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Zusammenfassung / Abstract

In this study the impact of car scrappage schemes is reassessed and disentangled for six OECD countries, namely Japan, Germany, South Korea, the Slovak Republic, the United Kingdom and the United States, following a rather novel empirical approach, the Synthetic Control Method using Time Series (SCMT). Scrappage schemes were implemented in many countries in response to the Great Recession of 2007-2009 and were hotly debated among economists and policymakers, as many disagreed about the sustainability of the programs' effects. With the use of the synthesized control units constructed transparently with SCMT, the effects of car scrappage schemes on vehicle registrations can be observed and calculated over time. Results suggest that despite scrapping subsidies induced some intertemporal substitution, net effects on car registrations remained positive in all investigated countries with the notable exception of the United Kingdom, where additional sales were completely crowded out by subsequent consumer reticence.

Schlagworte / Keywords: synthetic control method, scrappage schemes, automotive industry, intertemporal substitution, SCMT, pull-forward effects
JEL-Klassifikation / JEL-Classification: L52, L62

1 Introduction

What started with climbing default rates in the US subprime market in 2007 evolved into a full-blown international banking crisis within the following year, climaxing in the iconic collapse of Lehman Brothers in September 2008. The crisis swiftly spilt over to the real economy, where it affected many sectors besides financial services and caused a severe recession in global economies, with the automobile industry suffering particularly.

In the immediate aftermath of Lehman Brothers' bankruptcy filing, between September 2008 and January 2009, automobile manufacturers all over the world faced a sharp decline in their sales. Portugal and Ireland were hit most by these developments, with a slump in car sales by up to 43%. Major economies like the US and Japan were affected less severely, but still saw a reduction in sales by 21% and 18%, respectively. Across all OECD countries, demand for automobiles sunk by more than one-fifth on average. (OECD, 2009)

Several countries, especially those with sizable domestic car industries, responded with stimulating measures in order to stabilize this important economic sector and prevent spill-over effects to labor markets. Car scrappage schemes, costing up to several billion dollars, were introduced in order to incentivize customers to buy new vehicles. The effectiveness of these programs was hotly debated back then and still is today, as the coronavirus pandemic has recently shown, when industry lobbyists and policymakers in Germany were again fiercely fighting over a rebirth of the country's 2009 scrappage scheme, intended to relaunch the economy after the sharp recession caused by the pandemic.

When assessing the impact of scrappage schemes, it is not sufficient to count only the number of cars that were subsidized and bought under the respective program. It is equally important to look at the net effect of the program, i.e. the additional sales incentivized by the program. Otherwise one tends to overestimate the impact due to unaccounted intertemporal substitution and windfall gains. In order to assess the net effect of a policy change, researchers need to construct a feasible counterfactual as benchmark. In this chapter we want to relook at the evidence from several countries' scrappage schemes, applying a more recent empirical method for policy evaluation: the so-called Synthetic Control Method using Time Series (SCMT). With this method, we can estimate the net effect of interest on a more solid foundation by constructing a counterfactual as a linear combination of similar countries without scrappage schemes. The Synthetic Control Method has several advantages over the difference-in-differences approach, which is often applied for policy evaluation studies: The similarity between the treated country and its control is maximized, the method can be applied even when there is no single control country which is sufficiently similar to the treated one, and selection of controls follows a formal, transparent and objective approach in contrast to a selection at the researcher's discretion.

For this study we choose a geographically and economically heterogenous set of OECD countries, namely Japan, Germany, South Korea, the Slovak Republic, the United Kingdom and the United States, which also differ in implementation, size and timing of their scrappage scheme. For almost all of the aforementioned countries, our results show a remarkable stimulating effect of the scrappage programs on demand in domestic car markets – resulting in a net effect of almost 100% additional sales for some countries in selected periods. With the notable exception of the United Kingdom, we also find that these additional sales are largely persistent over time, hinting at only minor intertemporal substitution among buyers.

2 Literature Review

Already before the financial crisis of 2008, scrapping subsidies were a well-known policy tool targeted at stimulating demand in order to stabilize economic growth. Hence the introduction and implementation of car scrappage schemes as a response to the economic downturn following the Lehman Brothers collapse was not an outright leap in the dark for policy makers. Adda and R. Cooper (2000) studied the effects of tax credits in France in the early 1990s for consumers who scrapped their old cars and replaced them with newly purchased ones. In order to evaluate the effects, they construct a dynamic stochastic discrete choice model, which explains car ownership at the household level. They conclude that despite a stimulative effect in the short run, the French tax credits reduced purchasing activity in the following through the induced changes in the cross sectional distribution of car ages.

Alberini, Harrington, and McConnell (1995) investigated determinants of participation in accelerated vehicle-retirement programs by constructing a theoretical model of consumers' individual scrappage decisions and evaluating probable determinants empirically using data from an accelerated vehicle-retirement scheme implemented in the state of Delaware in 1992. The respective theoretical models and empirical results show that scrappage programs bring forward the optimal replacement time for car owners and therefore are effective in stimulating demand in the short term.

As scrapping subsidies are often motivated by ecological reasons in addition to solely economic ones, there is a strand of literature which is predominantly concerned with the environmental impact of scrappage schemes.

Baltas and Xepapadeas (1999) show that a Greek program for accelerated vehicle replacement between 1991 and 1993 resulted in a rejuvenation of the country's passenger car fleet and a sharp decline in pollutant concentrations. Hahn (1995) drafts a model design for a cash for clunkers program as it was envisioned by US President George Bus in 1992, when certain cities like Los Angeles were struggling to achieve compliance with federal pollution-control regulations. He concludes that a well-designed program is a cost-effective way to reduce emissions in urban areas.

The car scrappage schemes that were implemented in a number of developed countries in response to the economic downturn in 2008 and following inspired new academic interest in the understanding of such policies, i.a. because the magnitude of the scrappage subsidies paid out was unprecedented.Mian and Sufi (2012) were among the first to investigate the effects of the 2009 Cars Allowance Rebate System (CARS), which is the US' variant of scrappage programs. They provide evidence that there is an immediate and pronounced effect of the CARS program on car sales, which swiftly reverses in the 10 months after the program's expiration and thereby offsets most of the initially induced extra sales. Their findings imply that scrappage subsidies may have a role in smoothening economic outcomes like car purchases and implicitly growth and unemployment, but an intertemporal crowding-out occurs which yields a negligible net effect on purchases in the long term. Policy makers should therefore take this effect into account when assessing stimulating fiscal policies and extend their time horizon beyond the scrappage program's immediate duration. Copeland and Kahn (2013) substantiate this result by evaluating CARS' effects within an empirical model where time-series analysis is used to construct a counterfactual for car sales in absence of the program. As Mian and Sufi (2012), they estimate a cumulative effect of the program of essentially zero due to pull-forward- and (to a lesser extent) push-backward-effects, despite finding an initial impact of about 450,000 additional vehicle purchases.

Li, Linn, and Spiller (2013) estimate the effects of the CARS program within a difference-in-differences framework, using Canada as the control group due to the similarity of its automobile market and the absence of a scrappage scheme similar to CARS. They conclude that despite 680,000 transactions were made under the CARS program in total, only 370,000 cars were bought additionally to the counterfactual scenario. Hence according to Li, Linn, and Spiller (2013) a considerable bandwagon effect accompanied the program. Similar to Mian and Sufi (2012) and Copeland and Kahn (2013), they diagnose a crowding-out of future purchases by the program which resulted in a net-effect of practically zero beyond 2009. Hoekstra, Puller, and West (2017), applying a regression discontinuity design, argue that more than half of the program's payouts went to buyers who would have purchased a new vehicle anyway. Additionally, according to the authors, the fuel efficiency restrictions specified in the CARS program resulted in a demand shift towards less expensive cars and thereby reduced total expenses on new vehicles in the US by $5 billion.[1]

Concerning scrappage programs besides CARS, Cantos-Sánchez, Gutiérrez-i-Puigarnau, and Mulalic (2018) evaluate the effect of scrapping subsidies on Spain's vehicle market, applying probit and tobit models to individual household data. Their results show that on the one hand, the Spanish program increased the probability of purchasing a new car considerably in the short run. However, on the other hand, average household expenditure for a new car was reduced by the intervention.

Using a rich panel dataset with monthly vehicle registrations on the model-level, Grigolon, Leheyda, and Verboven (2016) evaluate the effects of scrappage schemes in several European countries[2], using Belgium as control in a difference-in-differences framework. In their approach, variation in the implementation periods of the programs is exploited to investigate effects of the respective programs. Their findings suggest that the subsidies pronouncedly increased demand for new vehicles across countries and thereby alleviated the slump in sales in the aftermath of the financial crisis.[3] Furthermore, they identify a crowding-out between eligible and non-eligible models, i.e. consumers' purchasing decisions were bent towards car models that profited from subsidies. However, in contrast to the aforementioned findings for the CARS scheme in the US (see Copeland and Kahn, 2013; Li, Linn, and Spiller, 2013; Mian and Sufi, 2012), their evidence for pull-forward effects is rather limited. Only in the case of Germany's scrappage program, Grigolon, Leheyda, and Verboven (2016) find clear evidence of intertemporal substitution.

Müller and Heimeshoff (2013) investigate the average effect of scrappage schemes across several OECD countries[4] and additionally simulate counterfactuals (as in Copeland and Kahn, 2013) for Germany, South Korea, the

[1]Other publications that assess the effects of the CARS program include Busse et al. (2012), A. Cooper, Chen, and McAlinden (2010), Gayer and Parker (2013) and Green et al. (2014).

[2]Estimation is conducted for France, Germany, Italy, Netherlands, Portugal, Spain and the UK, which all introduced scrapping allowances at different points in time.

[3]Grigolon, Leheyda, and Verboven (2016) estimate that in the counterfactual scenario in absence of scrapping allowances, car sales would have been 29.7% lower in the investigated countries.

[4]Müller and Heimeshoff (2013) estimate a fixed-effect model based on a panel dataset of aggregate car registrations and control variables in 23 countries. In an alternative approach, the authors construct simulated counterfactuals for selected countries.

United Kingdom and the United States. The picture painted by their regression results are mixed in respect to intertemporal substitution of vehicle purchases. Interestingly, according to their results, only Germany and the United Kingdom show signs of a pull-forward effect regarding car sales. In contrast the United States and South Korea do not display less vehicle registrations relative to their counterfactuals. Despite a sharp decline in purchases after the programs' expiration dates, the actual registration figures stay well above the counterfactuals. In respect to the CARS program, this result is in sharp contrast to the extensive pull-forward effects observed in other studies.[5] Marin and Zoboli (2020) follow another empirical strategy, when they apply a regression discontinuity design in order to evaluate the Italian cash for clunkers program, exploiting a discontinuity in the eligibility criteria for program participation. Their results are in line with those of Grigolon, Leheyda, and Verboven (2016), as they suggest that the 2009 scrappage scheme stimulated car sales in Italy considerably.

Focusing on the scrappage scheme in Germany, which stands out among the other programs in terms of its total volume, Kaul, Pfeifer, and Witte (2016) find heterogenous effects for different segments of the automobile market. Their estimations suggest that customers scrapping their vehicles were targeted by positive price discrimination in higher price segments, i.e. purchasers of expensive cars received discounts in excess of the government subsidy. Meanwhile buyers of cheap cars, who utilized the scrappage scheme, were facing slightly negative price discrimination. Hence non-subsidized customers received more discount in the market segment for less expensive vehicles. In another assessment of the German scrappage scheme's impact on car sales and the environment, Klößner and Pfeifer (2018) were the first to apply a variation of the Synthetic Control Method (SCM) developed by Abadie, Diamond, and Hainmueller (2010, 2015) on the topic. They find a considerable positive effect on car sales, somewhat mitigated by intertemporal substitution.

Albeit scrapping subsidies were also implemented by Asian governments in response to the financial crisis, there is little empirical research on these in comparison to their American and European counterparts. Min (2015) use Korean microdata on the household level within a difference-in-differences framework, where non-eligible households with vehicles younger than 10 years serve as control group. He concludes that the country's program increased the probability of buying a new car for eligible households by 6.8 percentage

[5] As aforementioned, Copeland and Kahn (2013) and Mian and Sufi (2012) both conclude that the cumulative effect of the program on sales was essentially zero due to intertemporal substitution.

points.[6] Konishi and Zhao (2017) apply a random-coefficient logit model to estimate demand for car models in Japan, concluding that the country's program significantly increased total car sales while also raising fuel efficiency. However, the authors don't weigh their results for the increase in sales against pull-forward effects, therefore potentially overestimating the program's impact.

3 Scrappage Programs and Data

3.1 Car Scrappage Schemes in the Great Recession

As laid out in the literature review, several countries implemented stimulating policies for the vehicle sector in response to the economic downturn following the financial crisis that erupted in 2008. One of those policies, as instituted in the six OECD countries we investigate, were direct subsidies to car purchasers in order to incentivize them to buy new vehicles. Japan's vehicle retirement program, called "Eco-Car", started in April 2009 and was originally designated to end in March 2010, but it was later extended until September 2010. New vehicles were eligible for subsidies when their fuel efficiency was at least 15% higher than Japan's 2010 fuel efficiency standard and their overall emission levels were 75% below 2005 Japanese standards (see Canis et al., 2010). The extent of the subsidies laid in the range of ¥125,000-250,000 ($1,031-2,577 at the time of program initiation) and the Japanese government allocated approximately ¥370 billion (about $3.8 billion in April 2009) in total to the country's scrappage program (see JAMA, 2009).

The program implemented by South Korea, another country with a strong domestic vehicle sector, ran from May to December 2009. A buyer who scrapped an old vehicle was eligible to a tax reduction of up to 2.5 million won (about $2,000 at that time) (Canis et al., 2010).

Another country with a sizable budget for scrapping subsidies was Germany, which spent €5 billion in order to incentivize the scrapping of almost 2 million old vehicles. The country's program was implemented in January 2009 and was closed for new applications almost nine months later on October 14th, when its funds were exhausted. Buyers were eligible for the subsidy of €2,500 when the scrapped car was more than nine years old and the newly purchased vehicle fulfilled at least the "Euro 4" emission standard.

The United States on the other hand implemented the "Car Allowance Rebate System" (CARS) with a total budget of $3 billion. CARS officially started in July 2009 and was terminated already after two months at the end

[6] In detail, according to Min (2015), purchase probability rose from 7.1 to 13.9 percent.

of August, when the budget appropriated to the US' scrappage scheme was exhausted due to strong demand. The amount of the subsidy was \$3,500 or \$4,500, depending on the purchased type of vehicle and the difference in fuel economy between the scrapped car and the new one (see OECD, 2009).

The Slovak Republic granted subsidies for scrapping cars in two short periods in March (9th-25th) and April (6th-14th) 2009, ranging from €1,500 in the first period to €1,000 in the second. The subsidy was only granted to car owners, if their old car was older than 10 years and the newly purchased vehicle was below €25,000 in value. Recipients of the scrapping bonus could use the subsidy for the purchase of a new vehicle until the end of 2009. The United Kingdom offered a comparable subsidy of £1,000, conditional on the manufacturers matching with an equal amount. The country's program started in May 2009 and was closed in March 2010 (see OECD, 2009).

3.2 Panel Data

A rich panel dataset on eighteen scrapping and non-scrapping countries was compiled for the analysis.[7] Since only OECD countries are included in our subsequent analysis, variables are mostly gathered from OECD's Main Economic Indicators database due to data availability and coherence. As the effect of the respective scrappage programs on vehicle purchases is our main research interest, OECD's seasonally adjusted index (2015=100) of monthly passenger car registrations is selected as dependent variable. However, in order to compute effects in absolute numbers, we additionally need absolute values of registrations for the base year. Those were gathered from Eurostat, national statistical bureaus and the International Organization of Motor Vehicle Manufacturers (OICA, 2020).

Sales instead of registration figures are also conceivable as dependent variable, but passenger car registrations are chosen for primarily two reasons: Firstly, in contrast to purchase transactions, data on vehicle registrations is gathered by administrative authorities in their official capacity and therefore of higher quality and reliability than sales data. Secondly, registration figures are available in monthly frequency, which allows us to study the evolution of the scrappage programs' effects in much more detail than otherwise. As car purchases directly translate into registrations, the latter is an almost perfect

[7] Countries in our database that implemented scrappage schemes are the United States, Japan, South Korea, Germany, the Slovak Republic and the United Kingdom. As countries without comparable scrapping subsidies we include Canada, Belgium, Denmark, Norway, Sweden, Poland, Norway, Czech Republic, Finland, Estonia, Latvia, Lithuania and Slovenia.

proxy for economic activity in the vehicle market.[8,9]

A set of covariates is gathered to reflect characteristics of countries with and without scrapping policies: GDP per capita (PPP, quarterly, s.a.), harmonized unemployment rate (yearly, s.a.), industrial production index (monthly, s.a.), consumer price index CPI (monthly, 2015=100) as well as a country's 3-month interbank interest rate (monthly). GDP per capita and industrial production indicate the overall economic performance of a country and are assumingly positively correlated with car registrations, as the economic climate is an important determinant for consumer spending. As the interbank interest rate translates into borrowing conditions for consumers and vehicles as costly durable goods are often financed, an interdependence between interest rate and registration figures is to be expected. As a proxy for the economic and industrial composition of a country we use a measure of CO_2-emissions per capita (yearly, in metric tons) from Worldbank's World Development Indicators database. Table 1 shows summary statistics for our index of passenger car registrations (2007-2011) and the aforementioned covariates (2007-2009) for all countries in our dataset.[10]

Table 1: Summary Statistics

	mean	median	min	max	std.dev	freq
reg.index	91.15	88.81	27.10	264.92	28.52	m
gdp.cap	34,464	35,933	17,263	61,089	10,804	q
unemp	6.66	6.09	2.56	17.57	2.93	y
indprod	94.28	94.57	58.80	128.14	14.89	m
cpi	89.09	89.65	74.51	99.50	4.34	m
intrate	4.06	4.19	0.15	21.25	2.51	m
co2.cap	9.54	9.35	3.38	19.22	3.69	y

[8] A slight delay between purchasing transaction and registration is of course to be expected. However, registration figures for the countries of interest show an immediate response to new scrappage programs within the same period. Sales and registrations can also deviate because of grey imports, but this goes both ways.

[9] Another technical reason stands in favor of using an index of passenger car registrations instead of absolute numbers: As the synthetic control units constructed in this paper are weighted averages of control countries from a donor pool, extreme values of the outcome variable could potentially not be captured by the synthetic counterpart. This means if the treated country is an outlier in terms of car registrations and not within the convex hull of potential donor countries, a suitable synthetic control unit cannot be constructed.

[10] Country-specific summary statistics for synthesized countries are shown in Appendix A1 and summary statistics for the group of donor pool countries can be found in Appendix A2.

This set of covariates serves as economic predictors for the empirical model outlined in Section 4, which is an application of the synthetic control method using time series (SCMT). As for the sake of the chosen econometrical approach economic predictors are only needed for pre-treatment periods, our dataset includes information from 2007 until the year of 2009, when scrappage programs where implemented at the latest. Index values for registration figures span from 2007 to 2011.

4 Empirical Strategy

4.1 Causal Inference & Policy Evaluation

In order to assess the impact of a scrappage program, it's not sufficient to look at the number of cars that was scrapped under the respective scheme. Firstly, among claimants of scrapping subsidies, there are certainly customers who would have bought a new vehicle anyway. For those buyers, subsidies were windfall gains and not decisive for their purchase decisions. Secondly, as the Great Recession unfolded following the 2008 financial crisis, macroeconomic conditions deteriorated across-the-board and led to constrained consumption and investments. Hence, we need to employ methods of causal inference in order to isolate a program's effect on the vehicle sector.

A causal effect can be derived from the difference between an actual observed and a corresponding counterfactual outcome, which would have been observed in absence of treatment. In the so-called potential outcome approach, also coined as Rubin causal model (RCM) by Holland (1986), both possible outcomes of each unit in a sample are compared. A policy intervention's effect then can be attributed to the gap between both outcomes. However, for each unit naturally only one outcome is realized and as a result the causal effect can never observed directly (Athey and Imbens, 2017). This challenge is what Holland (1986) calls "the fundamental problem of causal inference", which statisticians try to overcome with different identification strategies.

As Athey and Imbens (2017) explain in their recent review of policy evaluation methods in applied econometrics, random controlled experiments would be the "gold standard" for drawing inference. However, as the authors also point out, controlled experiments are rarely feasible due to political, financial or ethical constraints. Therefore, often one has to rely on observational data in order to evaluate the effect of a policy intervention. Matching, the Difference-in-differences approach and the synthetical control method are among the empirical methods for drawing inferences with observational data, where the latter is used in this paper to evaluate the impact of scrapping subsidies.

4.2 Synthetic Control Method

The Synthetic Control Method (SCM) is a more recent contribution to the toolset of researchers in the field of policy evaluation. Abadie, Diamond, and Hainmueller (2010) developed SCM, building on an idea in Abadie and Gardeazabal (2003), and applied it to the case of California's tabacco control program. The synthetic control method addresses methodological shortcomings of other empirical approaches that rely on the comparison of a treated units with one control unit, or alternatively the simple average of multiple units. In contrast to the difference-in-differences approach, SCM provides a data-driven procedure to construct a suitable counterfactual for a unit that undergoes treatment and does not rely on the arbitrary selection process of the empiricist. In the synthetic control method framework, a weighted average of a set of control units, often called donor pool in the SCM literature, serves as counterfactual to draw inference. The idea behind this approach is that a combination of units often provides a better comparison of the treated unit than any single unit alone. (Abadie, Diamond, and Hainmueller, 2010)

In the context of this paper's investigation, application of SCM therefore means that it's not necessary to choose exclusively between non-scrapping OECD countries like Belgium, Denmark and Canada (or the simple average of their outcomes) as controls for a country with a scrappage scheme like Germany. Alternatively, we can algorithmically construct a weighted average of a subset of OECD countries, which is more similar to Germany than any of the single countries alone would be.

In its original implementation by Abadie, Diamond, and Hainmueller (2010), the synthetic control method uses a minimum distance approach for calculating weights, is restricted to a single dependent variable and calculates weights using only the means of covariates without exploiting time series information. Recent extensions allow (1) for multiple dependent variables and can take into account their interdependencies and (2) make use of time series properties of variables (Gobillon and Magnac, 2016; Klößner and Pfeifer, 2018; Xu, 2017).

The synthetic control method as it is applied in this paper, is briefly summarized in the following.[11] Suppose there is a set of $J+1$ countries with the index j, where one country ($j = 1$) implements a scrapping policy and

[11] The description of the synthetic control method follows the original work of Abadie, Diamond, and Hainmueller (2010, 2015) as well as Becker and Klößner (2018) for the extension.

a corresponding synthetic control unit for this country is constructed as a weighted combination of a subset of J non-scrapping OECD countries, also referred to as "donor pool" in reference to the statistical matching literature (Abadie, Diamond, and Hainmueller, 2010). T are time periods (months in our case), T_0 is the number of pre-treatment periods and the scrappage scheme starts in $T_0 + 1$ (i.e. $1 \leq T_0 < T$).

On the one hand, Y_{jt}^N denotes the outcome (car registrations in our context) that would be observed for country j at time t without the treatment in form of a scrapping policy. On the other hand, Y_{jt}^I denotes the outcome for a country j at time t if it's treated in $[T_0 + 1, T]$. Under the assumption that a scrappage policy doesn't effect outcomes prior to its implementation, $Y_{jt}^I = Y_{jt}^N$ holds for periods $t \in \{1, ..., T_0\}$ and all countries $j \in \{1, ..., N\}$.[12] Then suppose the difference $\alpha_{jt} = Y_{jt}^I - Y_{jt}^N$ is the treatment effect for country j in period t and D_{jt} is a dummy variable indicating treatment. Then for each country j at time t the observed outcome of interest is

$$Y_{jt} = Y_{jt}^N + \alpha_{jt} D_{jt}. \tag{1}$$

The manifestations of the indicator variable D_{jt} follow this expression:

$$D_{jt} = \begin{cases} 1 & \text{if } j = 1 \text{ and } t > T_0 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

Hence, for the treated country $j = 1$, which introduces a scrappage scheme in $T_0 + 1$, the observed outcome Y_{1t} equals $Y_{1t}^N + \alpha_{1t}$ in the post-treatment periods $t > T_0$, which is the sum of the treatment effect and the outcome in an untreated state.

The ultimate goal of the synthetic control method is the estimation of the treatment effect α_{jt} in Equation 1 for the treated country $j = 1$, which, for $t > T_0$, equals

$$\alpha_{1t} = Y_{1t}^I - Y_{1t}^N = Y_{1t} - Y_{1t}^N. \tag{3}$$

For an estimation of the treatment effect α_{1t}, we therefore only need to estimate the counterfactual Y_{1t}^N, since in the post-treatment periods Y_{1t} equals the observed outcome under treatment (Y_{1t}^I). SCM suggests, in line with the difference-in-differences approach, that Y_{1t}^N can be derived from other countries without treatment but similar characteristics, or more formally, that Y_{1t}^N can be estimated by $\hat{Y}_{1t}^N = \sum_{j=2}^{J+1} w_j^* Y_{jt}$ for $t > T_0$, where w_j^* are optimal country weights and Y_{jt} outcomes of other countries from the "donor pool" that weren't exposed to a policy intervention.

[12] If this assumption is violated, i.e. one assumes an announcement effect, it's conceivable to define T_0 as the period in which a policy change is introduced to the public.

The value of a synthetic control unit, constructed from non-scrapping OECD countries in our case, for assessing the treatment effect, hinges on its ability to approximate the treated unit as closely as possible in the post-treatment periods in absence of the scrapping policy. This is achieved by an optimization process that maximizes the fit between the treated country and its synthetical counterpart. This similarity is not only achieved with respect to the outcome variable, but with respect to our set of covariates as well.[13] These variables are also labeled as predictors by Abadie, Diamond, and Hainmueller (2015) due to their explanatory power for the outcome variable.

The first branch of predictors in SCM contains m linear combinations of our outcome variable Y in M pre-treatment periods. The other branch of predictors is made up of r covariates with explanatory power for Y. The combination of K $(= m + r)$ predictors yields a $K \times 1$ matrix, X_1, for the treated country and a $K \times J$ matrix, X_0, for the controls from the donor pool.

The subsequent optimization process in order to find country weights that yield an optimal synthetic control unit is twofold. We want to identify the combination of countries from the donor pool, which minimizes the distance of predictors' manifestations between the treated country and the synthetic control unit. Therefore the penalty function

$$\|X_1 - X_0W\|_V := \sqrt{(X_1 - X_0W)'V(X_1 - X_0W)} \tag{4}$$

is the respective distance measure, where $W = (w_2, ..., w_{J+1})'$ is a $J \times 1$ vector of positive weights ($w_j \geq 0$) that sum to one ($w_2 + ... + w_{J+1} = 1$). Here each manifestation of W constitutes a different synthetic control unit, albeit not necessarily an optimal one (Abadie, Diamond, and Hainmueller, 2010).

Equation 4 entails a symmetric and positive semidefinite matrix V, which captures the relative importance of predictors in matrices $X_{0,1}$. To obtain weights in W and V that minimize the distance $\|X_1 - X_0W\|_V$, a twofold optimization process is conducted, an inner and outer optimization (Becker and Klößner, 2018). In order to find optimal weights for donor pool countries, denoted by $W^*(V)$, the following minimization problem is solved for given predictor weights V:

[13]GDP per capita (PPP, quarterly, s.a.), harmonized unemployment rate (yearly, s.a.), industrial production index (monthly, s.a.), consumer price index CPI (monthly, 2015=100) as well as a country's 3-month interbank interest rate (monthly), see Section 3.2.

$$\begin{aligned} \min_{W} \quad & \sqrt{(X_1 - X_0W)'V(X_1 - X_0W)} \\ \text{s.t.} \quad & W > 0, \\ & \sum\nolimits_{j=2}^{J+1} w_j = 1. \end{aligned} \tag{5}$$

As Abadie, Diamond, and Hainmueller (2010) point out, the choice of V influences the mean square prediction error (MSPE) of the synthetic control estimator. Therefore, the optimal vector V^* assigns weights to linear combinations of predictors in $X_{0,1}$, which minimize the estimators' MSPE. Attributing weights can sometimes bear on subjective assessments of the predictive power of variables. However, Abadie, Diamond, and Hainmueller (2010) and Abadie and Gardeazabal (2003) propose a data-driven approach to choose V such that the MSPE of the outcome variable is minimized in the pre-treatment periods. This is done by solving the so-called outer optimization problem

$$\min_{V} \quad (Z_1 - Z_0W^*(V))'(Z_1 - Z_0W^*(V)), \tag{6}$$

where Z_1 is a $T_0 \times 1$ vector with the outcome values for the treated country over the pre-treatment periods and Z_0 is a corresponding $T_0 \times J$ matrix for outcomes from the donor pool countries.

In this paper, an extended version of SCM developed by Klößner and Pfeifer (2018) is applied, labelled SCMT[14], which can make use of time series properties of predictors and therefore can construct synthetic control units that are better fitting counterfactuals. This does not change the base structure of the SCM concerning the two-fold optimization process in Equations 5 and 6 for obtaining country (W) and predictor weights (V), but the embodied distance metrics change to

$$\Delta_X(v_1, ..., v_k, W) := \sqrt{\sum_{k=1}^{K} v_K \frac{1}{N_K} \sum_{n=1}^{N_K} \left(X_{k,n,1} - \sum_{j=2}^{J+1} X_{k,n,j} w_j \right)^2} \tag{7}$$

and

$$\Delta_Y(W) := \sqrt{\frac{1}{M^{pre}} \sum_{m=1}^{M^{pre}} \left(Y_{m,1} - \sum_{j=2}^{J+1} Y_{m,j} w_j \right)}, \tag{8}$$

[14]Their full generalization of the synthetic control method (SCM) is actually labeled MSCMT, as it also allows for multiple outcome variables of interest in addition to the time series aspect. However, as only the latter is applied in this paper, we refer to their extension with the term SCMT.

where, following the notion of (Becker and Klößner, 2018), $Y_{m,j}$ denotes the mth outcome Y of the outcome variable for country j and $m = 1, ..., M^{pre}$ is running over the $M^{pre}(= T_0)$ pre-treatment observations. $X_{k,n,j}$ denotes the values of K economic predictors, with $k = 1, ..., K$ running over the set of predictor variables and $n = 1, ..., N_K$ running over the pre-treatment periods of each predictor k.

We solve the optimization problems above for each of the six scrapping OECD countries United States, Japan, South Korea, Germany, the Slovak Republic and the United Kingdom in order to construct the respective synthetic control countries. The donor pool J consists of Canada, Belgium, Denmark, Norway, Sweden, Poland, Norway, Czech Republic, Finland, Estonia, Latvia, Lithuania and Slovenia, as those are OECD countries with substantial domestic vehicle markets, but without scrapping policies.[15] Passenger car registrations are the outcome of interest and GDP per capita, unemployment rate, industrial production, CPI, the 3-month interbank interest rate and CO2-emissions per capita are the economic predictors in K (see Section 3.2). A comparison of the observed passenger car registrations with its synthetical counterfactual subsequently allows for insights if and to which extent scrappage schemes changed the trajectory of car markets.

5 Results

Figure 1 shows index values of actual passenger car registrations in scrapping OECD countries as well as index values for their synthetic counterparts. To illustrate the results of the SCMT approach, we inspect the evolution of passenger car registrations in the United States over time, which is shown in the top-right panel of the figure. Vertical lines indicate the treatment periods in the US, i.e. the time frame between July and August 2009, in which car purchases were eligible for scrapping subsidies under the CARS program. The curve of actual registrations shows a sharp downturn already beginning in the mid of 2008, which bottoms out in the first two quarters of 2009 after a decline of about 30 percent. Right after implementation of the scrappage program we can observe an immediate spike in car registrations in August 2009, even exceeding pre-crisis levels. However, after the program ended, car registrations again returned to levels way below the heights of 2008 and the subsidy-induced spike in August 2009. The sharp spike in passenger car

[15] Another consideration underlying country selection for the donor pool is data availability, as reliable and consistent date on passenger car registrations is only available for a limited set of countries.

registrations in July and August 2009 already hints at a strong, but short-lived impact of the CARS program.

As outlined in Section 4, a quantification of the net-effect of scrapping subsidies requires a comparison with the counterfactual situation. The evolution of registration figures in the US' synthetical counterpart is also depicted in the top-right panel of Figure 1. Conducting the optimization process formalized in Section 4, we obtain from the outer optimization the following optimal predictor weights in vector V^*: 0.0645 for GDP per capita, 0.1686 for the interbank interest rate, 0.5840 for the unemployment rate, 0.1828 for registration figures[16] and positive weights close to zero for CO2-emissions per capita, CPI and OECD's index of industrial production. This data-driven approach to obtain predictor weights, as proposed by Abadie, Diamond, and Hainmueller (2010), ensures that the mean square prediction error of the outcome variable is minimized in the pre-treatment periods.

We obtain the vector W^* with the optimal weights for donor pool countries by solving the inner optimization problem as in Equation 5 and 7 respectively. SCMT attributes positive weights to four OECD countries from the donor pool in order to synthesize the US car market: Canada is attributed a weight of 27%, Sweden 23%, Latvia 6% and Denmark 44%. Visual inspection of the top-right panel of Figure 1 shows that the in such a way constructed synthetical US closely resembles the evolution of actual registrations in the pre-treatment periods not only in the pre-crisis time frame, but also during the sharp decline after the onset of the financial crisis and before the implementation of scrapping subsidies.

Juxtaposition of actual and synthetic (counterfactual) registration figures for other scrapping OECD countries (see Figure 1, namely Japan, South Korea, Germany, the Slovak Republic and the United Kingdom), shows similar patterns as in the US. Until the onset of the country's respective scrappage program, curves for actual and synthetic registrations closely resemble each other (albeit with varying degrees of fitting). However, further inspection shows heterogeneity among the investigated countries concerning the post-treatment periods. In contrast to the US, other countries' actual registration figures show a more noticeable downward deviation in comparison to their counterfactual registrations in the periods after the scrappage schemes' completion.

[16] As Kaul, Klößner, et al. (2015) point out, one should never use all pre-treatment values of the outcome variable (here: passenger car registrations) as economic predictors, since it renders all other covariates in the model irrelevant. When synthesizing counterfactuals for the investigated scrapping countries in this paper, we therefore only use passenger car registrations index values from a few months prior to the intervention instead of the entire pre-treatment path.

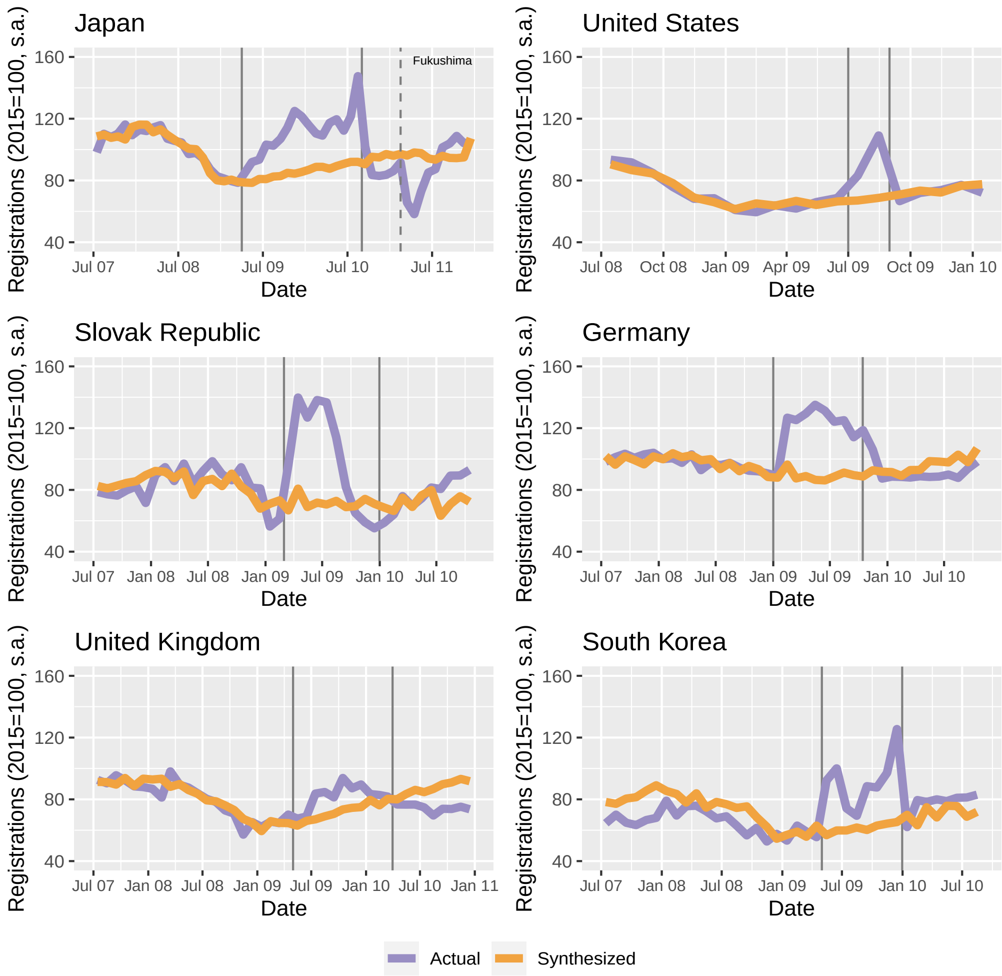

Figure 1: Actual vs. Synthetic Vehicle Registrations

In Japan, for instance, the registration index sharply declines with termination of the scrapping subsidies, resulting in index values even below its pre-intervention nadir in March 2009 (see top left panel of Figure 1). This observation suggests a strong pull-forward effect on sales due to the subsidies, thwarting the initial impact of the country's program. However, the case of Japan also exemplifies that one has to interpret post-treatment figures with increasing caution as we go ahead in time and depart from the treatment period. Other country-specific factors, like an additional exogenous shock, may then overlay the impact that can be causally attributed to the scrappage program and its aftereffects. In Japan, the sharp decrease in registration figures right after the termination of the country's scrappage scheme is later followed by a second, albeit smaller downturn starting in March 2011. It's likely that the Fukushima disaster triggered this second slump in vehicle sales and since Japan's synthetic control unit is naturally constructed out of countries which have not endured a nuclear accident within their own borders, the exogenous shock is insufficiently reflected in the synthesized registration figures. As a result, the performance of the Japanese scrappage program is most probably even more favourable than our results suggest.

One of the features of synthetic control units (and the very reason for inventing them) is their ability to show counterfactual developments for a country, i.e. the change in variables of interest in absence of an exogenous shock. However, as discussed above for Japan, this feature goes hand in hand with its inability to account for additional policy changes or other exogenous shocks that occur in the post-treatment period, as the composition of the synthetic control unit is determined priorly and fixed subsequently. In recognition of this limitation, we have to find the right balance in defining the length of the post-treatment interval we want to take into account in our analysis. Following this thought, we choose a time frame of about the same length as the duration of the respective scrappage program, as this will capture the bulk of any intertemporal substitution while avoiding to wrongly attribute effects of additional country-specific shocks and policy decisions to the scrappage program.[17] This approach seems validated by the observation that gap plots in Figure 2 don't show marked downward deviations anymore after a post-treatment interval of the same length as the treatment interval has elapsed. Nonetheless, we have to be aware that by doing so, we might not capture some remaining long-term effects that lie outside of the time frame under observation.

Undershooting of car registrations' counterfactual levels after program completion as observed for Japan can also be observed for Germany, the Slovak Republic and the UK. South Korea is the only exception, with no persistent undershooting of counterfactual registrations by the actual ones.

The findings as laid out above can be visualized in more detail by plotting gap graphs (see Figure 2), that show the deviation of actual and synthetic registration figures over time. The plots contained in this figure are constructed by subtracting registrations of the synthetical control country from actual registrations. This means positive values in the gap graphs shows actual registrations exceeding counterfactual ones and negative ones the opposite. Evidently, a gap of approximately zero then reflects equal registrations in a country and its synthetical control.

[17]For the programs of the United States and Germany, this time frame is slightly extended due to the very short duration of the former and the outstanding size of the latter, which suggests that post-treatment effects might take longer than the mere duration of the scrappage program to wear off.

Again, we use Japan's gap plot to illustrate the effect of the scrapping subsidy as carved out by the synthetic control method. Until April 2009, the onset of the country's scrappage scheme, the gap fluctuates around zero, turning strongly positive with the implementation of scrapping subsidies. In the case of Japan, the initial effect of the scrappage program gains strength during program duration, starting at a gap of just 9.4 index points in April 2009 and reaching its peak of remarkable 52.37 index points in August 2010, right before completion of the country's program. The subsequent fall mirrors this finding with a negative gap of -13.81 in October 2010 and a maximum negative gap of -40.96 in April 2011.

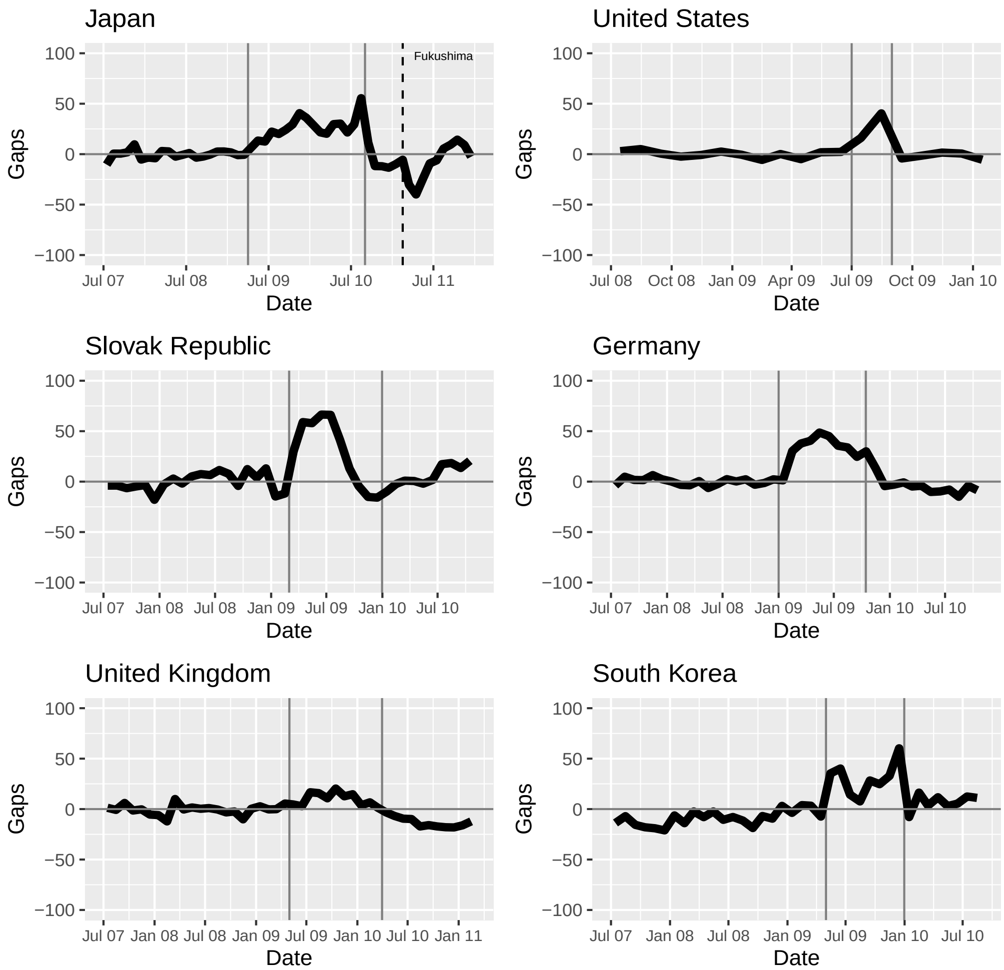

Figure 2: Gap Plots

Similar observations can be made for gap plots of the other countries depicted in Figure 2. Shortly after the introduction of Germany's cash-for-clunkers program, we can see a positive gap between actual and counterfactual registrations of 44.71 index points in February 2009, peaking at 56.94 points in May 2009 and staying well above 30 until October 2009. Interestingly, a positive gap remains even after the exhaustion of the program's funds on September 2nd, 2009. However, this can be explained by the delay between purchase date and registration date of a vehicle, as new vehicles are often made-to-order and therefore come with several weeks to months waiting time. Nevertheless, starting December 2009 the gap turns negative and remains below zero for the whole year of 2010, again hinting at a considerable pull-forward effect of the scrapping subsidies.

The gap plot for the Slovak Republic also reveals a remarkable stimulating effect of the country's scrappage program. Right with the start of the program in March 2009, the gap between actual and synthetic figures turns positive and increases up to 66.83 index points in June 2009, before falling sharply to negative values in the last quarter of 2009 and the beginning of 2010. Interestingly, the decline occurs already during the lifetime of the country's scrappage program. This observation can be explained by the features of the scrappage program in the Slovak Republic and furthermore gives insights into the reception of the program by its participants. Although the program ran until the end of 2009, subsidies were only granted for scrappings between the 9th and 25th of March 2009 in a first round and between 6th and 14th of April 2009 for a second round. In these two periods 44,200 vehicles were scrapped in total and former owners were qualified to use the received subsidy until the program's completion in December 2009. However, by the end of May already 31,589 new vehicles were purchased or ordered under the program (OECD, 2009). The construction of the scheme obviously tilted purchase dates towards the two scrapping periods in March and April 2009, as understandably most participants needed to replace their scrapped vehicle close in time. In the last quarter of 2009 and at the end of the program, the remaining stimulus from purchases under the program where not sufficient to compensate other effects like the global economic downturn and the intertemporal substitution of vehicle purchases. Hence, starting October 2009 the gap in registrations turns negative for Slovakia with negative values of up to -17.93 index points in December 2009, not recovering until June 2010. Further inspection of the gap plot for the Slovak Republic suggests a short anticipation period in the fist two months of 2009, where actual car registrations deviate by -13 and -12 index points in January and February from its synthetic control. As scrappage schemes were already widely discussed by European and national policy makers in the beginning of 2009, this explanation seems plausible.

In the public debate surrounding scrappage schemes it's often argued that they are only an expensive measure to induce intertemporal substitution, i.e. to pull forward purchases of the subsidized goods, but the resulting net effect is negligible or even completely absent. In order to evaluate this claim, we want to further inspect the evolution of scrappage schemes' effects on car sales and the overall net effect. Therefore we cumulate the gaps as shown in Figure 2 over time and furthermore translate the index values for car registrations into absolute registration numbers. The resulting plots for each country are shown in Figure 3. The plots with cumulative gaps in absolute registrations start at the point in time where the scrappage program is implemented and track the variable of interest during and after its duration. Vertical lines in Figure 3 indicate the respective end date of a country's scrappage program.

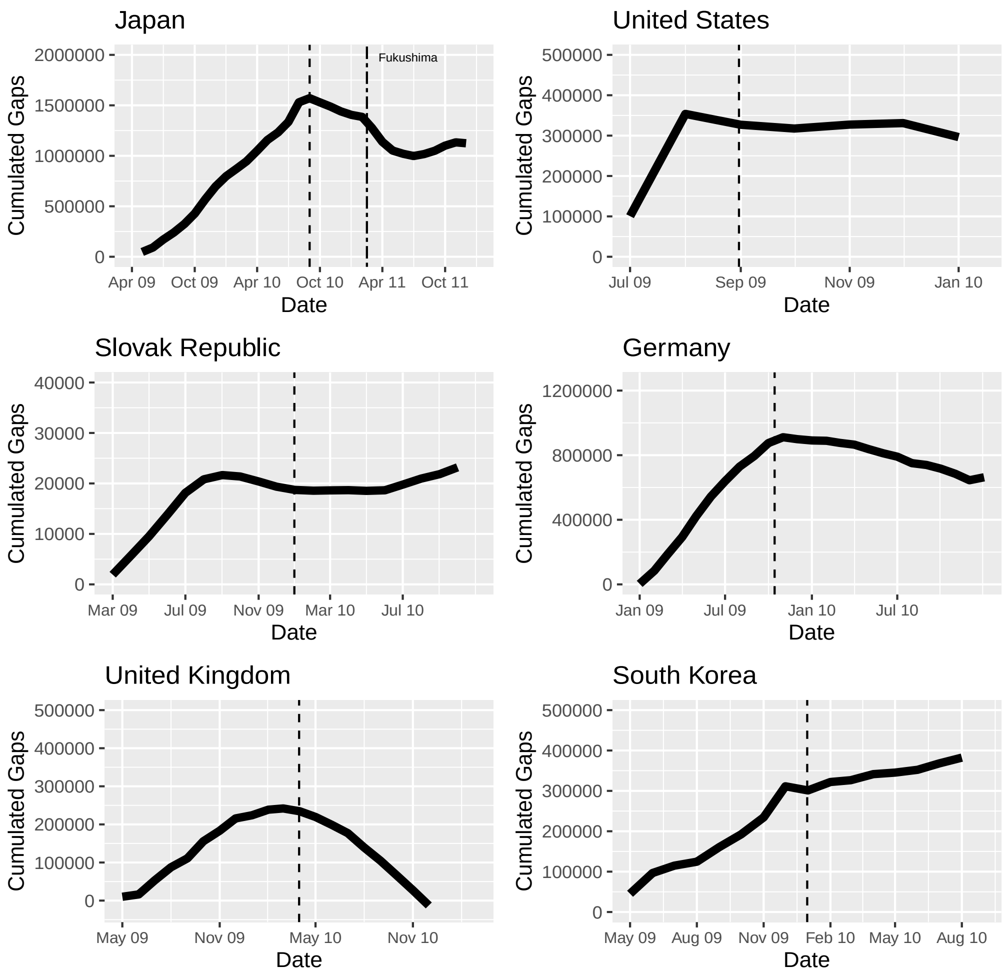

Figure 3: Cumulated Gaps in Absolute Values

The cumulated gaps from Japan's SCM results as depicted in Figure 3 illustrate the expected impact of the scrapping subsidies. The cumulated positive difference between actual and counterfactual registration figures climbs steadily until the end of the program where it reaches its turning point at about 1,670,000 additional registrations in September 2010. Subsequently, as the dampening effect of intertemporal substitution kicks in, the overall number of additional sales declines until it flattens out in the second half of 2011 at around 1,000,000 additional sales in contrast to the counterfactual situation in absence of a scrappage program. However, as already discussed above, the decrease in cumulated gaps from March 2011 onwards is assumingly partly caused by the general uncertainty in Japan following the Fukushima nuclear disaster in the same month. We find that the scrappage program's impact on car purchases in Japan was considerably large and induced a net effect of at least 1,000,000 additional sales, despite an intertemporal crowding out of up to 40 % of the initial increase. Under the plausible assumption that the catastrophe in Fukushima impacted consumer confidence substantially, we should interpret these results as a lower bound for absolute net-registrations and an upper bound for the crowding out effect. Since 3.6 million car purchases were subsidized through the Japanese program in total (Canis et al., 2010), our results suggest considerable windfall gains for vehicle buyers in Japan with only a fraction of the subsidies inducing additional purchases.

Inspection of the cumulated gaps of the other investigated scrapping countries in Figure 3 again reveals heterogeneity among countries in respect to their scrappage program's impact. Whereas the crowding-out effect due to pull-forward sales is comparatively small in Germany and the Slovak Republic and even completely absent in South Korea, plotting the cumulated gaps for the UK shows that the initial increase in vehicle purchases due to the country's scrappage scheme dissolves almost completely in the following months.

For the US the number of additional car purchases remains mostly stable for the rest of 2009 after the CARS program's completion in June. A possible explanation for the observed heterogeneity lies in the very different configurations of the scrappage schemes. For instance the short duration of the US' program obviously induced a strong spike in car registrations, but due to the limited extent of the scrappage scheme intertemporal substitution might be less noticeable since its dampening effect is spread out on more periods relative to the program duration.

Furthermore, it is conceivable that additional economic policies in reaction to the financial crisis also affected car registrations. It is for example a valid assumption that the vanishing of additional sales in the UK over time is not only caused by a strong occurrence of pull-forward sales, but also by a weakened consumer climate due to the austerity measures pursued by the UK government in 2010 and the following years. As discussed above in the context of Japan and the Fukushima nuclear disaster, the Synthetic Control Method cannot account for post-treatment shocks like changes in government policies and subsequent effects on macroeconomic conditions, since the construction of the synthetic control unit relies on pre-treatment manifestations of predictor variables. In recognition of this limitation we have to be increasingly cautious about interpreting gaps between actual outcomes and synthesized outcomes, the further we depart from the pre-treatment interval.

6 Placebo Tests as Robustness Check

One limitation of the Synthetic Control Method is that it does not allow for the use of traditional statistical inferential techniques such as t-tests, partly due to small sample size. However, Abadie, Diamond, and Hainmueller (2015) suggest alternative approaches to inference based on permutation techniques. This process is labelled as so-called "placebo studies" and entails a repeated application of the SCM algorithms sequentially to all untreated countries from the donor pool, assuming they were treated instead of the initially investigated country with an actual scrappage program. In other words, the treated country moves to the donor pool and each country from the donor pool is synthesized instead. Subsequently, we compare the results from these placebo applications to the baseline results. This allows us to evaluate if the identified treatment effect is observed by chance only or indeed reveals an impact that can be attributed to the policy intervention, namely a country's scrappage program. If the treatment effect of a country that actually implemented a scrapping policy stands out from the trajectories of the placebo results, we can assume safely that the observed trend in car registrations is caused by the subsidies.

In Figure 4 placebo tests for each of the investigated countries is shown. For all scrapping countries besides the UK we can see that during the treatment period, i.e. for the duration of the scrappage scheme, the country's trajectory of the gap plot stands out in contrast to the placebo results. Notably, for Japan and Germany, the countries with the most expansive scrapping budgets, the country's gap plot surpasses the placebo trajectories for almost the entire treatment period by a sizable amount. The same can be observed for the United States, whose program was less comprehensive, but concentrated within a shorter time period. Although we can observe a clear upward trend in registration figures for the UK after implementation of the scrapping subsidies, we cannot safely derive from the placebo tests that this

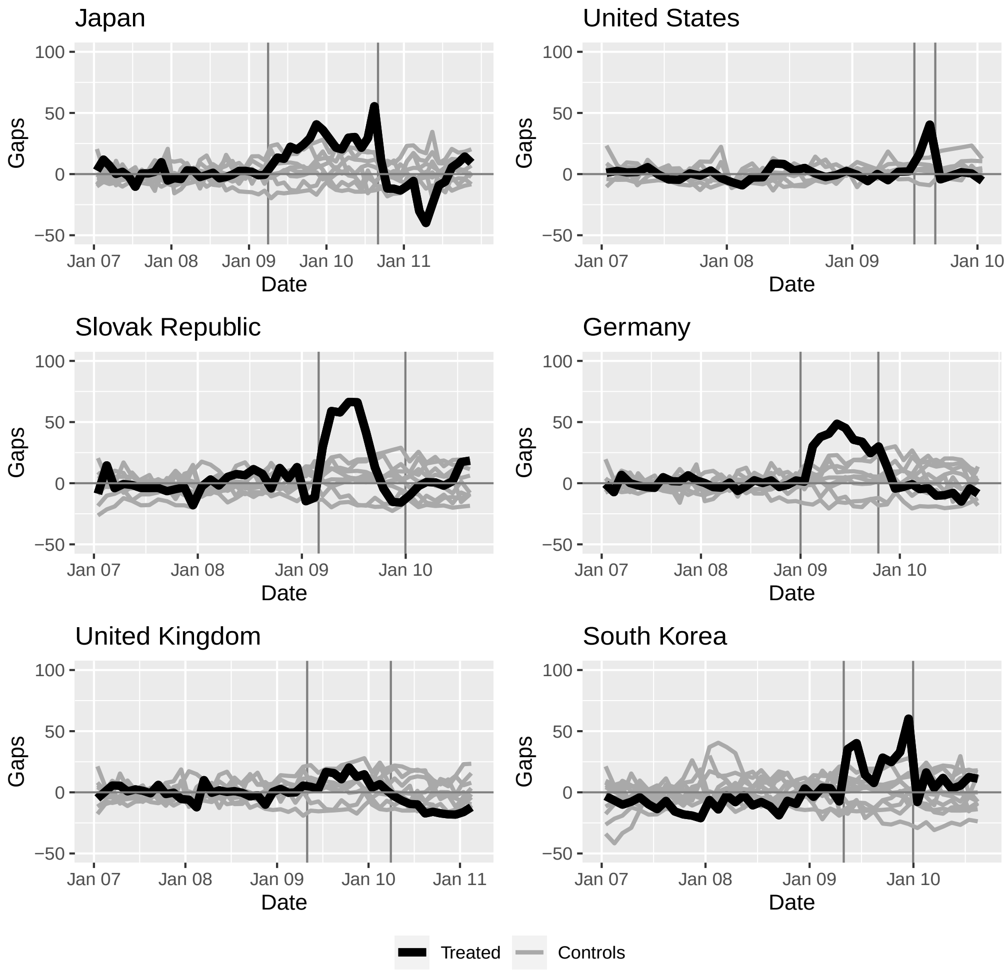

Figure 4: Placebo Tests

is caused by the country's scrappage scheme. This does not surprise given the fact that on the one hand the size of the UK's program was much less extensive than in other countries like Japan, Germany and the United States and on the other hand the program's duration was stretched out over a period of almost one year.

7 Conclusion

Scrappage programs for vehicles as implemented in Japan, Germany, Korea, the Slovak Republic, the US and the UK were adopted by policymakers in order to incentivize purchases and therefore stabilize demand in one of the most value-creating consumer markets in industrialized economies. However, these measures are costly and critics often cast doubt on whether their results are worth the considerable costs, which (measured in USD) in some countries lie in the billions. Protagonists of car scrappage schemes on the other hand point to the after all high number of applicants for the respective programs in order to justify these expenses, sometimes equating the number of subsidized automobiles with the extent of the stimulus. This of course oversimplifies the cause-effect chain put in motion by a scrapping subsidy, neglecting countering effects like pull-forward sales and windfall gains by consumers, who would have purchased a new vehicle anyway.

The Synthetic Control Method (using Time Series) approach as applied in this paper helps to better understand and disentangle these counteracting effects by constructing reliable counterfactuals for the OECD countries that implemented scrappage programs and were selected for our research. In contrast to a difference-in-differences framework, we don't have to rely on finding a single non-scrapping country that acts as a control for the treated country as best as possible and neither do we have to make a comparison with the unweighted average of a set of countries. Alternatively, SCMT allows to compute a synthetical counterpart as weighted average of OECD countries from the donor pool, based on the best fit concerning a set of economic predictor variables.

As we can see from our results, all of the six investigated OECD countries exhibit a visible upward deviation in car registrations in the wake of the implemented scrappage programs. However, in the case of the United Kingdom's relatively exiguous subsidy program totaling less than £500 Mio., the conducted placebo tests cannot establish statistical significance. Concerning intertemporal substitution, in several scrapping countries we observe negative gaps to the synthetic control units right after program completion, mitigating previous heights in the number of additional sales. In Japan, one of the countries with the best endowed schemes, the negative effect on future purchases due to pull-forward sales reduce the number of additional sales up to an upper bound of 40%, resulting in a net effect of at least 1,000,000 vehicle purchases. However, we cannot find any evidence for a predominant (or even total) intertemporal crowding out of sales in our findings. On the contrary, with the exception of the UK, net effects remain close to previous heights in the post-treatment interval. Even if we assume that some remaining intertemporal substitution could still materialize after the observed time frame, this cannot change the overall picture of considerable positive net effects.

According to our findings, the stimulative effect of scrapping grants is sustainable even after program termination and concerns that they are inevitably followed by a hard landing for the subsidized sector are unfounded. Notwithstanding, scrappage programs are costly for public budgets and the benefit of stabilizing the respective sector has to be carefully weighted against the considerable financial expenditures they carry with them. As expected, the number of additional registrations as identified in our empirical investigation lies well below the total number of claimed subsidies, indicating widespread windfall gains for consumers. Policymakers should keep this in mind when deciding on the choice of fiscal stimuli for the economy while public budgets are already under pressure. However, one can argue that even windfall gains for car buyers have a stimulative effect in other sectors of the economy, since they free up liquidity for consumption of other goods.

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Appendix

Table A1: Summary Statistics for Synthesized Countries

	Variable	mean	min	max	std. dev	time frame	freq
Japan	reg.index	102.97	78.49	116.27	11.72	Jan '07-Dec '11	m
	gdp.cap	35,346	33,065	36,175	1,061	Jul '07-Mar '09	q
	unemp	4.04	3.84	5.07	0.38	Jan '07-Mar '09	y
	indprod	111.12	79.65	119.47	11.72	Jan '07-Mar '09	m
	cpi	97.84	96.40	99.50	0.87	Jan '07-Mar '09	m
	intrate	0.78	0.54	0.89	0.10	Jan '07-Mar '09	m
	co2.cap	9.51	8.62	9.78	0.36	Jan '07-Mar '09	y
United States	reg.index	88.95	59.43	105.87	16.09	Jan '07-Jan '10	m
	gdp.cap	49,107	47,400	50,024	956	Jan '07-Jun '09	q
	unemp	6.01	4.62	9.27	1.74	Jan '07-Jun '09	y
	indprod	95.94	83.64	101.21	6.14	Jan '07-Jun '09	m
	cpi	89.31	85.40	92.81	1.93	Jan '07-Jun '09	m
	intrate	3.46	0.39	5.49	1.75	Jan '07-Jun '09	m
	co2.cap	18.50	17.16	19.22	0.77	Jan '07-Jun '09	y
Slovak Republic	reg.index	81.36	56.28	98.60	10.69	Jan '07-Oct '10	m
	gdp.cap	24,314	22,705	2,5470	1002	Jan '07-Feb '09	q
	unemp	10.54	9.57	12.12	0.94	Jan '07-Feb '09	y
	indprod	77.19	67.71	89.51	7.48	Jan '07-Feb '09	m
	cpi	87.94	84.91	91.15	2.28	Jan '07-Feb '09	m
	intrate	3.81	1.94	4.33	0.55	Jan '07-Feb '09	m
	co2.cap	6.88	6.32	7.01	0.18	Jan '07-Feb '09	y
Germany	reg.index	97.07	84.89	104.05	5.06	Jan '07-Oct '10	m
	gdp.cap	40,155	39,508	40,699	419	Jan '07-Dec '08	q
	unemp	7.98	7.42	8.54	0.57	Jan '07-Dec '08	y
	indprod	97.28	87.69	101.09	3.06	Jan '07-Dec '08	m
	cpi	90.80	88.35	92.83	1.38	Jan '07-Dec '08	m
	intrate	4.46	3.29	5.11	0.48	Jan '07-Dec '08	m
	co2.cap	9.50	9.49	9.51	0.01	Jan '07-Dec '08	y
United Kingdom	reg.index	82.17	57.12	98.10	11.48	Jan '07-Feb '11	m
	gdp.cap	37,439	35,621	38,346	906	Jan '07-Apr '09	q
	unemp	5.75	5.28	7.55	0.77	Jan '07-Apr '09	y
	indprod	107.68	98.02	111.65	4.45	Jan '07-Apr '09	m
	cpi	85.11	82.10	87.50	1.84	Jan '07-Apr '09	m
	intrate	5.30	1.62	6.74	1.42	Jan '07-Apr '09	m
	co2.cap	8.39	7.57	8.62	0.35	Jan '07-Apr '09	y
South Korea	reg.index	65.35	52.68	79.14	6.56	Jan '07-Oct '10	m
	gdp.cap	28,284	27,544	28,943	462	Jan '07-Apr '09	q
	unemp	3.28	3.17	3.63	0.15	Jan '07-Apr '09	y
	indprod	77.43	63.99	83.53	5.23	Jan '07-Apr '09	m
	cpi	84.67	80.64	88.41	2.43	Jan '07-Apr '09	m
	intrate	4.95	2.42	6.03	1.00	Jan '07-Apr '09	m
	co2.cap	10.27	10.18	10.35	0.08	Jan '07-Apr '09	y

Table A2: Summary Statistics for Donor Pool Countries

	mean	median	min	max	std.dev	time frame	freq
reg.index	92.81	90.30	27.10	264.92	32.67	Jan '07-Dec'11	m
gdp.cap	33,958	34,090	17,263	61,089	11,873	Jan '07-Dec'09	q
unemp	6.72	6.13	2.56	17.57	3.04	Jan '07-Dec'09	y
indprod	95.34	94.74	58.80	128.14	15.13	Jan '07-Dec'09	m
cpi	88.73	89.72	74.51	97.52	4.21	Jan '07-Dec'09	m
intrate	4.53	4.40	0.15	21.25	2.61	Jan '07-Dec'09	m
co2.cap	9.14	9.23	3.38	16.88	3.59	Jan '07-Dec'09	y

Donor pool countries: *Canada, Belgium, Denmark, Norway, Sweden, Poland, Norway, Czech Republic, Finland, Estonia, Latvia, Lithuania and Slovenia*

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