# Pass-through of Electric Vehicle Subsidies: a Global Analysis

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In recent years, governments around the world have put in place numerous policies to promote the transition from gasoline-powered cars to electric or hybrid vehicles. These measures, meant to reduce carbon emissions and mitigate the consequences of climate change, involve both financial incentives such as subsidies, tax credits and exemptions, as well as non-monetary incentives. According to the International Energy Agency (2021), governments worldwide spent USD 14 billion on direct purchase incentives and tax deductions for electric vehicles (EV hereafter) in 2020, accounting for 10% of total EV spending. While this percentage is lower than the 22% recorded in 2015, it still constitutes a significant portion of global spending. Based on the research of Li et al. (2022), government support has increased global EV sales by about 40%, which can be expected considering that electric vehicles' demand price elasticities are estimated to be around 3 (Gillingham, van Benthem and Weber, 2023). Such large-scale financial subsidies that are global in scope provide a valuable chance to examine the pass-through of subsidies to the final consumers and the extent to which automobile manufacturers benefit. Additionally, they offer a rare opportunity to analyze the pricing decisions of car manufacturers in response to a major shock to the industry.

In this paper, we analyze data from thirteen countries responsible for 95% of global EV sales from 2013 to 2020 to study the pass-through of government subsidies. We find pass-through rates of between 70-80%, consistent with existing studies that exploit data from the automobile sector in individual countries. We additionally observe that the pass-through is higher for firms that sell to global markets, such as Tesla and Volkswagen, and lower for those catering to a specific region, such as BYD. This could be due to the former set of companies being more cognizant of global reference pricing and the possibility of third-party arbitrage, which makes them less likely to adjust prices in response to local (country-level) shocks. Lastly, we find suggestive evidence that the pass-through rate is higher for tax incentives than for direct consumer subsidies.

## I. Literature Review

There is a large literature evaluating the pass-through rate of energy subsidies in a variety of contexts. Ganapati, Shapiro and Walker (2020) used U.S. manufacturing census data to estimate the pass-through of energy input cost changes to consumers, finding an average rate of 70%. Lade and Bushnell (2019) estimated the pass-through rate of the Renewable Fuel Standard (RFS) ethanol subsidies at between half and three-quarters. Pless and van Benthem (2019) estimated pass-through of solar subsidies in California, finding a rate of 78 cents per dollar for buyers of solar systems and $1.53 per dollar for lessees of solar systems (over-shifting).

Research examining the pass-through of hybrid and electric vehicle subsidies has found that, in many cases, the rate of pass-through for EV subsidies is close to one. Sallee (2011) found that tax incentives for Toyota Prius in California were fully captured by consumers. Gulati, McAusland and Sallee (2017) determined that the majority of hybrid electric vehicle subsidies in Canada were passed on to con-

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sumers once product quality was accounted for. Muehlegger and Rapson (2018) studied the Enhanced Fleet Modernization Program in California and concluded that the hypothesis of complete pass-through could not be rejected. Fournel (2022) reported an average pass-through rate of 98% for EV subsidies in Quebec, Canada. We contribute to this literature by investigating the pass-through of EV subsidies globally over nearly a decade. Our analysis highlights an important channel through which the global market structure can play a role in explaining the different pass-thorugh rates across different countries.

## II. Data

The paper exploits a global database on the electric vehicle market between 2013 and 2020, which includes data on EV sales, vehicle attributes, charging infrastructure, government policies, and demographic and socioeconomic variables for thirteen countries that account for 95% of global sales: Austria, Canada, China, France, Germany, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the U.K., and the U.S.. Our primary data sources include EV sales from the EV-volumes' database and financial and non-financial incentives collected by one of the coauthors.

For consistency across countries, we only consider central/ federal EV incentives. Financial incentives are collected at the country, year, and model level and include direct consumer subsidies, acquisition/ownership tax credits, income tax credits, exemption of sales taxes, and other central/federal EV incentives. For European countries, the incentives are primarily sourced from the European Automobile Manufacturers' Association's (ACEA) guide on purchase and tax incentives for electric vehicles. For China, Japan, Canada, and the U.S., the incentives are hand collected. The non-financial incentives include green plates, reduced parking fees and subsidized charging, and access to HOV lanes, which are the most widely utilized means to encourage EV adoption. This data source is identical to the one used in Li et al. (2022) and constitutes, to our knowledge, the most comprehensive data set available on the global EV market. Further information about the data construction can be found in that paper.

In our empirical analysis, we use manufacturer-suggested retail prices (MSRP), which are consistently reported across all countries. MSRP is the industry standard for price comparison across vehicle models and is often the only price featured in commercials. A benefit of MSRP is that it is determined by the manufacturers and is not affected by negotiations between buyers and dealers. This enables us to accurately assess how manufacturers alter their prices in response to government subsidies. On the other hand, to gain a more comprehensive understanding of pass-through, we would need transaction prices, which include trade-ins, features and options, and discounts and promotions from manufacturers and dealers. Unfortunately, we are unaware of any systematic databases that provide this information across multiple countries. As a result, the pass-through measure we report only accounts for pass-through by the manufacturers and excludes pass-through occurring through the distribution channel.[1]

## III. Descriptive Analysis

The EV price distribution is skewed, with the recorded maximum price at $1.14 million. We drop a handful of vehicle models above $210,000 (for a total of 43 observations). Table 1 reports the summary statistics for variables in our analysis. The average EV in our regression sample cost $61,880 and received a financial incentive of $3,214. Both consumer subsidies and tax incentives are widely used, with the former averaging $1,406 and the latter averaging $1,810.

One might be concerned that the find-

[1]MSRP excludes temporary discounts and promotions offered by manufacturers. While we lack systematic data to fully explore the matter, our research suggests that many of these discounts are seasonal in nature, such as year-end promotions, and do not appear to correlate with government policies.

ing of high pass-through rates in the automobile sector is because automobile firms do not change prices for existing vehicle models. There is ample evidence to the contrary. For instance, many EV producers lowered prices in the U.K. for the 2022 calendar year when the U.K. Department of Transportation reduced the EV subsidy from £2,500 to £1,500 and capped the price of eligible models to £32,000.[2] In our sample, the within country-model standard deviation of vehicle prices was $4,769 and the between country-model standard deviation was $36,072. While the within variation is much smaller than the between variation, it is non-negligible.

There is wide dispersion in financial support offered by central government as shown in Figure 1. Norway offers the most generous EV purchase incentives across the world with an average of $8,000 per vehicle, followed by the U.S. with an average of $6,000. The average EV purchase incentives in other countries range from $500 to $4,000.

## IV. Regression Analysis

In line with prior studies on pass-through, we conduct a regression analysis of post-subsidy EV prices on EV subsidies, controlling for country-model fixed effects, year fixed effects, and observable characteristics:

$$Price_{jct} = \lambda Incentive_{jct} + X_{jct}\beta + \delta_{jc} + \delta_t + \varepsilon_{jct} \tag{1}$$

where $jct$ denotes EV model $j$ in country $c$ and year $t$. $Incentive_{jct}$ is the financial support from the central government and $X$ is a vector of vehicle and battery characteristics, namely the battery capacity, vehicle size and horsepower, and whether vehicle $j$ is eligible for non-financial incentives (such as the green-plate policy and access to HOV lanes, etc.). While driving range is an important EV attribute, it is largely a function of battery capacity and vehicle size.[3] When battery capacity and vehicle size are taken into account, the driving range coefficient is mostly insignificant and has little impact on the pass-through estimates. $X$ also includes country-level observables: the number of charging stations (in logarithms) and per-capita income in country $c$ at time $t$. Due to the significant price variation reported above, we include country-model fixed effects $\delta_{jc}$ in all of our regressions. This allows us to identify pass-through from time-series variation – changes in subsidies and vehicle prices within the same country-model combinations. As a result, we report the within $R^2$.[4] We also include year fixed effects $\delta_t$. Standard errors are clustered by country-model.

Table 2 reports the results. Column 1 only controls for country-model fixed effects and year fixed effects. Column 2 add vehicle attributes. Column 3 and 4 further include country-level per-capita income and the size of the charging network. The pass-through rates remain fairly consistent across columns, ranging from 0.714 (Column 1) to 0.798 (Column 2). For each dollar of government financial support, consumers benefit on average 71 to 80 cents, consistent with the existing studies referenced previously.

Interestingly, the pass-through estimate without any vehicle attribute controls is similar to that with vehicle controls – we cannot reject the hypothesis that they are the same – despite the fact that the specification with vehicle attributes has a much better model fit with the within-$R^2$ three times higher (0.18) than column 1 (0.05). This suggests that the pass-through rates are not primarily driven by variations in model-specific pricing responses.[5]

Different from other automobile pass-through studies, we observe prices for the same model across multiple countries. On average, a vehicle model is sold in 7.8 countries. There is a lot of variation in the

[2]Source: https://insideevs.com/news/555047/uk-lowers-ev-subsidy/.

[3]The $R^2$ of driving range on battery capacity and vehicle size and the fixed effects is 0.966.

[4]The overall $R^2$ are all greater than 0.95, which is expected given that the majority of price variation is driven by differences across models and countries.

[5]Otherwise we would observe very different pass-through rates when we control for vehicle attributes. This observation helps alleviate the concern that discounts offered by manufacturers are not reflected in MSRP, which are mostly vehicle-model specific.

extent of global penetration across models, with the inter-quartile range varying from 3.5 countries to 11 countries. Tesla, for example, sells in all countries, whereas BYD and BAIC, two of the largest Chinese EV companies, mostly sell in China. This gives us a rare opportunity to examine how pass-through patterns depend on the global reach of vehicle manufacturers. A recent literature documents that national firms, such as large retail chains in the US, charge similar prices across local markets (DellaVigna and Gentzkow, 2019). If global EV manufacturers engage in uniform pricing (as we provide evidence for below), they may not adjust the MSRP in response to subsidy changes, resulting in a high pass-through rate.

To test this, we expand the baseline specification Equation (1) and interact the incentive variable with the global reach for model $j$:

$$Price_{jct} = \lambda_1 Incentive_{jct} + \lambda_2 Incentive_{jct} * Z_{jct} + X_{jct}\beta + \delta_{jc} + \delta_t + \varepsilon_{jct}$$

where $Z_{cjt}$ captures the extent of global reach for model $j$. We examine two sets of measures: the number of countries that sell model $j$ at time $t$, and dummy variables for whether model $j$ is sold in fewer than 4 countries, between 4 and 11 countries, and more than 11 countries.[6]

To conserve space, Table 3 only reports the key coefficients $\lambda$ using the most saturated specification (Column 4 in Table 2). The pass-through rate is 0.53 for products that are sold in one country,[7] but increases significantly by 0.037 percentage points with each additional country that sells product $j$ (Column 1). For the average model that is sold in 7.8 countries, the pass through estimate reaches 0.77, as reported in Table 2.

Column 2 reports pass-through rates separately for products that are sold in fewer than 4 countries, 4-11 countries, and 11+ countries. We cannot reject the complete pass-through hypothesis for products that are sold in more than 11 countries. In contrast, the pass-through rate for products sold in fewer than 4 countries is much lower at 0.54.

There are two potential explanations for the high pass-through rates for products sold in many countries. The first is 'uniform pricing', where firms prefer to use similar prices across markets and do not adjust prices to local shocks (DellaVigna and Gentzkow, 2019). Second, firms that operate in multiple countries may be worried about price comparison and arbitrage across countries, particularly when selling to EU countries. EU citizens are free to purchase and sell vehicles wherever they wish within the European Union and can transport and register them in their home country. This means that third-party arbitrage can limit firms' ability to set distinct prices in response to government support in different countries. To support these, we provide two pieces of evidence.

The first piece of evidence is that prices for the same model within the EU are relatively consistent. The inter-quartile range of observed prices for the same model is on average \$6,500 across European countries. Some of the price dispersion reflects differences in vehicle configurations and features across countries. The \$6,500 gap is consistent with the transportation costs of shipping vehicles across countries within the EU, as well as the hassle costs. In contrast, the inter-quartile range is much higher at \$11,000 across non-EU countries.[8] This constitutes evidence that the EU is a relatively integrated market and the ability of consumers to buy in any country limits firms' ability to charge different prices across countries, hence the high pass-through rates.

The second piece of evidence is that prices for identical models across countries tend to move together. We plot the distribution of the correlation between prices for the same model across pairs of countries and contrast it with the distribution of the cor-

[6]About 25% of observations are for models sold in less than 4 countries, and an additional 25% for models sold in more than 11 countries.

[7]Pass-through for products sold in one country is $\lambda_1 + \lambda_2$.

[8]The inter-quartile range for non-EU countries is \$9,600 when we exclude China.

relation of prices for pairs of similar models within the same countries.[9] As Figure 2 shows, the correlation coefficients for within-model pairs are higher than those for within-country pairs, despite widely different demand conditions and demographics across different countries. This data pattern, which is similar to that observed by DellaVigna and Gentzkow (2019) for US retail chains, is suggestive of uniform pricing.

Note that our estimate of an average 0.77 pass through rate is lower than the existing studies of the automobile sector in either Europe or the North America, which tend to find complete pass through. There are two potential explanations. First, our panel spans eight years and is significantly longer than other studies that focus on a relatively short period surrounding changes in government support. To the extent that automobile firms change prices infrequently (at the yearly level), a short panel might miss price adjustments that take time to materialize. Second, it appears that many EV models that are analyzed in the existing studies (e.g., Tesla) are sold in many countries in addition to the country of study. This is consistent with our finding that the pass-through rates are higher for products sold in multiple countries.

Next, we examine whether the pass-through rate differs between tax incentives (such as exemptions of sales tax or ownership tax) and direct consumer subsidies. We find that pass-through is nearly complete for tax incentives, with an average pass-through rate of 0.95. In contrast, the average pass-through is only 0.63 for consumer subsidies (Column 3 of Table 3). The results are similar if we also control for the effect of global reach (Column 4). One explanation for the high pass-through of tax incentives is that in the presence of search frictions, future consumers may base their purchase decisions on the current pre-tax EV price (Sallee, 2011). EV manufacturers might be unwilling to raise the MSRP for fear of hurting future demand, hence passing on the tax incentive to consumers.

[9]We construct the group of similar models by using models sold by other firms within the same segment.

Such considerations matter less for direct consumer subsidies, which are likely to be more visible to both current and future consumers. A limitation of this analysis is that we are not able to account for heterogeneity in how tax incentives or consumer subsidies are offered across different countries, which may matter for how salient they are to consumers.

## V. Conclusion

We study pass-through of EV subsidies across thirteen countries accounting for 95% of global EV sales between 2013 and 2020, extending the prior literature that focuses on individual jurisdictions. We find high pass-through rates, averaging 70-80 cents on the dollar. Pass-through is highest for global firms that sell the same EV models across multiple countries, consistent with uniform pricing by global firms, as well as the avoidance of third-party arbitrage (which may be particularly relevant for manufacturers selling in Europe). Pass-through rates also differ by subsidy type, with pass-through higher for tax incentives compared to the more salient consumer subsidies.

Our results have implications for the design of future EV subsidies. The pass-through and incidence of EV subsidies depend not just on country-specific conditions, but also on the global market structure. Paradoxically, a higher share of the benefits may be captured by consumers for EV models with a high global penetration. The incidence of EV subsidies also depends on how salient the subsidy is. We leave it to future analysis to examine how the EV manufacturers, as well as the upstream EV battery suppliers, benefit from government support. Contributing factors include direct sales expansion and cost reduction due to learning-by-doing, which are magnified when government support stimulates EV demand (Barwick et al., 2023).

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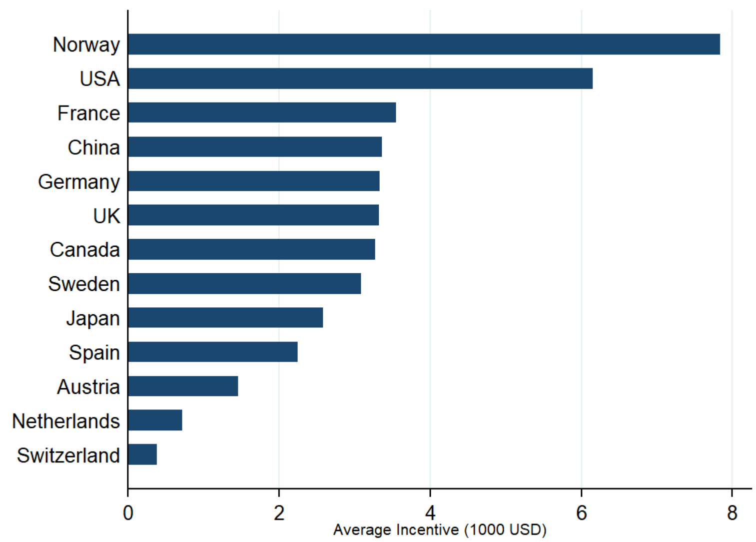


FIGURE 1. AVERAGE FINANCIAL INCENTIVE FROM CENTRAL GOVERNMENT 2013-2020

*Note:* This figure reports the average central government financial incentive per vehicle from 2013 to 2020 by country. Incentives offered by local governments (e.g., states, municipalities, provinces) are not included.

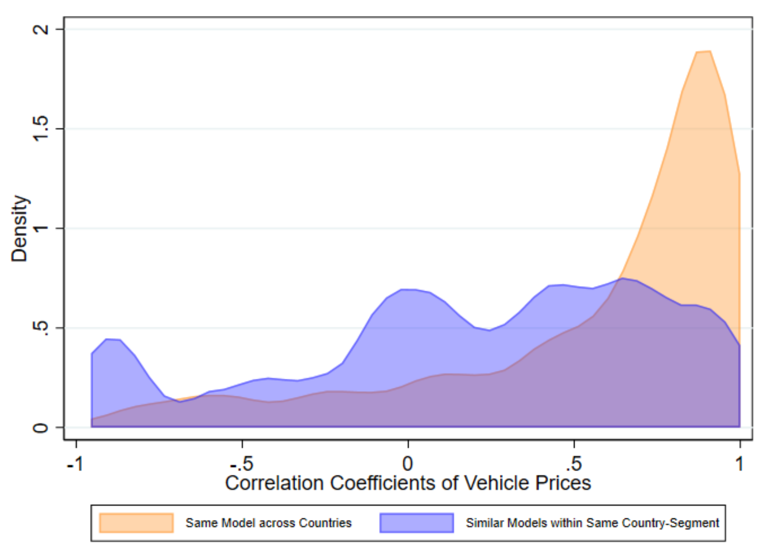


FIGURE 2. CORRELATION BETWEEN PRICES: WITHIN-MODEL VS. WITHIN-COUNTRY

*Notes:* The graph shows the kernel density for the distributions of pairwise price correlations. For each model that is sold in multiple countries with at least six years of observations, we calculate the price correlation coefficients for each country pair and report the distribution of these "within-model" correlations in the orange density plot. Similarly, we calculate the price correlation coefficients for pairs of similar models (in the same segment and sold in the same country but manufactured by different firms) and report the distribution of these "within-country" correlations in the blue density plot. Results are very similar for correlation coefficients of residualized prices that partial out country-model and year fixed effects.

Table 1—Summary Statistics

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| MSRP ($1000) | 4,768 | 61.88 | 37.85 | 4.81 | 208.37 |
| Incentive ($1000) | 4,768 | 3.21 | 3.62 | 0 | 56.32 |
| Consumer subsidy ($1000) | 4,768 | 1.41 | 2.23 | 0 | 9.76 |
| Tax incentive ($1000) | 4,768 | 1.81 | 3.64 | 0 | 56.32 |
| Battery capacity (kWh) | 4,768 | 25.82 | 21.43 | 4.4 | 100 |
| Size ($m^3$) | 4,768 | 12.67 | 2.53 | 6.26 | 26.71 |
| Engine horsepower | 4,768 | 195.42 | 97.78 | 11.83 | 625 |
| Non-financial incentives | 4,768 | 0.70 | 0.46 | 0 | 1 |

Table 2—Pass-through Rates: Baseline

| | Dependent variable: Post-Subsidy Price | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Incentive | -0.714*** | -0.798*** | -0.768*** | -0.772*** |
| | (0.112) | (0.088) | (0.090) | (0.086) |
| Battery capacity (kWh) | | -0.059* | -0.057* | -0.047 |
| | | (0.034) | (0.033) | (0.031) |
| Vehicle size ($m^3$) | | 2.473*** | 2.476*** | 2.639*** |
| | | (0.784) | (0.774) | (0.731) |
| Horsepower | | 0.111*** | 0.110*** | 0.110*** |
| | | (0.016) | (0.016) | (0.016) |
| Indicator of non-financial incentives | | -1.381** | -1.430** | -0.594 |
| | | (0.660) | (0.661) | (0.625) |
| Income | | | -0.134* | -0.031 |
| | | | (0.077) | (0.078) |
| Charging stations (log) | | | | -3.306*** |
| | | | | (0.699) |
| Country-by-Model FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| $R^2$, within | 0.05 | 0.18 | 0.18 | 0.20 |
| Observations | 4245 | 4245 | 4245 | 4245 |

*Notes:* Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3— Pass-through rates: global reach and incentive type

| | Dependent variable: Post-Subsidy Price | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Incentive | -0.492*** | | | |
| | (0.120) | | | |
| Consumer subsidy | | | -0.630*** | -0.392*** |
| | | | (0.120) | (0.132) |
| Tax incentive | | | -0.949*** | -0.650*** |
| | | | (0.118) | (0.161) |
| Incentive × No. of sales countries | -0.037*** | | | -0.035*** |
| | (0.011) | | | (0.011) |
| Incentive × Sold in less than 4 countries | | -0.541*** | | |
| | | (0.115) | | |
| Incentive × Sold in 4-11 countries | | -0.836*** | | |
| | | (0.086) | | |
| Incentive × Sold in over 11 countries | | -0.972*** | | |
| | | (0.134) | | |
| Fixed effects | Country-by-model and year fixed effects | | | |
| Vehicle characteristics | Battery capacity, size, horsepower | | | |
| Other Controls | Non-financial incentives, income, charging stations | | | |
| $R^2$, within | 0.21 | 0.22 | 0.20 | 0.21 |
| Observations | 4245 | 4245 | 4245 | 4245 |

*Note:* In column (1) and (4), we include an interaction between financial incentives and the number of countries where the model is sold (which varies from 1 to 13, with an average of 7.8 and an inter-quartile range of 3.5 to 11). In column (2), the effect of financial incentives differs by bins of the number of countries where a model is sold: $< 4$ countries, 4-11 countries, and 11+ countries. Columns (3) and (4) split financial incentives into consumer subsidies and tax incentives.

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