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Vorsprung durch Technik: Empirical Evidence of the German Scrappage Program

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Vorsprung durch Technik: Empirical Evidence of the German Scrappage Program

Veit Böckers, Ulrich Heimeshoff and Andrea Müller*

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. In order to address this question a unique 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. 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 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 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 end of 2008 and at the start of 2009. One part of the second one was 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 press and among economists as well as at regulars' tables throughout the country and abroad. Waldermann (2009) summarizes leading German economists' and lobbyists' opinion, that all opposed to this type of fiscal policy intervention. The objections concern the favoritism of the automotive industry over other industry branches, 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 and simulate a 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 forward their car consumption from the future?
2. How big is the overall effect comparing subsidy and after subsidy period?

Results suggest that predicted car registration numbers are only slightly above the realized ones for the years 2010 and 2011, i.e. sales have been brought forward only on a small scale at least for the two smallest market segments, which make up roughly 84% of the newly registered cars. Second, an overall effect of the policy of plus 1 million cars is found. And third, a robustness check suggests that the crisis in the automobile industry wasn't as profound as usually assumed.

The paper is composed of six parts. Section two discusses the related literature on evaluations of car scrapping subsidies and part three explains the

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

features and background of the German Cash-for-Clunkers program in some detail. Section four is dedicated to the empirical strategy, comprising the data-set used, as well as methodology model set-up and results. The last part concludes.

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 guaranteed through the program. Hahn (1995) calculates a bounty of \$1,500 being the optimal amount to reach cost-effectiveness of the 1992 scrapping 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 scrapping 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, summarized in the review of Van Wee et al. (2011). These evaluations exist for car scrapping 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 scrapping schemes in terms of emission reductions. The effects are however higher if car scrapping programs are implemented in densely populated areas and stronger effects are found in the 1990s when clunkers with no emission control technologies were substituted with new cars, equipped with catalytic converters or similar technologies.²

Work that is most similar to our approach is the more recent policy evaluation literature, analyzing 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

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

1990s with a discrete choice microlevel dataset. They find transitory sales' effects shortly after the program and negative effects in the long run. In addition, they point out that from governmental budget point of view, the policy effects were negative as the expenditures are not in equal quantity compensated through additional tax revenues. This approach is partly carried on by Schiraldi (2011). He extends the discrete choice model to a structural model, as well as an examination of the used car market to analyse the effect of an Italian car scrapping policy of the 1990s. Results suggest a smaller sales effect as simulated by Adda and Cooper (2000). More 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 panel analysis techniques. Both studies use car registration data and find a short term boost in sales followed by a substantial pull forward effect after the program. The latter approach evaluates the policy with the Canadian economy serving as the control group for the former American cross-city variations in terms of participation rates in the program. Mian and Sufi (2010) find 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 a still positive sales effect until December 2009. Furthermore positive effects on employment are discovered by the authors in cities with higher exposure to the CARS-program in Mian and Sufi (2010) and can be confirmed by Li et al (2010). Above all, they calculate a cost of \$92 for each avoided ton of CO₂, 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 additional cars and 40,200 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 Cash-for Clunkers program. The governmental agency that was responsible for the implemen-

tation of the program, "Bundesamt für Wirtschaft und Ausfuhrkontrolle" (BAFA), describes the application process and 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 policy 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 best to our knowledge there is no study evaluating this subsidy in detail until so far, taking into account counterfactual simulations. Secondly we use time-series econometric models for predicting the hypothetical sales pattern in absence of the policy. This approach is chosen as the policy period and the months afterwards are quite long (34 periods) and it can be shown in the literature that panel data models have substantial bias after several months of predictions. 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

As a method to counterbalance the negative private consumption effects of the financial crisis, 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 package, so roughly 3 percent. As applications for the scrappage subsidy increased⁴, German parliament decided to increase the overall budget of the policy to 5 billion €

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

⁴During the peak of consumer demand BAFA registered 270,000 incoming calls per day, see BAFA (2010), p.9 and received 7,000 applications per day on average, see BAFA (2010), p.7.

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

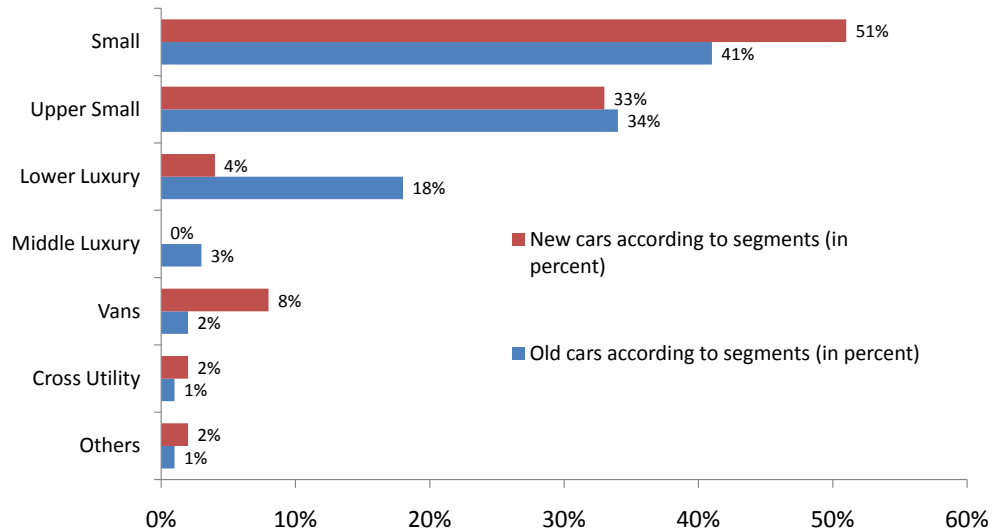
Timing	January 27, 2009 (start of application) until September 2, 2009 (budget exhausted)
Budget	5 billion Euros
Incentive	2,500 Euros per car
Old car precondition	1. Minimum age of nine years 2. Car had to be registered with the applicant for at least one year
New car precondition	1. Had to fulfill 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).

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 a 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 demanded 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.

⁵Number 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.

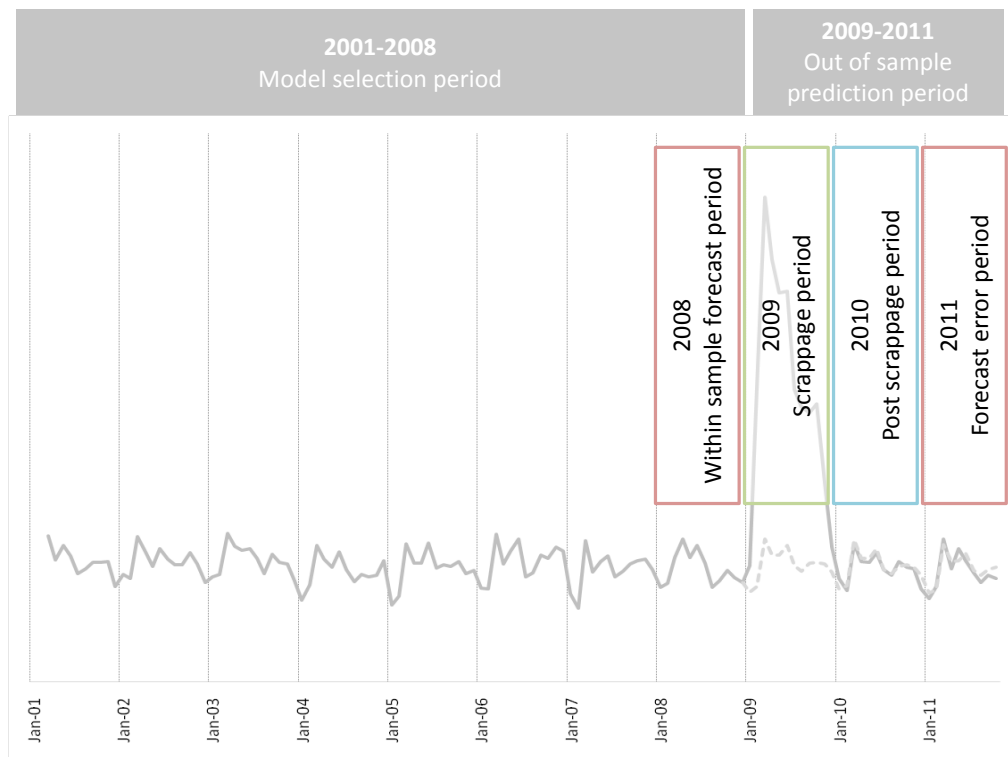
The final report BAFA (2010) stated two main effects of the German Cash for Clunkers Program. First an obvious downsizing effect in car size could be noted, as especially the smallest car segment gained most in sales if old cars scrapped and new cars bought are compared. These effects are summarized 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 afterwards. For 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 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 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 as 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 waiting time at that time was three months. We therefore specify the end of the policy period for our empirical investigation as December 2009.

4 Empirical 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 section 4.2, basically the question if multivariate (VAR) or univariate autoregressive models (AR) better fit the car sales pattern. This selection is confirmed by checking the within-sample forecast quality for 2008 using mean absolute percentage error (MAPE) and root mean square error (RMSE). We apply both tests as the MAPE is less affected by outliers in comparison of the RMSE. Subsequently, the appropriate model is used in order to predict the counterfactual car registrations for the year 2009 (the scrappage period) and 2010 (the post scrappage pe-

Figure 2: Empirical strategy and timeline



Source: Own graphic.

riod), the 10 months of 2011 are used to verify the forecast precision, as it is assumed that the subsidy effects will be worn out by then and simulated and realized car registrations should be more or less on equal paths again. The prediction results are comprehended in section 4.3. The next section deals with the data-set description and is followed by a formalization of the time-series models used.

4.1 Data

In order to evaluate the German Cash for Clunkers Program empirically, data on new car registrations on the segment level is gathered. 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 in-

dustry production in index format and the unemployment rate in percent, 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	38785	18641	21648	141686
upper small	128	33254	11598	17835	90981
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

Source: Own calculation.

Three alterations have been made to the original data stated above in order to evaluate the German Accelerated Scrappage Scheme:

First, as stated in the previous section commercial car holders did not qualify for the scrappage bounty, therefore they are excluded from total car registrations. The KBA introduced this differentiation on the segment level in January 2008, hence data is only available afterwards, but not before. Therefore the percentage 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.⁶ Throughout the following empirical strategy the absolute number of private car holders is serving as the dependent variable.

Second, the absolute value of the industry production could not be taken, as 12.34 percent⁷ 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.

⁶Table 6 in the appendix states the corresponding percentages and variances of private car holders for 2008, 2010 and 2011.

⁷Number is taken from Destatis (2011), p.12.

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 henceforth the natural segments to study.

4.2 Methodology

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

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

The (vector) autoregressive model, which is tested for autocorrelation and nonnormality of the residuals, contains a number of lagged endogenous and exogenous 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:

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

In the next step, we make dynamic predictions of the stable VAR process, denoted by h . So while the observed values of the exogenous variables are incorporated in these predictions, the endogenous lagged variables are based

on the predicted values. Such predictions, unlike the one-step-ahead forecasts, enables us to simulate the counterfactual situation, i.e. what might have happened without the scrappage program.

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

We subdivide the out of sample period into a scrappage period (2009) a period where we expect the potential negative influence of forwarded consumption to take 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

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 $i = 1 \dots z$ 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 insample close to the later sample size is preferred. The second problem addresses 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.

Before the estimation, each series is tested for its lag length using information criteria, e.g. Akaike and Schwarz-Bayes, and subsequently for stationarity using the Augmented Dickey-Fuller test. As can be seen in Table 7 in the appendix, a lag length of one is suggested for both univariate processes as well as the multivariate process, for which also two lags were suggested, and the series are stationary. Using only one lag, 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.

Table 3: Prediction Error, Model Selection

Series	VAR(2)	AR(1)/AR(2)
<u>MAPE</u>		
Small	4.66%	8.29%
Upper Small	6.78%	11.12%
<u>RMSE</u>		
Small	1895.075	3160.38
Upper Small	2118.528	3765.487

Source: Own calculation.

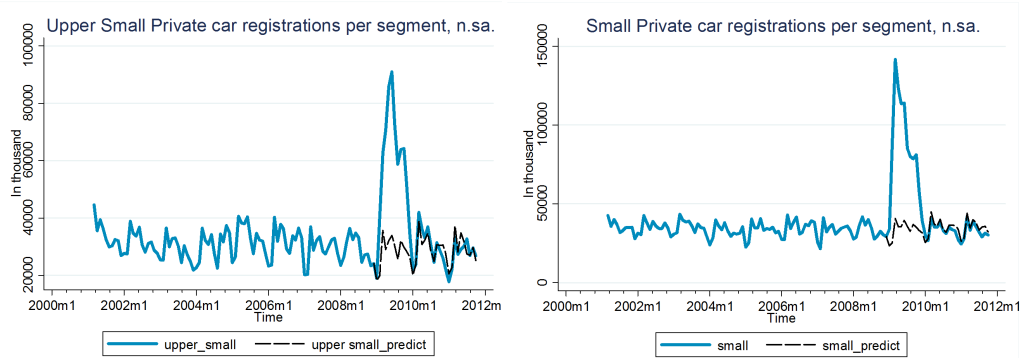
The comparison of the prediction quality as measured by MAPE and RMSE yields consistently better results with the VAR model, as the predic-

tion error is roughly 6.76% for upper small cars and 4.66% for small cars, respectively. In addition, granger causality tests also speak in favor of a VAR model as both nullhypothesis for granger-causal directions are rejected.

4.4 Results

Summarizing the 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 a very small level of sales being brought forward. New registration numbers for upper small cars, on the contrary, even exhibit a period where they are above the predictions and fall below the predictions in the last quarter of 2010.

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



Source: Own calculation.

The results of the ADF test and the residual analysis show that there is no autocorrelation and the errors are normally distributed (see Table 10 in the appendix for test results). The segments exhibit some form of intersegment competition (see appendix for the regression output). The series significantly granger-cause each other, which supports the choice of a VAR model over an univariate model.

We now turn to the prediction of the counterfactual situation. Therefore, the model dynamically predicts 34 steps from January 2009 up to October 2011. In the table 5 the effects of the car scrappage program are presented

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.

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

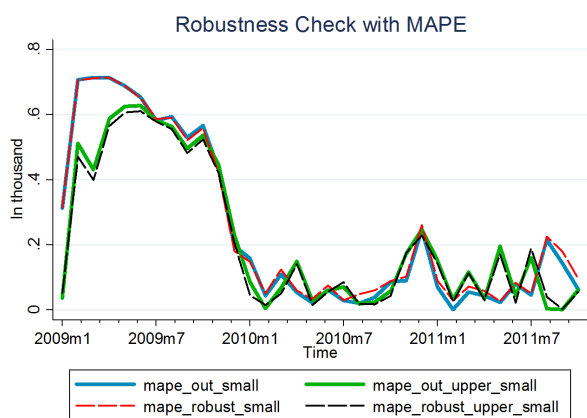
Month	Small	Upper Small
Scrappage Programm \sum 2009	630631	373125
Pulled-Forward Effect \sum 2010	-21381	4258
Pulled-Forward Effect \sum 2010 – 11	-44579	-4269

Source: Own calculation.

(see full monthly results in the appendix). Three main findings strike most. First, the negative pull-forward effect seems for small cars to be outweighed by the positive effects of the scrappage program. Second, for upper small cars there is, if the total year is considered, no pull-forward effect. Up until August 2010 the difference between the predicted values and the observed values is positive and then drops below -5000. So while the total sum is already positive, the scrappage program would have outweighed the effect anyways. We can therefore reject the second hypothesis, but cannot reject the first. The third finding relates to the prediction error, which is above that of the model selection phase, but still well below 10% on average (see Appendix). It could also be argued, that 2011 should also be included into the ex-post period of potentially brought forward consumption. It is, however, 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 is still very small in comparison to the incentivised new car registrations. So the overall assessment of the policy does not change.

Finally, we check whether the results are robust by reducing the insample 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. The means are statistically not significantly different from one another on a 1%-Level.⁸

Figure 4: Robustness Test through MAPE Comparison



Source: Own calculation.

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 program 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 the pull-forward effect. In detail, a vector autoregressive model is used to

⁸T-Test values are -0.32 and 0.07 for small cars and upper small cars, respectively. The critical values are 2.68(1%), 2.01 (5%) and 1.67 (10%).

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.

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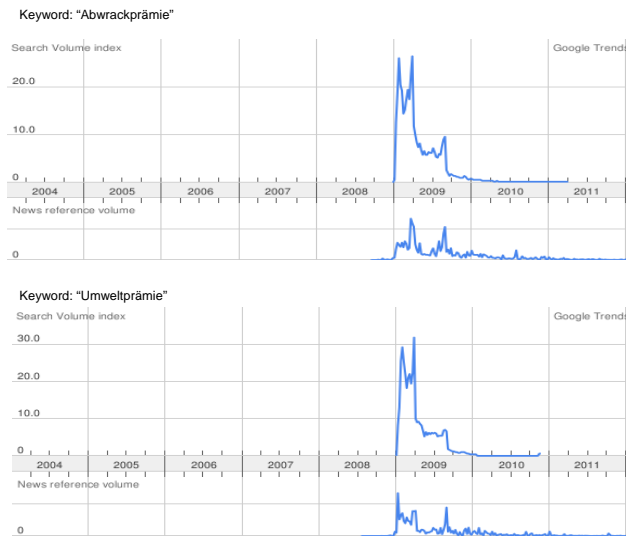
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6 Appendix

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 6: 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.

Table 7: Lag Length and Stationarity, Model Selection

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

Source: Own calculation.

Figure 6: ARIMA Output, Small, Model Selection

ARIMA regression

Sample: 2001m4 - 2007m12 Number of obs = 81
Wald chi2(16) = 213.05
Log likelihood = -737.1507 Prob > chi2 = 0.0000

	small	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]
small						
m1		-7188.213	1127.833	-6.37	0.000	-9398.726 -4977.7
m2		-6950.71	1297.827	-5.36	0.000	-9494.403 -4407.016
m3		5544.132	2395.738	2.31	0.021	848.5724 10239.69
m4		3150.11	1515.415	2.08	0.038	179.9506 6120.269
m5		1974.012	1578.877	1.25	0.211	-1120.529 5068.553
m6		3753.536	1575.504	2.38	0.017	665.6057 6841.467
m7		-982.1734	1289.121	-0.76	0.446	-3508.804 1544.457
m8		-836.4845	1563.312	-0.54	0.593	-3900.519 2227.55
m9		-1245.989	1862.117	-0.67	0.503	-4895.67 2403.692
m10		312.7463	1398.156	0.22	0.823	-2427.589 3053.082
m11		-306.8014	1569.531	-0.20	0.845	-3383.026 2769.423
unemployme		784.9938	1220.428	0.64	0.520	-1607.002 3176.99
industry_p		179.1892	76.65303	2.34	0.019	28.952 329.4264
unemployme						
L1.		-1062.497	1202.265	-0.88	0.377	-3418.893 1293.899
industry_p						
L1.		-166.4836	63.51233	-2.62	0.009	-290.9655 -42.00172
_cons		35718.27	6346.535	5.63	0.000	23279.29 48157.25
ARMA						
ar						
L1.		.2760226	.1228667	2.25	0.025	.0352083 .5168368
/sigma		2167.282	210.459	10.30	0.000	1754.79 2579.774

Source: Own calculation.

Figure 7: ARIMA Output, Upper Small, Model Selection

ARIMA regression

Sample: 2001m4 - 2007m12 Number of obs = 81
Wald chi2(16) = 433.93
Log Likelihood = -728.6658 Prob > chi2 = 0.0000

upper_small	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
upper_small						
m1	-5799.289	1065.689	-5.44	0.000	-7888	-3710.577
m2	-5472.021	1780.372	-3.07	0.002	-8961.486	-1982.557
m3	5609.088	1809.501	3.10	0.002	2062.53	9155.645
m4	3073.428	1579.2	1.95	0.052	-21.74729	6168.602
m5	4281.71	1629.055	2.63	0.009	1088.82	7474.6
m6	4264.416	3128.409	1.36	0.173	-1867.154	10395.99
m7	-497.0899	2462.705	-0.20	0.840	-5323.902	4329.722
m8	-2467.01	1986.919	-1.24	0.214	-6361.3	1427.28
m9	-440.305	1779.658	-0.25	0.805	-3928.371	3047.761
m10	-188.254	1446.006	-0.13	0.896	-3022.374	2645.866
m11	249.252	1264.984	0.20	0.844	-2230.071	2728.575
unemployme	317.6923	981.9137	0.32	0.746	-1606.823	2242.208
industry_p	236.5683	72.58409	3.26	0.001	94.30605	378.8305
unemployme						
L1.	74.04456	1022.915	0.07	0.942	-1930.833	2078.922
industry_p						
L1.	-115.0531	71.91026	-1.60	0.110	-255.9946	25.88845
_cons	14985.29	12540.26	1.19	0.232	-9593.172	39563.74
ARMA						
ar						
L1.	.6864007	.0810541	8.47	0.000	.5275377	.8452637
/sigma	1945.081	169.9472	11.45	0.000	1611.991	2278.171

Source: Own calculation.

Table 8: 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).

Figure 8: VAR Output, Model Selection

Vector autoregression

Sample: 2001m5 - 2007m12
 Log likelihood = -1411.931
 FPE = 2.27e+13
 Det(Sigma_ml) = 7.33e+12

No. of obs = 80
 AIC = 36.39827
 HQIC = 36.92353
 SBIC = 37.70839

Equation	Parms	RMSE	R-sq	chi2	P>chi2
small	22	2171.78	0.8354	406.0253	0.0000
upper_small	22	1836.06	0.8978	702.6031	0.0000

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
small					
small					
L1.	.1719747	.1118237	1.54	0.124	-.0471958 .3911452
L2.	.3736223	.1248854	2.99	0.003	.1288514 .6183931
upper_small					
L1.	.5669256	.1329197	4.27	0.000	.3064078 .8274433
L2.	-.4336494	.1283919	-3.38	0.001	-.6852928 -.182006
m1	-5654.752	1341.697	-4.21	0.000	-8284.43 -3025.075
m2	-3868.169	1586.992	-2.44	0.015	-6978.616 -757.7232
m3	6069.95	2025.971	3.00	0.003	2099.121 10040.78
m4	-3332.369	1957.662	-1.70	0.089	-7169.315 504.5779
m5	1619.458	1561.08	1.04	0.300	-1440.201 4679.118
m6	-293.8989	1538.601	-0.19	0.849	-3309.501 2721.703
m7	-4765.414	1430.361	-3.33	0.001	-7568.87 -1961.958
m8	561.8542	1211.976	0.46	0.643	-1813.575 2937.284
m9	-1155.32	1662.835	-0.69	0.487	-4414.418 2103.777
m10	-3529.074	1753.418	-2.01	0.044	-6965.71 -92.4392
m11	-2129.081	1394.215	-1.53	0.127	-4861.692 603.5307
unemploye-e					
--.	1621.339	998.3409	1.62	0.104	-335.3728 3578.052
L1.	-175.1245	1167.18	-0.15	0.881	-2462.755 2112.506
L2.	-1702.473	981.8172	-1.73	0.083	-3626.799 221.8538
industry_p-n					
--.	375.1423	66.72576	5.62	0.000	244.3622 505.9224
L1.	-265.1903	70.20677	-3.78	0.000	-402.7931 -127.5876
L2.	-86.75586	77.49855	-1.12	0.263	-238.6502 65.13851
_cons	12818.26	7374.886	1.74	0.082	-1636.252 27272.77
upper_small					
small					
L1.	-.443674	.094538	-4.69	0.000	-.628965 -.2583829
L2.	.0493683	.1055806	0.47	0.640	-.1575658 .2563024
upper_small					
L1.	.7065403	.1123729	6.29	0.000	.4862935 .9267872
L2.	.098051	.108545	0.90	0.366	-.1146933 .3107953
m1	-4958.24	1134.297	-4.37	0.000	-7181.421 -2735.059
m2	-5310.169	1341.674	-3.96	0.000	-7939.802 -2680.537
m3	5634.661	1712.795	3.29	0.001	2277.644 8991.678
m4	899.002	1655.046	0.54	0.587	-2344.828 4142.832
m5	4211.909	1319.767	3.19	0.001	1625.212 6798.605
m6	1695.362	1300.763	1.30	0.192	-854.0872 4244.812
m7	-2858.315	1209.255	-2.36	0.018	-5228.412 -488.2188
m8	-2442.388	1024.629	-2.38	0.017	-4450.623 -434.1527
m9	965.8012	1405.794	0.69	0.492	-1789.504 3721.106
m10	-1078.353	1482.374	-0.73	0.467	-3983.752 1827.046
m11	226.3826	1178.697	0.19	0.848	-2083.821 2536.586
unemploye-e					
--.	655.4457	844.017	0.78	0.437	-998.7973 2309.689
L1.	1675.122	986.757	1.70	0.090	-258.8858 3609.131
L2.	-2353.311	830.0476	-2.84	0.005	-3980.174 -726.4473
industry_p-n					
--.	299.3389	56.41127	5.31	0.000	188.7749 409.903
L1.	-148.3341	59.35419	-2.50	0.012	-264.6662 -32.002
L2.	-143.6903	65.5188	-2.19	0.028	-272.1048 -15.27584
_cons	19072.14	6234.874	3.06	0.002	6852.007 31292.26

Source: Own calculation.

Table 9: 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 10: VAR Residual Analysis

Test	Small	Upper	Small
ADF Value	-5.410		-5.188
5% Critical 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 11: Prediction Error 2011

Series	VAR(2)
<u>MAPE</u>	
Small	7.39729%
Upper Small	8.02839%
<u>RMSE</u>	
Small	2899.291
Upper Small	2977.611

Source: Own calculation.

Figure 9: VAR Output

Vector autoregression

Sample: 2001m5 - 2008m12
 Log likelihood = -1627.857
 FPE = 2.13e+13
 Det(Sigma_m1) = 8.02e+12

No. of obs = 92
 AIC = 36.34472
 HQIC = 36.8315
 SBIC = 37.55079

Equation	Parms	RMSE	R-sq	chi2	P>chi2
small	22	2140.94	0.8343	463.2214	0.0000
upper_small	22	1878.86	0.8881	730.4639	0.0000

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
small						
small						
L1.	.2148061	.1072136	2.00	0.045	.0046714	.4249408
L2.	.2631259	.1121972	2.35	0.019	.0432235	.4830283
upper_small						
L1.	.4171865	.1195261	3.49	0.000	.1829196	.6514534
L2.	-.3311664	.1176686	-2.81	0.005	-.5617925	-.1005402
m1	-6511.216	1179.577	-5.52	0.000	-8823.144	-4199.288
m2	-5371.91	1383.386	-3.88	0.000	-8083.297	-2660.523
m3	4024.302	1730.705	2.33	0.020	632.1835	7416.421
m4	-2318.08	1791.532	-1.29	0.196	-5829.419	1193.259
m5	1965.474	1382.922	1.42	0.155	-745.0036	4675.951
m6	-327.3596	1416.05	-0.23	0.817	-3102.766	2448.047
m7	-4817.361	1315.403	-3.66	0.000	-7395.503	-2239.218
m8	-77.1321	1108.569	-0.07	0.945	-2249.888	2095.624
m9	-2598.506	1526.122	-1.70	0.089	-5589.65	392.637
m10	-3519.568	1601.76	-2.20	0.028	-6658.96	-380.1751
m11	-2628.264	1224.747	-2.15	0.032	-5028.723	-227.8043
unemploye~e						
--.	2654.608	880.0464	3.02	0.003	929.7488	4379.468
L1.	-779.7196	1034.055	-0.75	0.451	-2806.431	1246.992
L2.	-2081.724	885.2485	-2.35	0.019	-3816.779	-346.6683
industry_p~n						
--.	411.6617	54.27509	7.58	0.000	305.2845	518.0389
L1.	-270.1958	61.54368	-4.39	0.000	-390.8192	-149.5724
L2.	-118.4256	60.26971	-1.96	0.049	-236.5521	-.2991849
_cons	16542.45	6370.252	2.60	0.009	4056.986	29027.92
upper_small						
small						
L1.	-.3681842	.0940892	-3.91	0.000	-.5525957	-.1837727
L2.	.0973108	.0984627	0.99	0.323	-.0956726	.2902943
upper_small						
L1.	.6950619	.1048946	6.63	0.000	.4894724	.9006515
L2.	.0697126	.1032644	0.68	0.500	-.1326818	.2721071
m1	-5352.7	1035.181	-5.17	0.000	-7381.618	-3323.783
m2	-5565.879	1214.041	-4.58	0.000	-7945.357	-3186.402
m3	4284.745	1518.844	2.82	0.005	1307.867	7261.624
m4	584.5608	1572.225	0.37	0.710	-2496.944	3666.065
m5	4160.057	1213.634	3.43	0.001	1781.378	6538.736
m6	971.4672	1242.707	0.78	0.434	-1464.193	3407.127
m7	-3390.318	1154.38	-2.94	0.003	-5652.862	-1127.775
m8	-2468.511	972.8657	-2.54	0.011	-4375.293	-561.7291
m9	-421.0232	1339.304	-0.31	0.753	-3046.011	2203.965
m10	-2020.23	1405.684	-1.44	0.151	-4775.319	734.86
m11	-967.0149	1074.822	-0.90	0.368	-3073.626	1139.597
unemploye~e						
--.	1712.896	772.3172	2.22	0.027	199.1823	3226.61
L1.	1570.869	907.4734	1.73	0.083	-207.746	3349.485
L2.	-3206.261	776.8824	-4.13	0.000	-4728.923	-1683.6
industry_p~n						
--.	371.6663	47.6311	7.80	0.000	278.3111	465.0215
L1.	-168.0487	54.00992	-3.11	0.002	-273.9062	-62.19119
L2.	-176.2905	52.8919	-3.33	0.001	-279.9568	-72.62432
_cons	13683.16	5590.449	2.45	0.014	2726.083	24640.24

Source: Own calculation.

Table 12: VAR Residual Analysis, Robustness Modell

Test	Small	Upper	Small
ADF Value	-5.410		-5.188
5% Critical 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 13: 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.