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Pull-Forward Effects in the German Car Scrappage Scheme: A Time Series Approach

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Abstract

The focus of this paper is the empirical evaluation of the German Accelerated Vehicle Retirement program, that was implemented in January 2009 to stimulate automobile consumption. To adress this question a monthly dataset of new car registrations owned by private consumers from March 2001 until October 2011 is created. Especially small and upper small car segments seem to have profited from the scrappage program as they make up 84% of the newly registered cars during the program. Using uni- and multivariate time-series models counterfactual car registrations are estimated for vehicles from the small and upper small car segment. The results suggest that the policy has been successful in creating additional demand for new cars during the policy period. We also find a small contraction in the year after the end of the policy for the small market segment. For upper small cars the pull-forward effect could only be identified for the last quarter of the ex-post period. So in summary, the overall effect of the German car scrappage program is positive for the two market segments.

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1 Introduction

In autumn 2008 the effects of the financial crisis spilled over to Germany and led in the fourth quarter of 2008 to a contraction in GDP growth of 2.2 percent. Against this background, fiscal policy interventions were called for on a broad basis and through all parties. This consensus finally culminated in the adoption of two large scale fiscal policy packages by the end of 2008 and at the start of 2009. The latter encompassed the German Car Scrappage Program or "Cash for Clunkers". A subsidy of 2,500 € was granted to private consumers for scrapping a used car and buying a new one

This policy was extensively discussed in the public and among economists. Waldermann (2009) summarizes the leading German economists' and lobbyists' opinion by stating that all opposed to this type of fiscal policy intervention. In more detail, the concerns refer to the favoritism of the automotive industry over other industry branches, the courting of specific voters in an election year and that a pull-forward effect will negate the positive contemporary effect of the policy.[1] Despite the growing debate about the German Cash for Clunkers program, it has not been empirically evaluated to the best of our knowledge. The aim of this paper is to close this gap using a time-series approach to simulate the counterfactual situation, taking the development of unemployment and domestic industry production into account. Our research questions focuses on the following two questions:

1. Did consumers bring their car consumption forward from the future?

2. How large is the overall effect of the treatment?

Results suggest that the predicted car registration numbers are only slightly above the realized ones for the years 2010 and 2011, i.e. pull-forward effects have been only modest at least for the two smallest market segments, which make up roughly 84% of the newly registered cars. Second, the policy seems to have had an overall positive effect as it lead to an additional one million new car registrations in comparison to the counterfactual situation. And third, results based on data from 2007, which is roughly one year before the financial crisis had an impact on Germany, suggest that the automobile industry may have been not as profoundly struck by the crisis as usually

[1] See Goerres and Walter (2010) for an interesting answer to this question.

assumed. This is also in line with research on the nature of the financial crisis, which provides evidence, that the effects of the last financial crisis are not fundamentally different compared to former financial crises (see Reinhardt and Rogoff, 2009 for a discussion). The remainder of the paper is as follows. Section two discusses the related literature on evaluations of car scrapping subsidies and part three explains the features and background of the German Cash-for-Clunkers program in some detail. Section four is dedicated to the empirical strategy, comprising the dataset used, as well as the model set-up and results. The last part concludes and gives an outlook on further research.

2 Literature Review

The literature on the Accelerated Vehicle Retirement-programs (AVR) started in the 1990s with the work on the optimal policy design of the car scrapping schemes. Hahn (1995) and Alberini et al. (1995) focus on the individual incentive guranteed through the program. Hahn (1995) calculates a bounty of $1,500$\$ being the optimal amount to reach cost-effectiveness of the 1992 scrappage program carried out in L.A. and Alberini et al. (1995) $1,300$\$ as optimal for meeting the targets of the Delaware program of 1992. Kavalec and Setiwan (1997) evaluate the car scrappage schemes of the L.A. region and come to the conclusion that targeting 20 year or even older cars is better for cost-effectiveness and distorts used-car prices less than targeting 10 year or older clunkers.

Another important strand of literature is concerned with the success of the policies in terms of emission reduction, which is summarized in the review by Van Wee et al. (2011). These evaluations exist for car scrappage programs worldwide. Work of this kind comprises Baltas and Xepapadeas (1999) for the Greek program, Van Wee et. al (2000) for the Netherlands, Dill (2004) and Allan et al. (2010) for the USA and Miravete and Moral (2009) for the Spanish program. These studies differ widely in results as some are taking into account the whole life cycle of a car (including production and scrapping). Nevertheless all studies mentioned above find small, but positive effects of the various scrappage schemes in terms of emission reductions. However, the effects are higher if car scrappage programs are implemented in densely populated areas and stronger effects are found in the 1990s when clunkers with no emission control technologies were substituted by new cars, equipped with catalytic converters or similar technologies.[2]

Most related to our approach is the more recent policy evaluation literature which analyzes the sales effects of different programs. This line of research was triggered by Adda and Cooper (2000), who try to measure and evaluate the long term effects of two French car scrapping programs of the 1990s by means of discrete choice methods applied to a microlevel dataset. They find transitory sales effects shortly after the program and negative effects in the long run. In addition, they point out that the policy effects were negative from governmental budget point of view as the expenditures are not fully compensated through additional tax revenues. This approach is partly carried on by Schiraldi (2011). He extends the structural discrete choice model to a full equilibrium structural model, including examination of the used car market to analyze the effect of an Italian car scrapping policy of the 1990s. Results suggest a smaller sales effect than that simulated by Adda and Cooper (2000).
Recently the American CARS program of 2009 was analyzed in terms of output and employment by Mian and Sufi (2010) and Cooper et al. (2010). Environmental effects were additionally investigated by Li et al. (2010). Mian and Sufi (2010) and Li et al.(2010) apply difference-in-difference techniques. Both studies use car registration data and find a short term boost in sales followed by a substantial decline via pull-forward effects after the program. The latter approach evaluates the policy using the Canadian economy as the control group for the former American cross-city variations in terms of participation rates in the program. Mian and Sufi (2010) show that seven months after the end of the policy the positive effect was completely reversed, so that the policy was even shorter lived than in Li et al. (2010), where they find positive sales effects until December 2009. Furthermore positive effects on employment are discovered in cities with higher exposure to the CARS-program in Mian and Sufi (2010) and are confirmed by Li et al (2010). Above all, they calculate a cost of 92$ for each avoided ton of CO_2, a value that is quite high compared to other environmental policy programs. Cooper et al. (2010) use a Two-Stage-Least-Squares (TSLS) time-series approach for simulating the counterfactual situation of no Cash-for-Clunkers program during the two months of the policy and two months afterwards. Their results suggest a boost in sales of 395,000 aditional cars and 40,200

[2]See Van Wee et al. (2011) for a detailed discussion of these effects.

new jobs and even net governmental revenues of 1.2 billion dollars.

Heimeshoff and Müller (2011) analyze the overall performance of the 2009-2010 programs worldwide by estimating a counterfactual situation using dynamic panel data analysis. Their results suggest different but overall positive sales effects with small pull-forward effects in most countries, suggesting that success of the car scrapping policies relies heavily on timing, budget and durations of the AVR-programs.

For Germany, two reports present descriptive statistics on the car scrappage scheme. The governmental agency that was responsible for the implementation of the program, "Bundesamt für Wirtschaft und Ausfuhrkontrolle" (BAFA), describes the application process as well as numbers of cars scrapped and bought during the subsidy period in BAFA (2010). Additionally IFEU (2009) report first effects of the car scrappage program in terms of environmental impacts using preliminary data from January 2009 until August 2009. These contributions do not take into account counterfactual situations, but solely depict sale patterns of all cars bought during the treatment period, without distinguishing between additional cars bought and vehicles purchased anyway.

Our contribution to the literature on car-scrapping evaluations is twofold. First of all, we focus on the German Cash-for-Clunkers program, as to the best of our knowledge there is no study evaluating this subsidy in detail until so far which takes into account counterfactual simulations. Secondly, we use time-series econometric methods to predict the hypothetical sales pattern in absence of the policy. This approach is chosen as a rather parsimonious way to predict the counterfactual situation. However, there are good reasons why to choose a time series approach instead of other econometric models for prediction. In empirical macroeconomics it has been shown, that quite simple time series models often outperform large macroeconometric models in terms of forecasting performance. This does not mean that structural models are not superior in terms of estimating causal effects, but for our purposes a time series approach is well suited (see e.g. Diebold, 1998 for a discussion of different paradigms of forecasting in macroeconomics). Apart from that, automotive sales and registration patterns exhibit strong dynamic effects. Therefore, neglecting lagged dependent variables in the model misses

an important aspect of analyzing car demand models.[3]
The following section discusses the German Cash for Clunker Program in detail.

3 The German Scrappage Program

Table 1: The German Cash-for-Clunkers Program "Umweltprämie"

Timing	January 27, 2009 (start of application) until September 2, 2009 (budget exhausted)
Budget	5 billion Euros
Incentive	2,500 Euros per car
Old car precondition	1. Minimum age of nine years 2. Car had to be registered with the applicant for at least one year
New car precondition	1. Fulfill emission standard Euro 4 2. New car or vehicle registered with another person or company for not more than 14 months (Jahreswagen)
Other features	1. Private consumers only 2. Short notice of policy
Aim	1. Reducing the age of the car fleet 2. Economic stimulus

Source: Own table, based on BMWi(2009).

As a method to counterbalance the negative private consumption effects of the financial crisis, the German government agreed upon two large fiscal policy intervention packages called "Konjunkturpaket 1" on November, 5 2008 and two months later "Konjunkturpaket 2" on January, 14 2009. The German Cash-for Clunkers program was part of the second fiscal policy package and amounted to a budget of 1.5 billion of the 50 billion EURO package, so roughly 3 percent. As applications for the scrappage subsidy increased[4], German parliament decided to increase the overall budget of the

[3] For a discussion of the path dependency of new car registrations see Ramey and Vine (1996) and Ryan et al. (2009)

[4] During the peak of consumer demand BAFA registered 270,000 incoming calls per

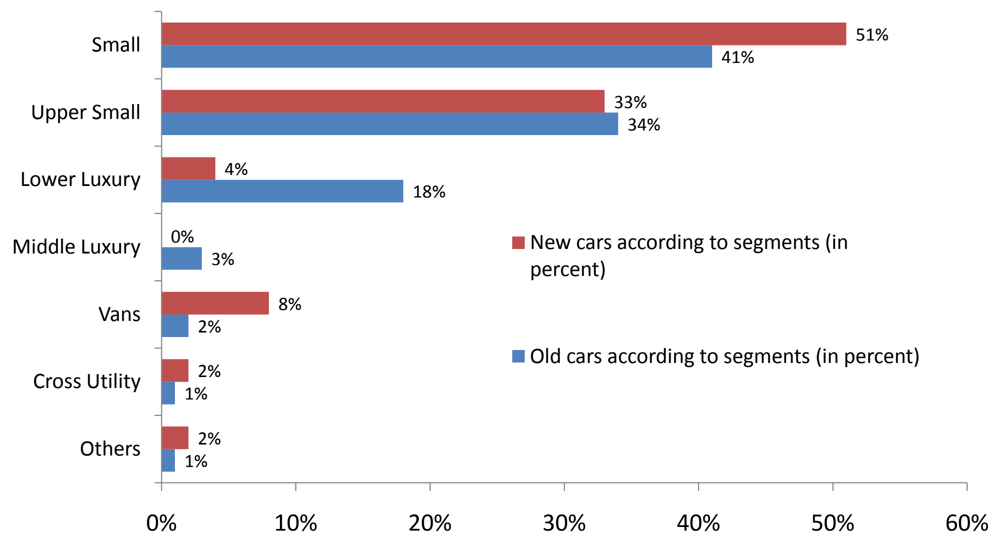
policy to 5 billion € end of March 2009. This was the second, after France, and largest program implemented in Europe during the 2009/2010 automotive sales crisis (see Heimeshoff and Müller (2011) for an overview of other policies conducted throughout this period). In contrast to other scrappage subsidies, like the American CARS scheme, and despite its official name, "environmental premium", the new car purchase was not tied to any environmental requirements. The demanded emission class *Euro 4*, that had to be fulfilled was mandatory for new car purchases on the EU level from January 2006, anyways. Additionally, the new car had to be continuously registered with the applicant for at least one year. Policy requirements for the new car purchased required a minimum age of nine years for the car scrapped, this led to an eligible pool of 17 million cars or 41 percent of all cars registered in Germany.[5] Moreover, under the German program the car did not have to be brand new, but a car registered to another person for at most 14 months did also qualify for the governmental subsidy of 2,500 € per vehicle. This incentive was only guaranteed to private car owners, commercial entities were excluded from AVR program.

The final report stated two main effects of the German Cash-for-Clunkers Program (BAFA, 2010). First an obvious downsizing effect in car size could be noted, as especially the smallest car segment gained most in sales if old cars scrapped and new cars bought are compared. These effects are summarized in Figure 1. Numbers indicate that the small car segment gained 20 percent in sales if one compares new cars bought under the program to cars scrapped under the policy, whereas luxury cars lost 17 percent. Another important winner are vans (+6 percent). Car registration percentages did not change considerably for sports utility, others and upper small market segments. Luxury cars and sport utility vehicles sales during the policy period were not influenced by the Accelerated Vehicle Scrappage program, as zero percent of all cars bought and scrapped belong to this group.
Before the empirical strategy is explained in the next section, the timing of the policy has to be discussed in some detail. As stated before, the Cash-for-Clunkers program passed parliament in January 14, 2009. The start of application was possible from January 27, 2009, so roughly two weeks

day, see BAFA (2010, p.9) and received 7,000 applications per day on average, see BAFA (2010, p.7).

[5]The numbers are taken from IFEU (2009), p.2.

Figure 1: Cars bought and scrapped during the German Cash-for Clunkers Program



Source: Own graphic based on BAFA(2010); upper luxury and sport utility segment, not included, amount to zero percent of cars bought and scrapped. Small segments is composed of so-called "small" and "mini" cars.

afterwards. For the empirical implementation it is important, that the car-scrappage subsidy was not extensively discussed before January 2009, as this would lead to a bias called Ashenfelters' dip problem[6] and the policy timing variable would have to be set to different months before January to capture all policy effects. However, this is not an important issue here, because the period between the discussion of the policy and the point of time it came into effect was very short.

We use the Google trends search volume index, where we search for the two German words for the policy "Umweltprämie"' and "'Abwrackprämie", to show how short the time span for a potential Ashfelter's dip was. The

[6]Ashenfelter (1978) analyzed the effect of training programs on earnings and found a potential bias caused by an individual's change in behaviour just shortly before the treatment period. The change can be attributed for example to anticipation. This anticipation leads to an adaption in behaviour, e.g. lower effort, work load etc.

corresponding graph is shown in figure 5 in the appendix and no peak in search volume is visible for November and December 2008. Therefore, and since we employ monthly data, the beginning of the policy is set to January 2009. The end of the German accelerated vehicle retirement program is not as clear cut. While the budget was exhausted on September 2, 2009, the period of new car registrations attributable to the scrappage program ends later. As the car industry suffered from substantial delivery delays at that time, because of the high demand for small cars, we set the end of the policy to December 2009, as the shortest delivery period was three months at that time. We therefore specify the end of the policy period for our empirical investigation as December 2009.

4 Empirical Analysis

4.1 Data

In order to evaluate the German Cash for Clunkers Program empirically, we gather data on new car registrations on the segment level. This data is available from the German Federal Transport Authority (KBA) on a monthly basis from March 2001 to October 2011. This data is amended by the industrial production index and the unemployment rate, available from the German Federal Statistical Office (Destatis). All variables used are not seasonally adjusted as this is done including seasonal effects into the regression to obtain comparable results for all estimates.

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
small	128	38,785	18,641	21,648	141,686
upper small	128	33,254	11,598	17,835	90,981
unemployment rate	128	8.7	1.6	5.2	12.2
industry production	128	101.9	9.8	83.2	122.7
interest rate	128	2.7	1.3	0.6	5.1
gasoline price	128	1.21	0.17	0.95	1.66

Three alterations have been made to the original data stated above. First, as stated in the previous section, commercial car holders did not qualify for the scrappage bounty and are excluded from total car registrations. The KBA introduced this differentiation on the segment level in January 2008, so there is no data available for previous months. To replace the missing data, the pecentage of private car holders is assumed to be constant for March 2001 until December 2007. This percentage is computed as the average in car holders for 2008, 2010 and 2011. The year 2009 is left out, as this period was distorted by the AVR program.[7].

Second, the absolute value of the industry production cannot be used because it may suffer from endogeneity as 12.34 percent[8] of the overall value is due to production of automobiles and automotive parts. These numbers are deducted from the total industry production aggregate, so that the altered industry production index could serve as an exogenous control variable in the time-series regression.

Third, our following analysis focuses on the two small car segments instead of all eight, as they amount to 84 percent of all cars bought under the car scrappage policy and are the natural segments to study.

4.2 Identification and Estimation Strategy

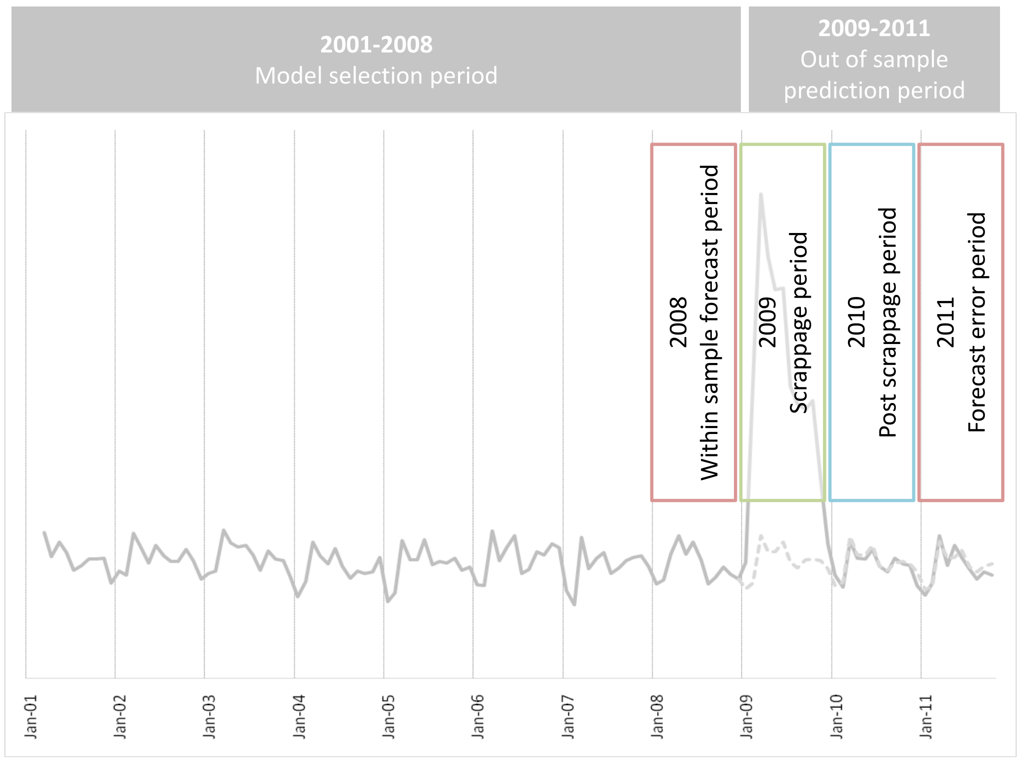
Figure 2 displays the time-series approach used to simulate the counterfactual situation. The dataset is divided into two parts: First the model selection period or pre-scrappage period and second the out of sample prediction period that encompasses the scrappage and post scrappage period. Details on the model selection period are presented in the next section which indicate whether multivariate (VAR) or univariate autoregressive models (AR) better fit the car sales patterns. This selection is confirmed by checking the within-sample forecast performance for 2008 using well established measures such as the mean absolute percentage error (MAPE) and root mean square error (RMSE) (see Celements and Hendry, 1999: 25-27 and Hamilton, 1994: 72-76). Both measures are used due to the MAPE's lower affection to outliers in comparison to the RMSE.

In the next step, the appropriate time series model, now using all data from

[7]Table 7 in the appendix states the corresponding percentages and variances of private car holders for 2008, 2010 and 2011.

[8]The numbers are taken from Destatis (2011), p.12.

Figure 2: Empirical strategy and timeline



Source: Own graphic.

2001 up to December 2008, is chosen to predict the counterfactual car registrations for the years 2009 (the scrappage period), 2010 (the first ex post period) and 2011 (October). The latter year is used to verify the forecast precision, as it is assumed that the subsidy effects will be worn out by then and the paths of the simulated and realized car registrations should be more or less equal again.

The (vector) autoregressive model, which is tested for autocorrelation and nonnormality of the residuals, contains a number of lagged endogenous and exogenous variables (see appendix for the description of the variables), which are represented through the lag operator L and N, respectively. The number of lags is determined by l and n, hence $L^l(y) = y_{t-l}$ and $N^n(x) = x_{t-n}$. So the AR and VAR model can be written in matrix form, where y_t is a scalar for the AR and a vector for the VAR model, respectively:

$$y_t = \beta(L)y_t + \delta(N)\ x_t + \gamma\ d_t + u_t \tag{1}$$

In the next step, we make dynamic predictions of the stable VAR process h steps ahead. While the observed values of the exogenous variables are incorporated in these predictions, the endogenous lagged variables for the treatment period are based on the predicted values. Such predictions, unlike the one-step-ahead forecasts, enable us to simulate the counterfactual situation, i.e. what might have happened without the scrappage program.

$$\hat{y}_{t+h} = c + \beta_1 y_{t+h-1} + ... + \beta_l y_{t+h-l} + \gamma_1 x_{t+h-1} + ... + \gamma_n x_{t+h-n} + \gamma\ d_{t+h} + u_t. \tag{2}$$

We subdivide the out of sample period into a scrappage period (2009) a period where we expect the potential influence of forwarded consumption to have an effect (2010) and a prediction error period (2011). The latter period serves as a benchmark of the forecast, which assumes that the full positive and negative effects of the scrappage program should have faded out in 2011. As a consequence, the hypotheses tested are:

- Hypothesis 1: The scrappage program has increased the total newly car registrations above the expected counterfactual level

$$\sum_{t=Jan2009}^{Dec2009} y_t - \hat{y}_t > 0$$

- Hypothesis 2: Future car purchases have not been brought forward

$$\sum_{t=Jan2010}^{Dec2010} (y_t - \hat{y}_t) = 0$$

4.3 Model Selection Criteria

An adequate time series model has to be chosen in order to forecast the counterfactual situation. Forecasting can be done either by estimating univariate or multivariate time series models. While vector autoregressive models capture the competitive relationship between small and upper small segments to some extent, we also rely on prediction error measures such as the mean absolute percentage error (MAPE) and the root mean squared error (RMSE) to decide between the different models. Let y_i be the observed value at time point $i = 1...z$ and $\hat{y}_i$ the predicted value, then

$$MAPE = \frac{1}{z}\sum_{i=1}^{z}(y_i - \hat{y})_i/y_i$$
$$RMSE = \sqrt{E[(y-\hat{y})^2]}$$

The period of model comparison encompasses the time from January to November 2008 for two reasons. First, a sample reduction is attended by a loss of degrees of freedom, hence choosing an in-sample close to the later sample size is prefered. The second problem adresses the selection of a period without any severe structural changes, such as the financial crisis, which had its observable impact on German production from December 2008 through 2009. The increase of the value-added tax in January 2007 may have brought future consumption forward in 2006, but this can be observed in the data only in a drop in registrations, ranging from December 2006 until February 2007. Including an impuls dummy to capture this very short negative effect did not deliver any significant results and is henceforth not included in the models.

It is a necessity to define the order of lags to be included using information criteria, e.g. Akaike and Schwarz-Bayes (see Lütkepohl, 2005: 137-157) first and subsequently test for stationarity applying the Augmented Dickey-Fuller test. A lag order of one and two are suggested for both the univariate as well as multivariate process (see Table 8 in the appendix). The series are found to be stationary by the means of the ADF. Estimating the model with with an autoregressive lag of one, however, produces autocorrelation in the vector autoregressive model. We therefore compare an AR(1) for upper small and small cars, respectively, with a VAR(2) model as this yields no autocorrelation and produces a stable process with normally distributed errors.

A comparison of the prediction quality as measured by MAPE and RMSE yields consistently better results with the VAR model, as the prediction error is roughly 6.78% for upper small cars and 4.66% for small cars, respectively. In addition, granger causality tests also indicate that a VAR model appears to be more appropriate as both null hypotheses for granger-causal directions are rejected.

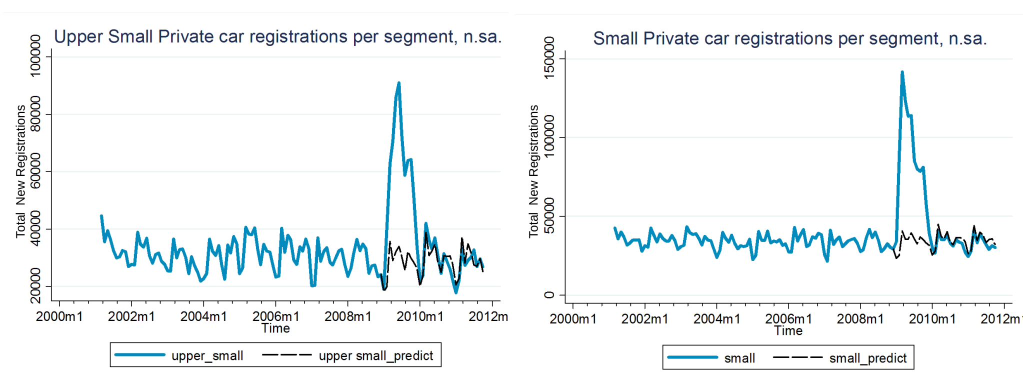
Table 3: Prediction Error, Model Selection

Series	VAR(2)	AR(1)/AR(2)
MAPE		
Small	4.66%	8.29%
Upper Small	6.78%	11.12%
RMSE		
Small	1,895.075	3,160.38
Upper Small	2,118.528	3,765.487

4.4 Results

The scrappage programm has led to an increase in new car registrations above the counterfactual situation and does not seem to have caused large pull-forward effects. The small segment seems to be slightly below the predicted values throughout the ex-post phase of the scrappage programm, indicating that sales have been brought forward on a very small level. New registration numbers for upper small cars, on the contrary, even exhibit a period where they are above the predictions and fall for the first time below the predictions in the last quarter of 2010.

Figure 3: Private car registrations per segment, n.sa.



The results of the ADF test and the residual analysis show, that there is no autocorrelation and the errors are normally distributed (see Table 14 in the appendix). The segments may exhibit some form of intersegment competition because the series significantly granger-cause each other, which supports the choice of a VAR model over an univariate model.

Table 4: Granger Causality between Segments

Excluded Variable	chi2	Prob > chi2
Small	15.882	<0.001
Upper Small	12.438	0.002

Source: Own calculation.

We now turn to the prediction of the counterfactual situation. Based on the estimation results, we dynamically predict the two time series 34 steps from January 2009 up to October 2011. In the table 5 the effects of the car scrappage program are presented (see detailed monthly results in the appendix).

Table 5: Car Scrappage Programm and Pull-Forward-Effect in absolute numbers

Month	Small	Upper Small
Scrappage Programm $\sum 2009$	630,631	373,125
Pulled-Forward Effect $\sum 2010$	-21,381	4,258
Pulled-Forward Effect $\sum 2010-11$	-44,579	-4,269

Source: Own calculation.

Three main findings strike most. First, the negative pull-forward effect for small cars seems to be outweighed by the positive effects of the scrappage program. Second, for upper small cars we found no pull-forward effect for the first months after the end of the scrappage program. Up until August 2010 the difference between the predicted values and the observed values is positive and then drops below -5000 cars. The overall sum of predicted new car registrations after 2009 is positive, which is suprising as a drop in car registrations would be expected. If the additionally incentivized cars during the scrappage program are also taken into account, the pull-forward effect would have been outweighed the effect just like in the case of the small cars. We can therefore reject the second hypothesis, but cannot reject the first.

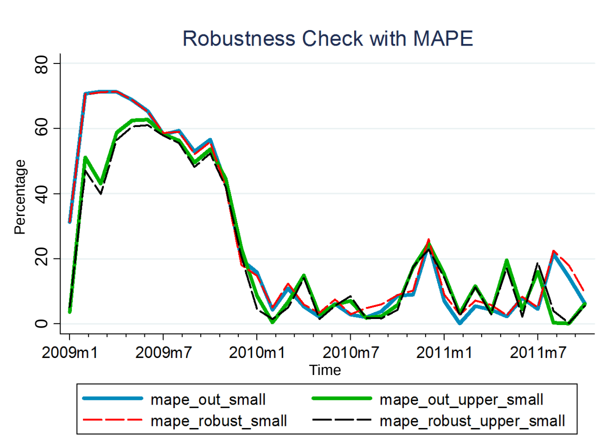
The third finding relates to the prediction error period, which we defined before as the months from January to October 2011. The deviations from the orignial series are above that of the model selection phase, but still well below 10% on average.

Table 6: Var(2) Prediction Error 2011

Series	MAPE	RMSE
Small	7.39%	2,899.291
Upper Small	8.02%	2,977.611

It could also be argued that 2011 should be included into the ex-post period of potentially brought forward consumption. However, it is not clear how long that period should be. If the data from 2011 is included in the period, the pull-forward effect is larger, but still very small in comparison to the incentived new car registrations. So the overall assessment of the policy does not change.

Figure 4: Robustness Test through MAPE Comparison



Source: Own calculation.

Finally, we check whether the results are robust by reducing the in-sample size back to the model selection period, i.e back to the end of 2007, and predict the periods from 2008 to 2011. As can be seen from the comparison of the MAPE there is only slight variation in the results, see Figure 4. While two-sample mean tests indicitate that the two models deliver statistically significantly different results for upper small cars and small cars on a 1%-Level,[9] average deviation is −0.7 and 0.9 percentage points and the largest differences below five percentage points for small and upper small cars, respectively.

Introducing the scrappage scheme seems to have been effective in terms of creating additional demand. Such an assessment, however, is purely focused on the automotive industry. The robustness of the forecasted time series can also be seen as an indicator for the actual impact of the financial crisis on car producers in Germany, meaning that all other policy measures, such as short-time work, seem to be have been succesful in stabilizing the economy. Therefore, an additional and industry-specific measure like the scrappage scheme may have been unnecessary. In addition, the one-time impulse in additional new car sales may have come at the expense of substitution of other goods, so that other industries have suffered from the car scrappage. How many of the car sales can be attributed either to a shift from a households savings to consumption or to the substitution of other consumable goods can certainly not be answered in this paper. At last, the true extent of the ex-post period of the potential pull-forward effect is unknown. It may well be that some individuals would have bought a new car two, three or four years later if not for the scrappage programm. If so, a decline in new car registrations should be expected over the next few years.

5 Conclusion

In the wake of the financial crisis in 2008, the German government set up a large investment program in order to stabilize the German economy. The German automotive industry is one of the most prominent examples, because a scrappage programm was introduced in order to stabilize the industry and replace older cars with new and more ecological cars. In this paper, we focus on the effect of the car scrappage program on new private car registrations in the small and upper small car segments. Therefore the analysis encompasses the extent to which additional new car sales have been induced in 2009 and

[9] T-Test values are -3.4066 and 3.1681 for small cars and upper small cars, respectively.

the pull-forward effect. A vector autoregressive model is used to forecast the potential new car sales before the introduction of the scrappage program and also before the outbreak of the financial crisis. While there seems to have been a small pull-forward effect for small cars, the overall impact of the scrappage program is positive, i.e., the scrappage effect is larger than the pull-forward effect. In addition, a robustness check indicates that other policy programs seem to have counterbalanced the impact of the financial crisis. In future research, it would be interesting to see what effects the scrappage program had on competition in the automobile industry. Descriptive statistics suggest that German car producers have extensively profited from the policy.

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6 Appendix

Let y denote the variable of interest, x an exogenous variable, c a constant factor, d a monthly detereministc effect and u an i.i.d. error term. Therefore, the setup of our vector autoregressive model is as follows:

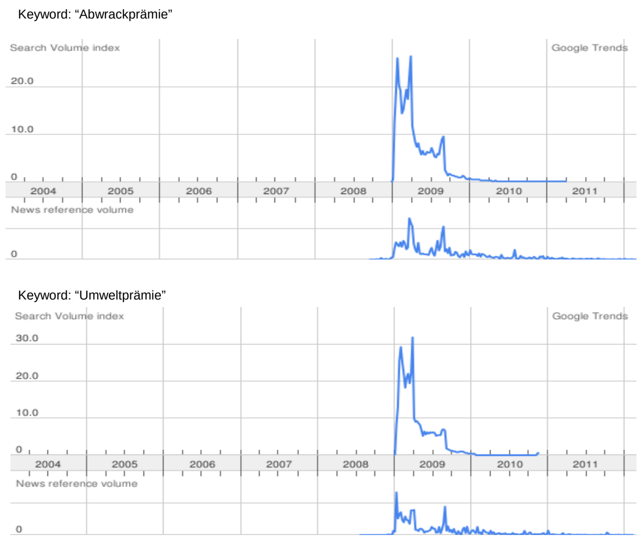
$$
\begin{aligned}
i &= small, upper\ small \\
j &= industry\ production, unemployment\ rate \\
t &= time\ period \\
l &= lag\ length\ of\ endogenous\ variable \\
n &= lag\ length\ of\ exogenous\ variable \\
y_t &= (y_{small,t}, y_{upper\ small,t}) \\
x_t &= (x_{industry\ production,t}, x_{unemployment\ rate,t}) \\
d_t &= (m_{1,t}, m_{2,t}, m_{3,t}, ...m_{11,t}) \\
u_t &= (u_{small,t} u_{upper\ small,t}) \\
\beta, \gamma, \delta &= Matrix\ of\ coefficients
\end{aligned}
$$

Table 7: Mean and variance 2008 to 2011 (without 2009) of the percentage of private car holders of all car holders per segment

	Small	Upper small
Mean	51.4	42.5
Variance	1.4	5.2

Source: Own calculations.

Figure 5: Google Trends search volume and news reference volume index



Source: Google Trends, available: http://www.google.de/trends [accessed 29 Feb 2012].

Table 8: Lag Length and Stationarity, Model Selection

Test	Small	Upper Small	VAR
Information Criteria			
SBIC	19.1586	18.9459	37.7385
AIC	18.621	18.4084	6.5252
Stationarity			
Lag Length	1	1	1/2
ADF Value Lag(1)	-6.654	-5.789	
ADF Value Lag(2)	-5.099	-5.072	
5% Cricical Value	-2.925		
10% Critical Value	-2.598		

Source: Own calculation.

Table 9: ARIMA Output, Model Selection Period, 2001m4 - 2007m12

	small	upper small
L1 small	0.28**	
	(0.12)	
L1 upper small		0.69***
		(0.08)
unemployment	784.99	317.69
	(1220.43)	(981.91)
industry prod.	179.19**	236.56***
	(76.65)	(72.58)
L1 unemployment	- 1062.50	74.04
	(1202.27)	(1022.91)
L1 industry prod	- 166.48***	- 115.05
	(63.51)	(71.91)
constant	35718.27***	14985.29
	(6346.54)	(12540.26)
monthly dummies included	yes	yes
No. of obs.	81	81
Wald chi2(16)	213.05	433.93

Note: standard errors in paranthesis; stars indicate significance levels:
*** 1%-level; ** 5%-level; * 10%-level

Table 10: VAR Output, Model Selection Period, 2001m5 - 2007m12

	small	upper small
L1 small	0.18	- 0.44***
	(0.11)	(0.09)
L2 small	0.37***	0.05
	(0.12)	(0.11)
L1 upper small	0.56***	0.71***
	(0.13)	(0.11)
L2 upper small	- 0.43***	0.10
	(0.13)	(0.11)
unemployment rate	1621.33	655.45
	(998.34)	(844.02)
L1 unemployment rate	- 175.12	1675.12*
	(1167.18)	(986.76)
L2 unemployment rate	- 1702.47*	- 2353.31***
	(981.82)	(830.05)
industry production	375.14***	299.34***
	(66.73)	(56.41)
L1 industry production	- 265.19***	- 148.33**
	(70.21)	(59.35)
L2 industry production	- 86.76	- 143.69**
	(77.5)	(65.52)
constant	12818.26*	19072.14***
	(7374.89)	(6234.87)
monthly dummies included	yes	yes
No. of obs.	80	80
RMSE	2171.78	1836.06
R squared	0.8354	0.8978

Note: standard errors in paranthesis; stars indicate significance levels:
*** 1%-level; ** 5%-level; * 10%-level

Table 11: Residual Analysis of the univariate process, Model Selection

Test	Small	Upper Small
Portmanteau Test Q-Statistic	36.5911	44.2963
Prob>chi2	0.5346	0.2232
Skewness	-0.0708212	-0.3254085
Kurtosis	2.861152	4.79931
adj. chi2 -joint*	0.08	7.26
Prob>chi2	0.9602	0.0265

Source: Own calculation.
* Test based on D'Agostino et al. (1990) and improved by Royston (1991).

Table 12: VAR Residual Analysis, Model Selection

Test	VAR(1)	VAR(2)
LM Value Lag 1	13.7739	0.8697
Prob >chi2	0.00805	0.92887
LM Value Lag 2	-	7.1267
Prob >chi2	-	0.12934
Jarque-Bera Test Value	1.216	3.072
Jarque-Bera Prob > chi2	0.87543	0.54577

Source: Own calculations.

Table 13: VAR Output, 2001m5 - 2008m12

	small	upper small
L1 small	0.21**	- 0.37***
	(0.11)	(0.09)
L2 small	0.26**	0.10
	(0.11)	(0.10)
L1 upper small	0.42***	0.70***
	(0.12)	(0.10)
L2 upper small	- 0.33***	0.07
	(0.12)	(0.1)
unemployment rate	2654.61***	1712.9**
	(880.05)	(772.32)
L1 unemployment rate	- 779.72	1570.87*
	(1034.06)	(907.47)
L2 unemployment rate	- 2081.72**	- 3206.26***
	(885.25)	(776.88)
industry production	411.66***	371.67***
	(54.28)	(47.63)
L1 industry production	- 270.2***	- 168.05***
	(61.54)	(54.01)
L2 industry production	- 118.43**	- 176.29***
	(60.27)	(52.89)
constant	16542.45***	13683.16**
	(6370.25)	(5590.45)
monthly dummies included	yes	yes
No. of obs.	92	92
RMSE	2140.94	0.83
R suared	1878.86	0.89

Note: standard errors in paranthesis; stars indicate significance levels:
*** 1%-level; ** 5%-level; * 10%-level

Table 14: VAR Residual Analysis

Test	Small	Upper Small
ADF Value	-5.410	-5.188
5% Cricical Value	-2.925	
10% Critical Value	-2.598	
LM Value Lag 1	2.8389	
Prob > chi2	0.58513	
LM Value Lag 2	5.5188	
Prob > chi2	0.23808	
Jarque-Bera Test Value	4.539	
Jarque-Bera Prob chi2	0.33792	

Source: Own calculation.

Table 15: VAR Residual Analysis, Robustness Modell

Test	Small	Upper Small
ADF Value	-5.410	-5.188
5% Cricical Value	-2.925	
10% Critical Value	-2.598	
LM Value Lag 1	0.8697	
Prob > chi2	0.92887	
LM Value Lag 2	7.1267	
Prob > chi2	0.12934	
Jarque-Bera Test Value	3.072	
Jarque-Bera Prob chi2	0.54577	

Source: Own calculation.

Table 16: Car Scrappage Programm and Pull-Forward-Effect in absolute numbers

Month	Small	Upper Small
2009m1	10636.91	693.181
2009m2	60738.58	20863.86
2009m3	101053.9	26986.76
2009m4	87762.23	41527.11
2009m5	78140.18	53650.11
2009m6	74556.4	57033.48
2009m7	49686.25	42363.68
2009m8	47604.2	33138.26
2009m9	41697.41	31683.87
2009m10	45945.42	34451.24
2009m11	25074.67	22736.15
2009m12	7735.303	7998.016
Scrappage Programm $\sum$ 2009	630631	373125
2010m1	4774.467	1914.05
2010m2	-1163.674	105.2886
2010m3	-4438.004	2838.12
2010m4	-1889.943	5399.208
2010m5	-767.3217	934.3842
2010m6	-2328.498	2210.187
2010m7	-928.1021	2164.392
2010m8	-664.6636	-445.9706
2010m9	-1356.253	752.7696
2010m10	-2912.879	-1668.609
2010m11	-2994.291	-4529.208
2010m12	-6712.125	-5416.36
Pulled-Forward Effect $\sum$ 2010	-21381	4258

Source: Own calculation.

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