 percentage point increase in the market share of new BEV, while 1000 CHF tax credit increases the market share by 0.1 percentage points or less. Thus, the effect of one CHF spent on purchase rebates is approximately equivalent to 6 CHF spent on tax discounts. These results are reinforced when comparing only municipalities at the border of cantons with different treatment statuses; we find larger increases in BEV share from the purchase subsidy.

Our results support the hypothesis that purchase subsidies are more effective than tax subsidies in promoting BEVs. A possible reason is that consumers are poorly aware of the tax discount for BEVs. This explanation is supported by Cerruti et al. (2023), who show that only a minority of Swiss consumers is correctly informed about the existence of these types of tax discount. However, our explorative back-on-the-envelope calculations suggest that both measures are a very expensive way to promote the adoption of BEVs and reduce carbon emissions due to the presence of individuals who receive the incentive but would have bought a BEV regardless. Therefore, policymakers should rethink the policies to promote the adoption of BEVs, with the exception of the very early stage of BEV market adoption.

In the second part of the paper, using an instrumental variable approach, we find that the stock of solar panels has a positive effect on the diffusion of BEVs, suggesting potential spillover effects for government policies aiming to increase the adoption of rooftop solar PV for residential buildings. Our results look in part similar to the findings in the United States by Lyu (2022), who, similarly to us, finds a positive effect of solar PV on the diffusion of plug-in vehicles.

References

ACEA (2023). Tax benefits and purchase incentives. https://www.acea.auto/files/Electric_cars-Tax_benefits___purchase_incentives_2023.pdf.

Callaway, B. and P. H. Sant'Anna (2021). Difference-in-differences with multiple time periods. *Journal of econometrics 225*(2), 200–230.

Cerruti, D., C. Daminato, and M. Filippini (2023). The impact of policy awareness: Evidence from vehicle choices response to fiscal incentives. *Journal of Public Economics 226*, 104973.

Clinton, B. C. and D. C. Steinberg (2019). Providing the spark: Impact of financial incentives on battery electric vehicle adoption. *Journal of Environmental Economics and Management 98*, 102255.

Coffman, M., P. Bernstein, and S. Wee (2017). Integrating electric vehicles and residential solar pv. *Transport Policy 53*, 30–38.

De Chaisemartin, C. and X. d'Haultfoeuille (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review 110*(9), 2964–2996.

Kaufmann, R., D. Newberry, C. Xin, S. Gopal, et al. (2021). Feedbacks among electric vehicle adoption, charging, and the cost and installation of rooftop solar photovoltaics. *Nature Energy 6*(2), 143–149.

Lamp, S. (2023). Sunspots that matter: the effect of weather on solar technology adoption. *Environmental and Resource Economics 84*(4), 1179–1219.

Liang, J., Y. L. Qiu, and B. Xing (2022). Impacts of the co-adoption of electric vehicles and solar panel systems: Empirical evidence of changes in electricity demand and consumer behaviors from household smart meter data. *Energy Economics 112*, 106170.

Lyu, X. (2022). Are electric cars and solar panels complements? *Journal of the Association of Environmental and Resource Economists*.

Martin, H., R. Buffat, D. Bucher, J. Hamper, and M. Raubal (2022). Using rooftop photovoltaic generation to cover individual electric vehicle demand—a detailed case study. *Renewable and Sustainable Energy Reviews 157*, 111969.

Morrison, W. and D. Taubinsky (2023). Rules of thumb and attention elasticities: Evidence from under-and overreaction to taxes. *Review of Economics and Statistics 105*(5), 1110–1127.

Muehlegger, E. and D. S. Rapson (2022). Subsidizing low-and middle-income adoption of electric vehicles: Quasi-experimental evidence from california. *Journal of Public Economics 216*, 104752.

Münzel, C., P. Plötz, F. Sprei, and T. Gnann (2019). How large is the effect of financial incentives on electric vehicle sales?–a global review and european analysis. *Energy Economics 84*, 104493.

Sexton, S. (2015). Automatic bill payment and salience effects: Evidence from electricity consumption. *Review of Economics and Statistics 97*(2), 229–241.

Sheldon, T. L. (2022). Evaluating electric vehicle policy effectiveness and equity. *Annual Review of Resource Economics 14*, 669–688.

Springel, K. (2021). Network externality and subsidy structure in two-sided markets: Evidence from electric vehicle incentives. *American Economic Journal: Economic Policy 13*(4), 393–432.

Sun, L. and S. Abraham (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics 225*(2), 175–199.

Taubinsky, D. and A. Rees-Jones (2018). Attention variation and welfare: theory and evidence from a tax salience experiment. *The Review of Economic Studies 85*(4), 2462–2496.

Wee, S., M. Coffman, and S. La Croix (2018). Do electric vehicle incentives matter? evidence from the 50 us states. *Research Policy 47*(9), 1601–1610.

A Effect size specifications

Table 1: Regression results for incentive size, 7 years lifetime, 3% discount

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.002**	0.001***	0.001	0.001**
	(0.001)	(0.000)	(0.001)	(0.000)
rebate (1000 CHF)	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
N	15462	24876	15462	24876

Notes: Regression results from Equation 1. The amount for the tax credit is calculated considering 7 years of vehicle lifetime and a 3% discount rate. The dependent variable is the share of new BEVs per municipality. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

Table 2: Regression results for incentive size, 10 years lifetime, 1% discount

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.001**	0.001***	0.001	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
rebate (1000 CHF)	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
N	15462	24876	15462	24876

Notes: Regression results from Equation 1. The amount for the tax credit is calculated considering 10 years of vehicle lifetime and a 1% discount rate. The dependent variable is the share of new BEVs per municipality. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

Table 3: Regression results for incentive size, 7 years lifetime, 1% discount

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.001**	0.001***	0.001	0.001**
	(0.001)	(0.000)	(0.001)	(0.000)
rebate (1000 CHF)	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
N	15462	24876	15462	24876

Notes: Regression results from Equation 1. The amount for the tax credit is calculated considering 7 years of vehicle lifetime and a 1% discount rate. The dependent variable is the share of new BEVs per municipality. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

Table 4: Regression results for incentive size, 10 years lifetime, 5% discount

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.001**	0.001***	0.001	0.001**
	(0.001)	(0.000)	(0.001)	(0.000)
rebate (1000 CHF)	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
N	15462	24876	15462	24876

Notes: Regression results from Equation 1. The amount for the tax credit is calculated considering 10 years of vehicle lifetime and a 5% discount rate. The dependent variable is the share of new BEVs per municipality. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

Table 5: Regression results for incentive size, 7 years lifetime, 5% discount

	Unweighted		Weighted	
	2014-2021	2010-2021	2014-2021	2010-2021
	(1)	(2)	(3)	(4)
tax credit (1000 CHF)	0.002**	0.001***	0.001	0.001**
	(0.001)	(0.000)	(0.001)	(0.000)
rebate (1000 CHF)	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
N	15462	24876	15462	24876

Notes: Regression results from Equation 1. The amount for the tax credit is calculated considering 7 years of vehicle lifetime and a 5% discount rate. The dependent variable is the share of new BEVs per municipality. In columns 1-2, we used the unweighted average of the discount and the rebate; in columns 3-4, we considered the average of the discount and the rebate weighted by registrations in each canton. Standard errors in parenthesis, clustered at the municipality level.

Working Papers of the Center of Economic Research at ETH Zurich

(PDF-files of the Working Papers can be downloaded at www.cer.ethz.ch/research/working-papers.html).

23/388 D. Cerruti, M. Filippini, J. Savelsberg
Adoption of Battery Electric Vehicles: the Role of Government Incentives and Solar PV

23/387 G. Casey, W. Jeon, C. Traeger
The Macroeconomics of Clean Energy Subsidies

23/386 L. Bretschger, E. Komarov, M. Leuthard
Overcoming the Carbon Trap: Climate Policy and Technology Tipping

23/385 M. Alsina-Pujols, I. Hovdahl
Patent Protection and the Transition to Clean Technology

23/384 L. Bretschger, E. Komarov
All Inclusive Climate Policy in a Growing Economy: The Role of Human Health

23/383 D. Bounie, A. Dubus, P. Waelbroeck
Competition Between Strategic Data Intermediaries with Implications for Merger Policy

23/382 J. Lehtomaa, C. Renoir
The Economic Impact of Tropical Cyclones: Case Studies in General Equilibrium

23/381 S. Srinivasan
Social Policies and Adaptation to Extreme Weather: Evidence from South Africa

23/380 L. Barrage
Fiscal Costs of Climate Change in the United States

23/379 S. Bansal, M. Filippini, S. Srinivasan
How Regulation Might Fail to Reduce Energy Consumption While Still Stimulating Total Factor Productivity Growth

22/378 A. Jo, C. Karydas
Firm Heterogeneity, Industry Dynamics and Climate Policy

22/377 V. da Cruz
Cap-and-Innovate: Evidence of regulation-induced innovation in California

22/376 G. Loumeau
Land Consolidation Reforms: A Natural Experiment on the Economic and Political Effects of Agricultural Mechanization

22/375 L. Bretschger
Green Road is Open: Economic Pathway with a Carbon Price Escalator

22/374 A. Goussebaïle
Democratic Climate Policies with Overlapping Generations

22/373 H. Gersbach, O. Tejada, J. Wagner
Policy Reforms and the Amount of Checks & Balances

22/372 S. Houde, W. Wang
The Incidence of the U.S.-China Solar Trade War

22/371 J. A. Bingler
Expect the worst, hope for the best: The valuation of climate risks and opportunities in sovereign bonds

22/370 A. Bommier, A. Fabre, A. GoussebaÃ¯le, and D. Heyen
Disagreement Aversion

22/369 A. Jo, A. Miftakhova
How Constant is Constant Elasticity of Substitution? Endogenous Substitution between Clean and Dirty Energy

22/368 N. Boogen, M. Filippini, A. L. Martinez-Cruz
Value of co-benefits from energy saving ventilation systems–Contingent valuations on Swiss home owners

22/367 D. Bounie, A. Dubus, P. Waelbroeck
Market for Information and Selling Mechanisms

22/366 N. Kumar, N. Kumar Raut, S. Srinivasan
Herd behavior in the choice of motorcycles: Evidence from Nepal

21/365 E. Komarov
Capital Flows and Endogenous Growth

21/364 L. Bretschger, A. Jo
Complementarity between labor and energy: A firm-level analysis

21/363 J. A. Bingler, C. Colesanti Senni, P. Monnin
Climate Transition Risk Metrics: Understanding Convergence and Divergence across Firms and Providers

21/362 S. Rausch, H. Yonezawa
Green Technology Policies versus Carbon Pricing: An Intergenerational Perspective

21/361 F. Landis, G. Fredriksson, S. Rausch
Between- and Within-Country Distributional Impacts from Harmonizing Carbon Prices in the EU

21/360 O. Kalsbach, S. Rausch
Pricing Carbon in a Multi-Sector Economy with Social Discounting

21/359 S. Houde, T. Wekhof
The Narrative of the Energy Efficiency Gap

21/358 F. Böser, H. Gersbach
Leverage Constraints and Bank Monitoring: Bank Regulation versus Monetary Policy

21/357 F. Böser
Monetary Policy under Subjective Beliefs of Banks: Optimal Central Bank Collateral Requirements

21/356 D. Cerruti, M. Filippini
Speed limits and vehicle accidents in built-up areas: The impact of 30 km/h zones

21/355 A. Miftakhova, C. Renoir
Economic Growth and Equity in Anticipation of Climate Policy

21/354 F. Böser, C. Colesanti Senni
CAROs: Climate Risk-Adjusted Refinancing Operations

21/353 M. Filippini, N. Kumar, S. Srinivasan
Behavioral Anomalies and Fuel Efficiency: Evidence from Motorcycles in Nepal

21/352 V. Angst, C. Colesanti Senni, M. Maibach, M. Peter, N. Reidt, R. van Nieuwkoop
Economic impacts of decarbonizing the Swiss passenger transport sector

21/351 N. Reidt
Climate Policies and Labor Markets in Developing Countries

21/350 V. Britz, H. Gersbach
Pendular Voting

21/349 E. Grieg
Public opinion and special interests in American environmental politics