Scrapping Subsidies during the Financial Crisis - Evidence from Europe

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Abstract

We study the effects of car scrapping subsidies in Europe during the financial crisis. We make use of a rich data set of all car models sold in eight European countries, observed at a monthly level during 1998-2011. We employ a difference-in-differences approach, exploiting the fact that different countries adopted their programs at different points in time. We find that the scrapping schemes played a strong role in stabilizing total car sales in 2009: they prevented a total car sales reduction of 30.5% in countries with schemes targeted to low emission vehicles, and a 29.0% sales reduction in countries with non-targeted schemes. We find evidence of crowding out due to substitution from non-eligible to eligible cars in France and Spain. Because eligible cars tend to be more fuel efficient, targeted scrapping schemes had significant environmental benefits in the form of improved fuel consumption: without the schemes, the average fuel consumption of new purchased cars would have been 3.6% higher. Those benefits did not materialize under non-targeted schemes, in which the fuel consumption would have been only 0.7% higher absent the scheme. Finally, we find some evidence that domestically produced cars benefited at the expense of foreign competitors especially in countries where the schemes were not targeted.

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1 Introduction

The European automotive sector has been particularly and significantly affected by the most recent financial turmoil and the severe economic downturn. The sector has been hit by a sharp and uniform drop in demand for passenger cars. From 2000 until the first half of 2008, new passenger car registrations in Western Europe ranged from 14.2 to 14.8 million units on a yearly basis. In the second half of 2008 car registrations dropped dramatically, which led to a number of temporary plant closures and layoffs, and to a low rate of capacity utilization. While car registrations temporarily stabilized at 13.7 million units in 2009, they dropped further to 13.0 million units in 2010.[1] At the same time, many automotive companies have reported problems with access to credit financing, in particular in getting loans on reasonable terms.

In response to the financial and economic crisis, many European countries have introduced scrapping programs to foster car purchases, and thus cushion the impact of the sharp downturn on their domestic car production industry (see e.g. Car Communication (2009)[2], IHS Global Insight (2010a), IHS Global Insight (2010b), ACEA (2010) for an overview). The schemes were most active in 2009, and they were also introduced in other parts of the world, e.g. the US Car Allowance Rebate System (CARS) of 2009 or so called “Cash for Clunkers” Program, or Japanese Eco-Friendly Vehicle Purchase Program of 2009.

The concept of car scrapping schemes is simple: vehicle owners receive state money to trade in their old vehicles for new, usually more fuel-efficient ones. The schemes’ underlying rationale is also straightforward: for countries with significant car production, a fall in demand for vehicles would raise the risk of bankruptcies and unemployment, thereby triggering severe consequences for workers in the car industry and for the industry’s suppliers and distributors. Hence, for the major car-producing countries, the scrapping programs serve to promote car purchases to adjust strong pro-cyclical demand behavior, and consequently to save production and jobs.

However, scrapping schemes are not new for the past crisis. They have also been widely used before the crisis, mainly to reduce carbon dioxide (CO_2) and other emissions by taking older, more polluting cars off the road, or to improve road safety by reducing the age of the car fleet on the roads and by selling new cars with better equipment (such as ABS, ESC, airbags and navigation systems). These environmental motives can especially be strong in countries that have little or no domestic car production.

[1] The figures are based on the statistics for new car registrations in Western Europe, published by the European Automobile Manufacturers’ Association (ACEA) in its EU Economic Report in July 2011.

[2] Commission Communication “Responding to the Crisis in the European Automotive Industry” COM(2009) 104 (“Car Communication” thereafter).

In this paper we study the impact of the scrapping schemes that were adopted during the recent economic crisis. Our first main question deals with the incentive effects of the scrapping schemes. To which extent did the schemes stimulate total demand for cars, or at least did they serve to temporarily stabilize demand? And to which extent did the scrapping schemes also stimulate the demand for fuel-efficient cars and subsequently yield environmental benefits in the form of fuel consumption savings on new purchased vehicles? Our second question is on crowding our effects: was there substitution from non-eligible to eligible cars, or intertemporal substitution? Our third question is whether the scrapping schemes affected production and the characteristics of newly sold cars: did domestic firms benefit more than their foreign competitors, and did volume brands win at the expense of premium brands?

To address these questions we collected a unique dataset that enables us to combine the specific features of the European scrapping schemes with detailed data on car sales and product characteristics. We use monthly data for the period 2005-2011, and focus on eight European countries: Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and the United Kingdom. These countries make up for 90% of the car sales in the European Union. To estimate the impact of the scrapping schemes we follow a difference-in-differences approach, exploiting the fact that the specific timing of the scrapping schemes differed between countries. We also account for heterogeneity in the effects of scrapping programs across countries and identify country-specific effects of the scrapping schemes by focusing the estimation on one treatment country at the time while using the same control country, Belgium, in which scrapping policies were not implemented. We distinguish between targeted and non-targeted schemes. Targeted schemes provide a subsidy if the new car satisfies certain environmental eligibility criteria (mainly based on CO_2 emissions), and were adopted in France, Italy, Portugal and Spain. Non-targeted schemes provide a subsidy regardless of the new car that is purchased. These were introduced in Germany, the Netherlands and the United Kingdom.

Our empirical findings can be summarized as follows. First, scrapping schemes had a strong stabilizing impact on total car sales, especially in countries with targeted schemes: if there had been no schemes in 2009, total sales would have been 30.5% lower in the countries with targeted schemes, and 29.0% lower in countries with non-targeted schemes. Although scrapping policies stabilized sales in all countries, their individual performance varies considerably: a 1% increase in the subsidy raises sales of cars in Germany (implementing a non-targeted scheme) by 3.8%, while in other countries with non-targeted schemes the effect is lower: 2.9% in the Netherlands and 1.3% in the UK. The heterogeneity is evident also in countries with targeted schemes: for example, a 1% increase in subsidy raises sales by

9.1% in France and 5.3% in Italy. Crowding out effects due to substitution from non-eligible to eligible cars (with better fuel efficiency) are sizeable in France and Spain where, during the targeted schemes, sales of non-eligible cars were negatively affected during the period when the scheme is effective. As a result, the targeted scrapping schemes had significant environmental benefits in the form of improved fuel consumption of new purchased cars: absent the schemes, average fuel consumption would have been 3.6% higher in countries with targeted schemes. Those benefits did not materialize under non-targeted schemes, in which fuel consumption would have been only 0.7% higher absent the scheme. That is, the main effect of European scrapping schemes in the financial crisis was to temporarily stabilize total car sales, and their impact on the demand for fuel-efficient cars and related environmental benefits in the form of improved fuel consumption was significant only under targeted schemes that were explicitly designed to encourage the adoption of low-emission vehicles.

Second, intertemporal substitution effects are generally small, apart from Germany, in which sales would have been 30.4% higher during the first three months of 2010, after the end of the scrapping scheme. Third, the scrapping schemes had various effects on production. Scrapping schemes benefited domestic production: domestic producers gained proportionally more than foreign ones from scrapping subsidies when the programs were non-targeted (as in Germany and the United Kingdom). We find only some limited evidence that the schemes caused severe production imbalances and saturated plant capacity with the need to increase imports to satisfy the increased domestic demand for cars, not produced locally. Finally, premium brands lost market share in favor to volume brands only in the case of targeted schemes.

Our study is timely for two major reasons: (i) most empirical work on the incentive effects of scrapping schemes has focused on non-crisis times, and has not compared the effects on total car sales with benefits on fuel consumption; (ii) no work has considered the effects on competition and production. We discuss both contributions in turn.

First, despite a number of theoretical and policy studies related to scrapping subsidies, there are just a few studies that empirically investigate the economic effects of scrapping schemes.[3] Some authors apply a dynamic structural framework that enables them to differentiate between the short-term and long-term effects of scrapping schemes on sales of new cars and to analyze the effects of schemes on the used car market, for instance Adda and

[3] Theoretical papers on the design of "cash-for-scrappage" subsidies are, for instance, Hahn (1995), Alberini et al. (1995), Esteban (2007). Policy papers include the automotive consultancy IHS Global Insight (IHS Global Insight (2010a), IHS Global Insight (2010b)), which has analysed economic, environmental and road safety effects of European scrapping schemes introduced in response to the last financial and economic crisis in the study for the European Commission. Several other policy studies concentrate on the environmental or safety impacts of scrapping schemes (e.g. OECD (1999), OECD/ITF (2011)).

Cooper (2000) for French scrapping subsidies between 1994 and 1996, or Schiraldi (2011) for Italian scrapping subsidies in 1997 and 1998.[4] While these papers focus on scrapping schemes in non-crisis times, only a few studies estimated the car demand effects of schemes during the last financial and economic crisis. Mian and Sufi (2012) and Li et al. (2013) apply a difference-in-differences approach to quantify the sales effects of the US CARS program: Mian and Sufi (2012) use variation across the US cities in ex-ante exposure to the program (based on the number of available clunkers), while Li et al. (2013) choose Canada as a control group for identification. These US studies find positive short-term effects of the program on car sales, but this effect erodes if a longer time horizon is considered.[5]

With our study, we aim to contribute to this empirical literature on the economic effects of scrapping programs, using a panel data approach and exploiting country-by-country program variation to identify the impact of scrapping policies (i.e. a country difference-in-differences approach). For this purpose, we exploit a unique monthly car model-level dataset, enriched with detailed data on the timing and design of the scrapping schemes and information on the location of production, for a rich sample of eight European countries. This enables us to systematically compare the total sales effects with the fuel consumption benefits of the different types of schemes. Our study also fits well into the more general empirical literature related to the *ex post* evaluation of competition policy, applied in the context of scrapping incentives in our paper.[6]

Second, apart from the total sales effects of scrapping programs and their impact on the demand for fuel-efficient cars, we study their effect on competition and production in the light of the European Commission's policy towards scrapping subsidies. There is no notification requirement for state aid and no formal assessment of scrapping schemes by the

[4]The authors find that the scrapping policies stimulate car sales in the short run, followed by a sales contraction in the long run. Licandro and Sampayo (2006), using a hazard function approach and ignoring the second-hand market, find a high positive effect of 1997 Spanish scrapping subsidy on sales in the short run, but small in the long run.

[5]Cooper et al. (2010) and Copeland and Kahn (2011) estimate a time-series forecasting model to predict counterfactual sales. Busse et al. (2012) study the price effects of the US CARS Program and find evidence for considerable consumer benefits due to three reasons: 1) consumers benefited fully from the scrapping rebates, 2) consumers gained even more since the program stimulated car producers to increase their own rebates, 3) the program had little effect on the prices in the used car market. Since we only observe list prices and not transaction prices, we cannot unfortunately quantify the price (pass-through) effects of scrapping subsidies.

[6]The difference-in-differences approach has become a standard method in the *ex post* evaluation of competition policy. Compared to most *ex post* merger studies (for instance, Ashenfelter et al. (2009), Ashenfelter and Hosken (2010), Weinberg (2011)), we use a country difference-in-differences approach rather than choose a control product group (i.e. products not affected by the merger) in the same geographic market for identification. Only a few studies rely on another geographic market as a control group (for instance, Hosken et al. (2011)). Several papers use the difference-in-differences approach also to investigate the impact of cash promotions, e.g. Busse et al. (2006) in the context of auto manufacturer promotions.

European Commission, although the Commission recognizes their possible adverse effects on competition and trade.[7] In particular, the Commission requires that scrapping schemes are non-discriminatory with respect to the origin of a car. That is, the schemes should avoid favouring only the sale of vehicles of domestic manufacturers by including, for instance, car characteristics, which could discriminate against similar cars coming from other member states. Moreover, the schemes should be compatible with other parts of Community legislation, in particular concerning type-approval of vehicles (Euro IV emission limit values). Therefore, there is a notification requirement for the conditions of schemes related to the technical characteristics of cars at draft stage. The Commission has the right to issue comments on the technical specifications where the fiscal or financial incentives can potentially hinder trade in the internal market. However, no official decision of the Commission is yet published.

Empirical evidence on the effects on competition and production of schemes is very scarce. For instance, IHS Global Insight (2010a) discuss the market structure effects of "crisis" scrapping schemes and argue that market segments, including medium and large cars as well as premium and luxury vehicles, only marginally benefited from the schemes. OECD (1999) also report higher benefits of scrapping schemes for the producers of small cars at the expense of large cars. Li et al. (2013) argue that Japanese car producers Toyota, Honda and Nissan benefited much more from the targeted US CARS Program than other firms. Overall, the program has not however led to any significant shifts in market shares among car producers. As there is hardly any comprehensive analysis of competitive and trade effects of schemes in the existing empirical studies, we aim to fill in this gap in the literature. Generally, our rich empirical evaluation of scrapping subsidies' effects follows the structure of economic compatibility assessment by the European Commission in the case of state aid (that balances its positive and negative effects) that we implement in the context of scrapping incentives.

The rest of the paper is organized as follows. Section 2 provides an overview of the design and economic assessment of scrapping schemes related to our sample of European countries. Section 3 presents our empirical approach to the analysis of scrapping schemes. We first describe the data, and then depict our identification and estimation strategy. In Section 4 we discuss our empirical findings. Conclusions follow in Section 5.

[7]The Car Communication - Annex 3, "Guidance on Scrapping Schemes for Vehicles", summarizes the policy of the European Commission towards scrapping schemes.

2 Design and economic assessment of scrapping schemes

2.1 Definition and design of scrapping schemes

Many European countries have introduced large-scale scrapping programs as an economic stimulus to increase market demand for the car sector during the last financial and economic crisis.[8] Scrapping schemes have been formulated in a variety of ways. Most of them are designed to take old (polluting) cars off the road and to replace them typically with new, or younger (more fuel-efficient) models. Such schemes are called "cash-for-replacement".[9] Only rarely a scheme is designed as "cash-for-scrappage", i.e. without any condition on the age of a replacement car or obligation to purchase a replacement car at all.[10] Generally, scrapping schemes put different conditions on the duration of the program, the size of the incentive, the form of the incentive (tax rebates, price discounts, etc.), the age of the old vehicle which is retired and scrapped, and the conditions on a new vehicle that can be purchased. We discuss these features in more detail below.

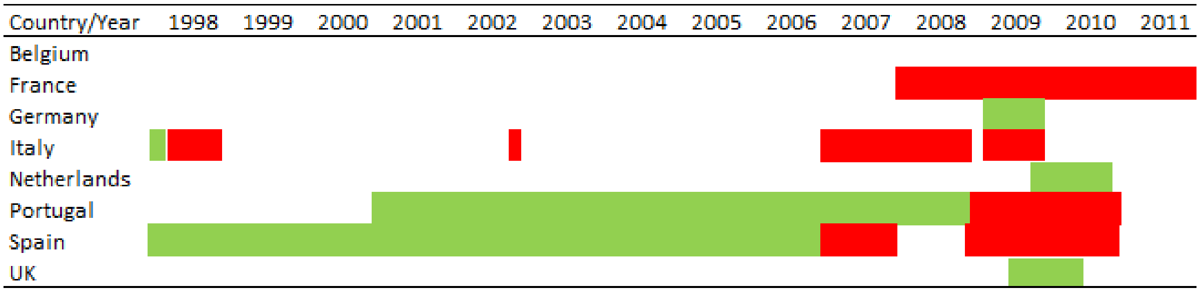
Duration First, scrapping schemes differ in their duration, as shown in Figure 1. Some countries introduce schemes that run for several years (e.g. Portugal and Spain), whereas other schemes have a short duration to temporarily stimulate demand (as, for instance, during the most recent economic crisis in Germany, the United Kingdom, etc.). Some countries phase out their scrapping schemes gradually (e.g. in France that gradually reduced the incentive size from €1,000 in 2009 to €750 in the first half of 2010 and to €500 in the second half of 2010), while other countries end them abruptly (e.g. in Germany). We will account for these varying intensities in our empirical analysis. For example, France is part of the treatment group between 2008 and 2011, while part of the control group in other years.

[8] In our discussions we focus on eight European countries: Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and the United Kingdom, for which we do our empirical analysis. Only Belgium has not adopted any scrapping scheme at all.

[9] The 2009 US "Cash for Clunkers" Program falls under this type of scrapping incentives.

[10] OECD (1999) introduced the distinction between "cash-for-replacement" and "cash-for-scrappage" subsidies. The Greek scheme of 2009 is an example of "cash-for-scrappage" scheme as it was not conditioned on the purchase of a new car.

Figure 1: Timing of scrapping schemes in selected European countries



The figure depicts scrapping schemes in eight European countries based on IHS Global Insight, ACEA and various national sources. The official duration of a scheme is given (i.e. not taking into account the extended period for registration, usually up to three months). Red color means that a scheme is "targeted". Green color means that a scheme is "non-targeted".

Size Scrapping schemes differ in their intensity as reflected by the size of incentive and overall government budget available for a scheme, and subsequently the maximum number of cars that can be purchased under the scheme (see Table A.1 in Appendix). In 2009 the scrapping subsidies varied from €1,000 (e.g. in France) to €2,500 (in Germany).[11] Incentives are usually financed by the government (either central or local), but car manufacturers may commit themselves to contribute to the incentive as well (e.g. 50:50 incentive in the United Kingdom). The German Government introduced the most generous scrapping program in 2009 (with an overall budget of €5 billion).[12]

Targeted versus non-targeted Scrapping schemes differ in their eligibility criteria. We will distinguish between targeted schemes (red/dark shading in Figure 1) and non-targeted schemes (green/light shading). Targeted schemes put conditions on a new vehicle that can be purchased, in terms of maximum CO_2 emissions, engine displacement, or price. For instance, in France cars with CO_2 emissions that do not exceed 160 grams per kilometer were eligible for the scrapping program in 2009. Conversely, non-targeted schemes apply widely to virtually all cars in the country. For instance, in Germany the condition on new cars is rather lax:

[11] The choice of optimal incentive size is far from obvious. For instance, Esteban (2007) argues that a subsidy lower than the price of a used car in the absence of subsidy can still induce scrappage. Alberini et al. (1995) argue that at low offer prices, vehicles that are in the poorest conditions, with relatively short remaining life are likely to be scrapped. At higher offer prices, vehicles in a better condition, with longer expected lives will be attracted under the scheme.

[12] Usually scrapping schemes foresee a fixed budget and state the final date of a scheme, or specify that the scheme ends as soon as the budget expires. In the case of the former condition, there might be a spyke in sales in the last month(s) of the scheme. In the case of the latter condition, the program may have a stronger effect on sales at the beginning (Li et al. (2013)).

eligible vehicles have to meet Euro 4 emission standards, which is automatically satisfied for all cars since the European Commission introduced these standards in 2005. Under some schemes, an old car may be purchased as a replacement car as well (e.g. up to one year old in Germany, or up to eight years old in the Netherlands).

Age The effectiveness of schemes in stimulating car purchases may also differ depending on conditions put on the age of a vehicle that can be scrapped (i.e. only vehicles older than a certain age are eligible for the scheme) and, consequently, the age of the existing car fleet and its vintage distribution in a country.[13] The lowest minimum age requirement for scrapped cars is 8 years (in Portugal). The highest age requirement is 15 years (e.g. in France in 2008 and in 2011). A higher age threshold for a scrapped car may narrow the base for the scheme and lower its overall success measured by the number of vehicles sold all other things being equal.[14] On the other hand, it may ensure that the most polluting cars are scrapped and thus render higher environmental benefits.[15]

Complexity In general, some European countries have introduced simple transparent scrapping schemes. For instance, in Germany there was one incentive of €2,500 for any type of new car purchased in the form of price discount, which might be clear and appealing to consumers. On the other hand, other countries have approved more complex schemes with a system of subsidies depending on the type of vehicle. For instance, the Italian scrapping scheme in 2002 had a number of conditions that determined the size of incentive depending on engine displacement, which eventually might make the program less comprehensive to consumers (who cannot correctly assess the associated benefits) and, therefore, might limit the scheme's success. Past Spanish scrapping schemes are also perceived to be unsuccessful due to their complex implementation that required the involvement of banks and finance companies (ACEA (2010)).

[13] For instance, Adda and Cooper (2000) emphasize that the cross sectional distribution of car vintage determines the initial effects of scrapping policies, in particular the fraction of cars older than a (new) optimal scrapping age. The changes in the distribution of car ages, induced by the policies, reduce the car production considerably in the future periods.

[14] Schiraldi (2011) finds that reducing an age of a scrapped car from 10 to 8 years increases the effect of scrapping schemes on sales.

[15] Alberini et al. (1995) for example argue that since older vehicles have a less sophisticated pollution-control requirement, a policy directed at scrapping older model vehicles may reduce total emissions. There is however uncertainty as for how effective the schemes are in reducing emissions.

2.2 Economic assessment of scrapping schemes

Our empirical evaluation of scrapping subsidies largely follows the structure of the *ex ante* economic compatibility assessment of state aid by the European Commission. This assessment is essentially about striking a balance between the benefits and costs of state aid (the so called "balancing test") that we apply to the *ex post* assessment of scrapping incentives.[16] We provide a brief overview of the relevant literature here, which motivates the empirical framework outlined below in section 3.2.

Incentive effects: demand and environmental effects Scrapping schemes have a general objective of stimulating demand of vehicles to support the automobile industry, especially in the crisis that was accompanied by the worsening of confidence and degradation of households' access to finance. Around 60-80% of new European private car purchases are financed through some form of credit (IHS Global Insight (2009)).

Since scrapping schemes aim at removing inefficient, high polluting vehicles from circulation and stimulating purchases of more fuel-efficient cars, they have an efficiency objective, in particular with regard to the over-provision of a negative externality such as pollution. The schemes may also be aimed to improve road safety, thus generating a positive externality. However, the environmental and road safety benefits of scrapping schemes are somewhat questionable in practice.[17]

Following these demand and environmental motives to introduce scrapping programs, we can assess their benefits, and especially evaluate whether total new car sales and average fuel efficiency of new cars would have been lower absent the schemes, i.e. we can quantify the "incentive effects". The difference in total car sales and average fuel consumption with scrapping incentives (actual) and without scrapping incentives (counterfactual) can be viewed as the incentive impact of the scrapping subsidies. Since the actual outcomes are usually observed, a major challenge in practice is to estimate the counterfactual outcomes.

Crowding out effects: temporal and intertemporal substitution Two major types of crowding out effects are relevant in the case of scrapping schemes: temporal substitution, i.e. substitution between cars, and intertemporal substitution.[18]

[16] See, for instance, Grigolon et al. (2014b) for the presentation of this economic framework in general and its discussion as related to scrapping schemes.

[17] See, for instance, OECD (1999), Sinn (2009), IHS Global Insight (2010a), OECD/ITF (2011), Li et al. (2013), Li and Wei (2013) for related evidence and detailed discussion.

[18] Scrapping schemes can crowd out demand for other durable goods, for example, used cars (Schiraldi (2011)). Busse et al. (2012) point out another type of crowding out effect. In particular, they investigate whether government scrapping rebates may crowd out manufacturer rebates in the case of the US CARS Program and find that the program has in fact stimulated manufacturer rebates. The evaluation of these

As related to temporal substitution between cars, there may be a substitution from non-eligible cars to eligible ones in the case of targeted schemes. That is, during the program period, the sales of eligible cars may go up, whereas the sales of non-eligible cars may go down. For instance, Copeland and Kahn (2011), Li et al. (2013) report that during the US CARS Program some consumers that would have purchased a car that is not eligible for a scheme have bought a car eligible for the scheme attracted by the availability of a rebate. Also, there may be a substitution effect between different types of cars, for example from large to small cars under any type of scheme.

As related to intertemporal substitution, first an anticipatory effect arises when a consumer correctly anticipates the introduction of a scrapping program and delays the purchase of a vehicle that he would have bought anyway. Thus, one can observe a reduction in sales before a scheme starts. Second, scrapping schemes can induce a pull-forward effect, which arises when a scrapping incentive induces sales of vehicles that would otherwise have occurred in the near future: i.e. car sales today at the expense of car sales in the future (European Commission (2009), Cooper et al. (2010)). A consequence of this effect is that following the expiry of schemes, there is a sharp decrease in sales. The exact timing (a few weeks, a few months or longer), or the dynamic pattern of this effect is difficult to estimate.

Effects on domestic production Scrapping schemes can cause distortions that favor domestic producers. Scrapping schemes can be *de facto* selective: they can cause subsidy competitions among countries, where each country designs environmental conditions linked to the incentives (e.g. in terms of CO_2 emissions) to favour domestic producers with respect to foreign ones. Several European countries have imposed environmental requirements on new cars that can be purchased under their schemes. For instance, in France a car is qualified for a scrapping bonus if it emits less than 160 grams CO_2 emissions per kilometer (in 2009), or in Italy a new petrol car should emit at most 140 grams CO_2 emissions per kilometer (or 130 grams CO_2 emissions per kilometer in case a diesel car is bought). Similar environmental conditions were set for schemes in Portugal and Spain.

In addition, scrapping schemes can cause imbalances in production. In particular, scrapping schemes can only be attractive for certain models of a car producer. Thus, scrapping programs may result in uneven plant utilization: some plants may be obliged to allocate workers on short-time working schemes, while other plants may be obliged to use overtime or shift labour force from one plant to another to meet the increased demand, as reported by Eurofound (2010) and by carmakers themselves.[19]

effects are beyond the scope of this paper.

[19] See for instance, http://www.fiatgroupreport.com/2009/bilancio.php?lang=en

3 Empirical approach

3.1 Data description

Our first dataset is a European car registration dataset from JATO. It covers eight countries: Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and the United Kingdom. Taken together, these countries make up more than 90% of the EU car market. The dataset covers the period between 1998 and 2011. The data are at a high frequency, at a monthly level, and at a very disaggregate level: the individual car model and car variant (engine type, body style, etc.). These data include monthly car registrations, list prices and technical specifications (horsepower, various measures of fuel consumption, fuel type, length, width, height, weight, body style, etc.). Although we focus on the effect of the scrapping schemes on car registrations, the information on prices and technical specifications is indirectly also very useful: it enables us to determine which cars are eligible in a targeted scrapping scheme and to measure the (relative) size of the scrapping incentive. We have information on the car's brand, its country of origin, and the firm ownership.

We define the unit of our analysis as the combination of model group, body and fuel type, for example the Volkswagen Golf, hatchback, diesel engine. This detailed level enables us to account for various eligibility criteria in the case of targeted schemes, in particular also criteria that are linked to CO_2 emissions and gasoline versus diesel car engines (as in the Netherlands or Italy).

Our second dataset consists of information on the European scrapping programs. For each country and each month, we know whether a scrapping scheme was active. In the case of targeted schemes, we also know which eligibility criteria applied (as summarized above in Table A.1). We have collected this information from various sources. First of all, the automotive consultant IHS Global Insight summarizes scrapping schemes for the EU member states in its report to the European Commission, with a specific focus on the schemes introduced in response to the last financial and economic crisis (IHS Global Insight (2010a), IHS Global Insight (2010b)). In addition, the European Automobile Manufacturers' Association (ACEA) gives an overview of scrapping schemes introduced in the EU countries in 2009 and 2010 (ACEA (2010)). We have cross-checked both major sources of information on scrapping programs with national legislation and government sources for verification and collected missing pieces of information necessary for our empirical analysis.

We combine the car registration data with the information on the European scrapping schemes. We thus obtain a very detailed picture on the scrapping scheme conditions of every car model/fuel engine, in each of the eight countries during each month between 2005 and 2011. More specifically, for every model/engine, country and period, we construct a dummy variable indicating whether the model/engine is eligible for a car scrapping scheme. In the case of targeted schemes, this depends on CO_2 emissions criteria, engine displacement, price or other criteria. Furthermore, we construct a variable for the size of the incentive (which may also depend on the criteria in the case of targeted schemes) and some additional information, such as the minimum age of a car that can be scrapped (country/month specific information). We set the duration of a scrapping scheme to be equal to its official duration according to a respective regulation or legislative act.[20]

Finally, to investigate the effect of scrapping schemes on domestic production and plant utilization, we complement the main dataset with additional data from PwC: we obtained information on the location and the maximum capacity of the main assembly plant for each model and year of the dataset.

Table 1 provides descriptive statistics for the main variables in 2009 for all countries (when all countries in our sample, except for Belgium, introduced scrapping programs, although during different months) and for Germany, France and Italy separately: much of our work will be at country level and we will focus on those three countries as main countries of our dataset when we present the estimation results. Summary statistics for all the other countries are provided in Appendix at Table A.2. We distinguish between countries with non-targeted schemes (left hand side) and targeted schemes (right hand side). Germany is the main country adopting a non-targeted scheme in 2009, while France and Italy opted for targeted schemes. In the case of targeted schemes, we also distinguish between eligible cars and non-eligible cars. For targeted schemes, eligible cars are fewer than non-eligible cars (9,689 model observations versus 15,452 observations for the non-eligible models), but they have on average much higher sales (386 versus 58 cars). The eligible cars also tend to be sold at a much lower price (average of €19,400 versus €44,600 for the non-eligible models), and, by construction, they are much more fuel-efficient. For countries with non-targeted schemes, the summary statistics typically fall in between these extremes. For example, the average price in countries with non-targeted schemes is €35,200. The average relative incentives are 7.2% for eligible cars in the case of targeted schemes and 5.6% across all cars in the case of non-targeted schemes.

The country-by-country summary statistics reveal considerable heterogeneity both in the characteristics of the fleet and the design of the scrapping programs. In Germany, the average incentive is 9.8%, which is considerably higher than all the other countries implementing a non-targeted scheme (2.4% in the Netherlands and 7.9% in the UK). Domestic production

[20] We also allow for an extended period to register a car as part of our sensitivity analysis. The extended period usually takes up to three months after the official expiry date of schemes and captures the time gap between sale and registration of a car.

in Germany is also higher than any other country with non-targeted schemes. Comparing countries with targeted schemes, we see that in France the relative incentive is lower with respect to Italy, but sales of eligible cars are higher, which could be attributed to the laxer conditions on car purchase of the French scheme in terms of CO_2 requirements. Domestic production of eligible cars is higher in France.

Figure 2 depicts the evolution of seasonally adjusted monthly car sales in Belgium, which will be used as control country as scrapping policies were not implemented, Germany, France and Italy. In all countries sales declined in the second half of 2008 in response to the worsening financial and macroeconomic conditions. The scrapping programs could have helped to stabilize the car sales and prevented them from a sharper decline. Especially the German scrapping scheme seems to have caused a spike in the car sales during the treatment period of scrapping subsidy, followed by a noticeable decline afterward, while in Italy sales continued to decline also during the scrapping schemes. In general, however, it is difficult to draw clear conclusions from the Figure, since there are many factors that may have affected sales before and after the treatment period. Our empirical framework below aims to disentangle the various effects and obtain conclusive evidence on the effects of programs.

We have extended our European car scrapping database with macroeconomic data on European countries in our sample: GDP per capita (Eurostat, quarterly), unemployment rate (Eurostat, monthly), consumer confidence index (OECD, monthly), price of fuel/diesel (OECD, quarterly) and total number of passenger cars in use, or number of passenger cars in use more than 10 years old (Eurostat, yearly).

3.2 Identification and estimation strategy

To identify the effects of the car scrapping subsidies, we employ a difference-in-differences approach. The idea is to compare the change in sales in the treatment countries, where the scrapping policies took place during certain time periods, with the change in sales in the control countries, where the scrapping policies did not take place, or took place during different time periods. Our identification strategy thus exploits a unique feature of the European scrapping programs, i.e. that they were implemented at different time intervals during the 1998-2011 period, as shown earlier in Figure 1. We can follow this approach because we have detailed information on sales by car model for many European countries at a high, monthly frequency.

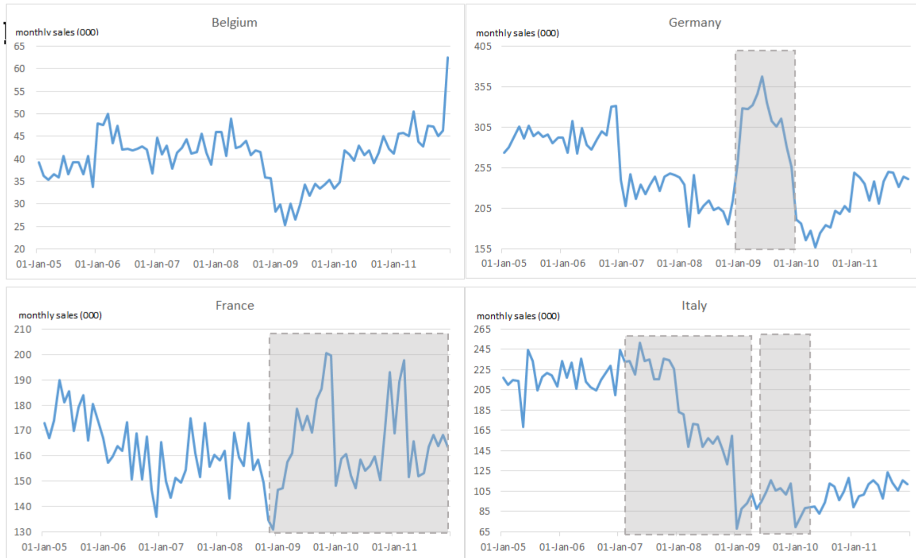
A simple difference-in-differences approach would consider one treatment and one control group, and only two time periods. The identifying assumption in such a setting is that the treatment and control groups follow the same trend in the absence of the treatment

Table 1: Descriptive statistics for European scrapping schemes (2009)

	All countries						Germany	France		Italy	
	Non-targeted		Targeted				Non-targeted	Targeted		Targeted	
	All cars		Eligible		Non-eligible		All cars	Eligible	Non-eligible	Eligible	Non-eligible
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.	Mean	Mean	Mean	Mean	Mean
Sales (units)	279.6	857.0	385.7	842.6	58.0	142.8	432.0	537.2	37.7	628.9	96.4
Price (€1,000)	35.2	40.1	19.4	8.1	44.6	44.7	37.0	20.9	53.3	15.2	40.0
CO_2 emissions (gram/km)	180.0	61.3	129.0	14.9	200.5	58.7	184.3	135.0	221.5	122.1	196.7
Fuel consumption (liter/100km)	7.31	2.68	5.12	0.71	8.12	2.58	7.47	5.36	9.02	4.88	7.95
Horsepower (kW)	117.0	70.6	71.3	21.4	134.4	71.5	121.6	77.8	154.3	62.5	131.0
Width (cm)	179.2	8.7	173.0	8.3	182.0	7.1	179.2	175.0	183.8	169.5	181.5
Length (cm)	444.1	41.7	410.4	43.2	457.1	30.4	444.4	419.6	462.2	393.4	453.9
Height (cm)	152.8	13.7	150.2	7.2	154.3	16.1	152.8	150.2	155.4	149.8	154.5
Domestic. Prod. (0-1)	0.11	0.32	0.09	0.28	0.06	0.24	0.19	0.13	0.08	0.07	0.07
Premium cars (0-1)	0.30	0.46	0.12	0.33	0.38	0.49	0.30	0.16	0.43	0.08	0.36
Scrapping dum (0-1)	0.74	0.44	1.00	0.00	0.00	0.00	0.92	1.00	0.00	1.00	0.00
Rel. incentive (%)	5.62	5.81	7.19	3.69	0.00	0.00	9.80	5.63	0.00	11.09	0.00
# models	925		906		978		771	356	387	179	576
# countries	3		4				1	1		1	
# observations	20,950		9,689		15,452		8,163	3,648	3,231	1,608	4,829

The table reports means and standard deviations for our main variables for all countries in the case of non-targeted (left hand side) and targeted (right hand side) schemes in 2009 and for Germany, France and Italy separately. In the case of targeted schemes we distinguish between eligible and non-eligible cars. Countries with targeted schemes include France, Italy, Portugal, and Spain. Countries with non-targeted schemes include Germany, the Netherlands, and the United Kingdom. Belgium does not have any scrapping scheme, so it is not presented in the table. The variables are expressed as averages per model. Prices are retail prices (i.e. after VAT and other taxes).

Figure 2: Car sales in selected European countries (monthly, seasonally adjusted)



The figure depicts seasonally adjusted monthly car sales from 2005 onwards in Belgium, Germany, France and Italy. Shaded areas denote the duration of the scrapping schemes: Germany: 14 Jan 2009 - 31 Dec 2009; France: 1 Jan 2009 - 31 Dec 2010; Italy: 3 Oct 2006 - 31 Dec 2007; 1 Jan 2008 - 31 Dec 2009; 7 Feb 2009 - 31 Dec 2009.

(scrapping program). We can extend this assumption both to (i) multiple time periods, while keeping one treatment country and one control group and to (ii) multiple countries and multiple time periods. Most of our work will focus on one treatment country at the time and the same control country, Belgium, in which scrapping policies were not implemented (see Figure 2).

We will also control for (i) macro-economic variables that may evolve differently across countries, such as monthly GDP and fuel prices; (ii) other policies that were implemented during the period, such as the green incentives implemented in Belgium during 2008-2011 ("eco-incentives" in the form of price reductions of up to 15%) and France during 2008-2011 ("bonus-malus" in the form of a staggered tax rebate of up to €5,000 for cars with low CO_2 emissions and an extra charge of up to €2,600 for cars with high CO_2 emissions).

Since we observe sales and car specifications at the level of individual car models, we can further enrich the framework in various ways. First, we account for the size of the scrapping policy incentive, which may differ depending on the car specifications. Second, we account for various possible crowding out effects of the scrapping schemes. In the case of targeted scrapping schemes, we can assess the differential effects on the eligible cars (usually with low CO_2 emissions) and non-eligible cars (with high CO_2 emissions). We also assess the intertemporal effects: anticipatory and pull-forward effects. Third, we consider the effects of the scrapping schemes on competition and domestic production. Perhaps the most relevant question from a European policy perspective is whether domestically assembled models benefit more from scrapping subsidies than non-domestically assembled models. We will also compare different effects between volume and premium brands.

Incentive effects With multiple countries and time periods, one can implement the difference-in-differences approach using a panel fixed effects estimator. We include a full set of model/month fixed effects, and country/year fixed effects, as well as various control variables that may vary over models/countries/months. We will mainly focus on country pairs (treatment and control country) with Belgium as control group: we will therefore account for the heterogeneity in the effects of scrapping programs across countries and identify country-specific effects of the scrapping schemes by estimating the following models for each country pair separately.

We start from the following basic specification, which focuses entirely on the incentive effects of the scrapping subsidies:[21]

$$\log(\text{sales}_{jct}) = \alpha_{jm} + \theta_{ct} + \delta \ \text{scrap}_{jct} + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}, \tag{1}$$

where j is the car model (i.e. model group/body type/fuel type, as defined above), c is the country, and t denotes the time periods (months and years between 1998 and 2011). The dependent variable is the logarithm of sales of a model in a country during a certain month. The first two terms on the right hand side are the essential parts of the difference-in-differences approach and control for several sources of unobserved heterogeneity. First, α_{jm} consists of a full set of model/month fixed effects, controlling for differences in demand across models and time periods. Second, θ_{ct} captures country/year fixed effects during the period 1998-2011: these account for country-specific macro-economic shocks that affect car sales. We also account for other country-specific time-varying effects at monthly level in a flexible way through the term $w_{ct}\gamma$, as discussed further below. In sum, our rich set of fixed effects controls for unobserved country-specific economic conditions that could be correlated both with the scrapping subsidies and the demand for cars.

Our main variable of interest is scrap_{jct}, which measures the scrapping policy for a model, country and time period. The variable scrap_{jct} is a dummy variable equal to 1 if the scrapping policy is active and if the car model is eligible (in the case of a targeted scheme), and equal

[21] We therefore follow a reduced form approach, where sales are expressed as a function of exogenous demand and supply covariates. In this case the estimated coefficients would neither estimate parameters of the demand curve nor of the supply curve, but would instead estimate the effect of each covariate on equilibrium sales, once demand and supply responses are taken into account.

to 0 otherwise. As an alternative to scrap_{jct}, we also use the variable scrap_pct_{jct}, which is the percentage monetary incentive (subsidy as a percentage of the car's list price) if the scrapping policy is active, and 0 otherwise:

$$\log(\text{sales}_{jct}) = \alpha_{jm} + \theta_{ct} + \delta \ \text{scrap\_pct}_{jct} + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}. \tag{2}$$

This takes into account the fact that size of the schemes may differ across models, and vary across countries and time periods.

The parameter δ measures how sales change after the scrapping policy in the treatment country, compared with the change in sales in the control country. When we use the dummy variable scrap_{jct}, δ is the percentage sales increase, regardless of the size of the scheme. When we instead use the percentage monetary incentive variable scrap_pct_{jct}, δ is the elasticity of the incentive, i.e. the percentage sales increase when the monetary incentive increases by 1 percent.

The other terms in (1) and in (2) control for other, model- and/or country-specific factors that may vary over time. The vector x_{jct} includes car characteristics that may vary over time and between countries (horsepower, displacement, fuel consumption, width and height). The vector w_{ct} includes various country-specific macro-economic variables that may vary over time, namely income per capita, unemployment, a consumer confidence index and fuel prices. Finally, ε_{jct} is an error term. To account for the possibility of heteroscedasticity and serial correlation of model sales over time, we use clustered standard errors at model level for the two specification above and all the other specifications below as emphasized by Bertrand et al. (2004) in the difference-in-differences context.[22]

We now extend this basic framework to account for other possible effects of scrapping schemes, including crowding out as well as the effect on domestic production.

Crowding out effects Specifications (1) and (2) do not distinguish between targeted and non-targeted schemes. The treatment group thus includes all cars in the country where the non-targeted schemes is active, and includes all eligible cars in the country with a targeted schemes. The control group includes all cars in the country where no scheme is active (Belgium), but also the non-eligible cars in the country where the targeted scheme is active (see Table 1). This specification may be restrictive for targeted schemes if there are substitution effects: it is possible that the eligible cars gain proportionately more, and that the non-eligible cars actually lose sales (rather than being unaffected). To allow for the possible

[22] Standard errors are clustered at model level so we obtain White standard errors robust to within model correlation. According to Bertrand et al. (2004), the adjustment of the standard errors works well when the number of clusters is above fifty, a condition we definitely meet in our sample.

differential impact of targeted and non-targeted schemes, we extend (2) to the following specification:

$$\log(\text{sales}_{jct}) = \alpha_{jm} + \theta_{ct} + \delta_1 \text{ scrap\_pct}_{jct} \times \text{NT}_{ct} + \delta_2 \text{ scrap\_pct}_{jct} \times \text{T}_{ct} + \delta_3(1 - \text{scrap}_{jct}) \times \text{T}_{ct} + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}. \quad (3)$$

The variable NT_{ct} is a dummy variable equal to 1 if country c at time period t adopted a non-targeted scheme, and 0 otherwise. Similarly, the variable T_{ct} is a dummy variable equal to 1 if country c at time period t adopted a targeted scheme. The parameter δ_1 then measures the sales effect of a non-targeted scrapping scheme on all cars in the country. Similarly, δ_2 measures the sales effect of a targeted scheme on the eligible cars (which satisfy the CO_2 requirement or other stipulated criteria). Finally, δ_3 measures the sales effect of a targeted scheme on the non-eligible cars (which do not satisfy the eligibility criteria). One may expect that $\delta_2 > \delta_1 > 0 \geqslant \delta_3$, i.e. eligible cars benefit more under targeted than all cars under non-targeted schemes, and non-eligible cars under targeted schemes lose if there is a substitution effect to eligible cars. Also, one may expect that those effects differ across countries and depend on the design of the scrapping program. Specification 3 is based on the percentage monetary incentive variable scrap_pct_{jct} and takes into account the size of the monetary incentive.

We consider specification (3), which extends specification (2), our base specification as it accounts for the incentive effects of the scrapping schemes (δ_1 and δ_2) and a main potential crowding out effect under targeted schemes: the between-car substitution effect from non-eligible to eligible cars (δ_3).

The between-car substitution effect is a crowding out effect that may happen during the scheme. We also extend (3) to consider intertemporal crowding out effects, which may occur before or after the scheme. First, we consider before-subsidy anticipatory effects. If the scheme is announced some time before it comes into force, consumers may delay their car purchases to benefit from the program. One may then observe a drop in car sales before the program. To consider this effect, we include a dummy variable in (3) for the first month of the scheme (when it may not yet have been effective).

Second, we consider post-subsidy pull-forward effects. Consumers may decide to purchase a car during the scheme for a planned purchase after the scheme. Consequently, following the expiry of schemes, car sales may go down. To investigate this effect, we introduce a dummy variable for the first three months (and five months as a robustness check) after a scheme expires. Note that the post-scheme effect may also capture the extended period for car registrations, during which the sales effect due to the scrapping subsidies may still be high.

Effects on domestic production Specification (3) assumes that the effects of the scrapping schemes are homogeneous across car models. In practice, scrapping schemes may have differential effects, so that some cars obtain a competitive advantage. We focus here on the possible differential effects between domestically produced and non-domestically produced cars, but in our empirical analysis we also consider the differential effects between volume and premium brands. To differentiate between the effects of the scrapping schemes on the sales of domestically and non-domestically produced cars, we consider the following generalization of (3):

$$\begin{aligned}\log(\text{sales}_{jct}) \;=\;& \alpha_{jm} + \theta_{ct} + \delta_1 \text{ scrap\_pct}_{jct} \times \text{NT}_{ct} + \delta_2 \text{ scrap\_pct}_{jct} \times \text{T}_{ct} \\ & + \delta_{1D} \text{ scrap\_pct}_{jct} \times \text{NT}_{ct} \times \text{DOM}_{jct} + \delta_{2D} \text{ scrap\_pct}_{jct} \times \text{T}_{ct} \times \text{DOM}_{jct} \\ & + \delta_3 (1 - \text{scrap}_{jct}) \times \text{T}_{ct} + \delta_{3D} (1 - \text{scrap}_{jct}) \times \text{T}_{ct} \times \text{DOM}_{jct} \\ & + \delta_4 \times \text{DOM}_{jct} + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}, \end{aligned} \tag{4}$$

where DOM_{jct} is a dummy variable equal to one if a car model j is assembled in country c at period t. The interaction terms between the scrapping variables and the domestic firm dummy variable have parameters δ_{1D}, δ_{2D} and δ_{3D}. These capture the additional effect of the scrapping program if the car is domestically assembled: δ_{1D} refers to the additional sales effect for domestically produced cars under a non-targeted program; δ_{2D} refers to the additional sales effect for domestically produced cars that are eligible under a targeted program; and δ_{3D} measures the additional sales effect for domestically produced cars that are not eligible under a targeted program.

We will also use a variant of specification (4), to see whether there are different effects of the scrapping programs on volume and premium car brands. Premium brands include cars produced by Audi, BMW, Mercedes, and some small luxury brands. This will allow us to make inferences about the effect of schemes on the characteristics of the fleet.

4 Empirical findings

We now present our empirical findings on the effects of the scrapping schemes. We begin with the basic framework where we consider the incentive and crowding out effects. We then extend the analysis to consider the effects on competition and production, i.e. differential effects of the scrapping schemes across different models.

Incentive and crowding out effects Table 2 reports the results with all the countries and time periods. Columns (1) and (3) are based on specifications (1) and (2). These assume that the scrapping schemes have the same effect on all cars, without distinguishing between targeted and non-targeted schemes. Column (1) is based on the dummy variable scrap_{jct}, so it measures the effect of the scrapping scheme regardless of the size of the incentive. This shows that the sales effect of scrapping schemes is positive, statistically significant, and its magnitude is large: the coefficient of 0.525 implies that sales go up on average by 69.0% due to the scheme.[23] Column (3) is based on the percentage subsidy variable scrap_pct_{jct}, so it considers the effect of a percentage scrapping subsidy. The effect of a percentage increase in the scrapping subsidy is also positive and statistically significant: a 1% increase in the scrapping subsidy raises car sales by 4.2%.

Columns (2) and (4) are both based on specification (3). Column (2) is a variation of specification (3) based on the dummy variable scrap_{jct}, which considers the scrapping scheme regardless of the size of the incentive. Column (4) takes into account that the scrapping schemes have a differential effect for targeted and non-targeted schemes, and also consider the crowding out effect on non-eligible cars in the case of targeted schemes.

Column (2), based on the dummy variable scrap_{jct}, suggests that the average effect of scrapping schemes on sales is statistically significant both under targeted and non-targeted schemes. Under non-targeted schemes, the coefficient of 0.056 implies that sales go up on average by 5.76%. The average effect of scrapping schemes on sales is much larger when they are targeted: the coefficient of 0.440 implies an average 55.3% increase in sales of eligible cars. Crowding out effects are also sizeable: sales of cars not eligible for purchase under targeted schemes decrease by 27.1%. Column (4) is based on the percentage subsidy variable instead of the scrapping dummy variable: it shows a positive sales effect in the case of both the non-targeted and the targeted types of schemes. The implied subsidy elasticity is about 2.5, which is lower than price elasticities reported in the car market literature (though these are typically at the product level instead of a group of products). Note that the effect of the percentage subsidy is now slightly stronger under a non-targeted than under a targeted scheme (2.7 versus 2.4). The result is somewhat counterintuitive (as targeted schemes can also steal business from non-eligible cars) and it may be attributable to the fact that this pooled specification ignores the possible heterogeneous impact of scrapping schemes across countries. As before, we find significant crowding out effects.[24]

[23] This is calculated as 1-exp(0.525) since a semilog sales model is estimated.

[24] The market shares are heterogeneous in the number of units. We checked the robustness of our work by weighting the observations. This specification does not qualitatively change the results of our analysis: crowding out effects appear to be more accentuated using weights.

Table 2: Incentive and crowding out effects of scrapping schemes: all countries

	Scrapping dummy		Relative incentive	
	(1)	(2)	(3)	(4)
scrap	0.525		4.202	
	(16.693)		(13.945)	
scrap $\times$ NT*		0.056		2.709
		(3.668)		(9.661)
scrap $\times$ T*		0.440		2.388
		(14.844)		(5.571)
$(1 - \text{scrap}) \times$ T		-0.316		-0.464
		(-11.782)		(-12.036)
scrap $\times$ NT* = scrap $\times$ T*		122.84		0.46
Prob > F-stat		(0.0000)		(0.4993)
# models	1,446	1,446	1,446	1,446
# countries	9	9	9	9
# model/month fixed effects α_{jt}	16,397	16,397	16,397	16,397
# country/year fixed effects θ_{ct}	126	126	126	126
# observations	698,025	698,026	698,027	698,028
R-squared	0.325	0.327	0.327	0.329

The table reports the parameter estimates and t-statistics (in parenthesis). Columns (1) and (3) are based on specifications (1) and (2). Columns (2) and (4) are based on specifications (3), where column (2) is based on the dummy variable scrap_{jct}. The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and dummies (or respectively, relative size) for green rebates in Belgium and France are included but not reported.
'*' means that we use either a dummy for scrapping policy in the left hand side of the table (columns (1) and (2)), or a percentage monetary incentive in the right hand side of the table (columns (3) and (4)).

The specification above for multiple countries and time periods pooled together allows us to identify only an average effect of the scrapping schemes across countries. As noted above in Table 1, scrapping programs differed across countries, as well as the characteristics of the fleet. To avoid that country-specific unobserved conditions may influence both the effect of scrapping schemes and the demand of cars, we turn to the separate estimation of specification (3) on country pairs (a treatment and a control country). We always use Belgium as control group. We will therefore identify country-specific effects of the scrapping schemes. Table 3 reports the results for the main three countries of our sample, namely Germany, France, and Italy. Estimation results for the other countries are reported in Appendix, Table A.3. We consider specification (3), based on the percentage subsidy variable instead of the scrapping dummy variable, our preferred specification, since it accounts both for the differences in magnitudes of the subsidy across cars and crowding out effects.[25]

Results show that the sales effect of scrapping schemes is always positive and statistically significant, but the size of the effect varies considerably across countries: a 1% increase in the subsidy raises sales of cars in Germany (implementing a non-targeted scheme) by 3.8%, while in other countries with non-targeted schemes the effect is lower: 2.9% in the Netherlands 2.9% and 1.3% in the UK. The heterogeneity is evident also in countries with targeted schemes: for example, a 1% increase in subsidy raises sales by 9.1% in France and 5.3% in Italy. Substitution effects from non-eligible to eligible cars under targeted schemes are significant in France and Spain, but not in Italy and Portugal. In sum, scrapping schemes had a strong stabilizing impact on car sales: the impact was heterogeneous across countries and larger in countries with targeted schemes.[26]

[25] We checked the robustness of our results by allowing the effect of the percent monetary incentive to differ for the period before and after the 2008-2009 crisis. The test can be applied only to Italy, Portugal and Spain, the three countries in which scrapping schemes were present both before and after the crisis. Results are reported in table A.4. Results show that the schemes had very similar effects before and after the crisis for Italy and Portugal (we do not reject the hypothesis that the two effects are equal). Only for Spain we find that the schemes had a stronger effect before the crisis and the equality test is rejected, but the result can be attributed to the different nature of the scrapping schemes before and during the crisis (non-targeted versus targeted) which is taken into account in our main specification.

[26] We checked the robustness of our specification with respect to null sales, when a model is unsold in a certain year and month. Null sales occur for only 7 to 8% of the model/year/month combinations and this does not substantially vary between periods with and without scrapping schemes. To see the possible consequences of the limited number of null sales, we run specification (3) focusing only on cars for which null sales do not occur in our sample (see Table A.5 in Appendix). All coefficients remain very similar and fall within the 95% confidence interval of the coefficients reported in Table 3 (which includes the cars reporting null sales). An alternative approach to avoid empirically observed null sales would be to draw a new vector of sales from a fitted distribution, by modifying the approach of Gandhi et al. (2014) in a logit demand system.

Table 3: Incentive and crowding out effects of scrapping schemes: by country

	Germany	France	Italy
scrap_pct $\times$ NT	3.795		3.691
	(7.740)		(5.952)
scrap_pct $\times$ T		9.122	5.278
		(6.106)	(9.400)
$(1 - \text{scrap}) \times$ T		-0.277	0.037
		(-4.381)	(0.996)
scrap_pct $\times$ NT = scrap_pct $\times$ T			7.70
Prob > F-stat			(0.0056)
# models	1,250	1,191	1,230
# countries	2	2	2
# model/month fixed effects α_{jt}	14,415	13,612	13,940
# country/year fixed effects θ_{ct}	28	28	28
# observations	178,301	165,756	166,250
R-squared	0.415	0.286	0.295

The table reports the parameter estimates and t-statistics (in parenthesis). Results are based on specification (3). The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

We performed some counterfactuals based on the estimates of Table 3 to quantify the impact of scrapping schemes on car sales and average fuel consumption of new cars for each country (see Table 4). We find that European car sales (in countries with scrapping policies) would have been 29.7% lower in 2009 absent the schemes. The sales would have been 30.5% lower in countries with targeted schemes: 39.1% lower for the eligible cars and 6.3% higher for non-eligible cars. In countries with non-targeted schemes sales would have been 29.0% lower. Although scrapping policies thus stabilized sales in all countries, their individual performance varies considerably, showing the importance of focusing the analysis on each country separately. For instance, in Germany, with its non-targeted scheme, around 1.4 million cars (or 40.1% of total German car sales in 2009) would not have been purchased without the scheme in that period. In the UK, only 13.1% of total sales would have not been purchased absent the scheme. In France, where a targeted scheme was adopted, 40.0% of cars would not have been purchased absent the subsidy in 2009. Scrapping schemes also caused sizeable substitution effects from non-eligible to eligible cars: absent the scheme, sales of non-eligible cars would have been 31.9% higher. Crowding out effects are sizeable also in Spain, while absent in another country adopting a targeted scheme, Italy.

We have also investigated how the schemes affected the sales-weighted average fuel consumption (measured in liter/100km) of new cars. Under targeted schemes, we find a beneficial environmental impact because consumers substitute to more fuel efficient cars in response to the schemes: while in countries with non-targeted schemes, average fuel consumption would have been only 0.7% higher in the absence of the schemes, under targeted schemes that were explicitly targeted to low emission vehicles, average fuel consumption would have been 3.6% higher.[27] The improvement in average fuel consumption is driven by the large shift from non-eligible cars with low fuel efficiency to eligible cars with high fuel efficiency. The sales-weighted average fuel consumption change of eligible cars is negligible (0.003%), which shows there was indeed very limited substitution within the group of eligible cars. The effects are also quite heterogenous across countries. For example, the targeted scheme improved average fuel consumption by 3.8% in France, but by only 2.0% in Spain. In 2009, the monetary incentive was higher in Spain, but the conditions on the retired vehicle and the purchase of the new vehicle were laxer in France, ensuring a wider potential base.

Finally, on the basis of the counterfactuals, we perform a simple cost-benefit analysis by calculating the implicit cost per extra unit of sale stimulated by the programs. In practice we calculate the ratio (R) between the total cost of the program and the difference between the actual sales and the counterfactual sales.[28] A higher value of the ratio indicates a worse

[27] Using a back-of-the-envelope calculation in which we assume that consumers drive on average 14,700 km (as reported in the most reliable source on mileage travelled by consumers, the 2007 UK National Travel Survey), the saving in terms of CO_2 emissions would amount to 1,773 million of ton under the targeted programs, while only to 539 million of ton under the non-targeted programs. The calculation is clearly limited by the assumption of homogeneity in driving behavior: see Grigolon et al. (2014a) for an investigation on the issue. In addition, the environmental impact could be weakened by inefficiencies arising from rebound effects: drivers of new, fuel-efficient cars could drive more miles then they did with their old inefficient car.

[28] We calculate the following ratio:

$$R = \frac{\sum_{j=1}^{J} \text{scrap\_abs}_j \times \text{sales}_j^{ACTUAL}}{\sum_{j=1}^{J} (\text{sales}_j^{ACTUAL} - \text{sales}_j^{NO\ SCRAP})}.$$

The ratio is defined as the total cost of the program (the absolute size of the incentive for each model, scrap_abs_j, multiplied by actual model sales under the scrapping schemes, sales_j^{ACTUAL}) divided by the difference between the actual sales and the counterfactual sales ($\text{sales}_j^{ACTUAL} - \text{sales}_j^{NO\ SCRAP}$). For simplicity we omit the country and time subscript in the above equation.

performance of the program, either because, all else being equal, the cost of the program is higher or because the stimulus on sales is not effective. On the basis of our ratio, the best performance of the 2009 programs is registered in countries with targeted schemes. Spain has a ratio $R = 1,965$, meaning the implicit cost per extra unit of sale is €1,965. In other countries with targeted schemes the ratio's were, in increasing order: $R = 2,112$ in France, $R = 2,474$ in Portugal and $R = 2,923$ in Italy. In countries with non-targeted program the cost per extra unit of sale is much higher, both because the incentive is granted to all cars, as in the German case (R=5,929), and the stimulus is not as effective as under the targeted schemes, as in the Netherlands ($R = 6,251$) and the UK ($R = 10,748$).

Intertemporal effects We showed that targeted programs caused sizeable crowding out in France and Spain because they increased sales of eligible cars at the expense of the sales of non-eligible cars, while causing a positive effect on the average fuel consumption of the fleet. We now extend the analysis to account for another possible type of crowding out effect, in particular across different time periods rather than between eligible and non-eligible cars.

We investigate two types of intertemporal effects: anticipatory (before-subsidy) and pull-forward (after-subsidy) effects. To estimate possible anticipatory effects of the scrapping schemes, we include a dummy for the first month of the scheme. To estimate whether there are any pull-forward effects of the scrapping schemes we include a dummy for three months and five months after a scheme expires. We do not differentiate the anticipatory effect between targeted and non-targeted schemes as well as between eligible and non-eligible cars. Specific details of schemes are not known *a priori*, so that a consumer most plausibly does not know which type of a car is exactly eligible for a scheme before the scheme is actually approved, and the official decision is published and the scheme comes into effect. However, we differentiate the pull-forward effects between targeted and non-targeted schemes, and in the case of targeted schemes between eligible and non-eligible cars.

Table 5 reports the results for France, Germany and Italy (results for other countries are reported in Table A.6 in Appendix). The scrapping effects during the scheme change only slightly compared with the previous specifications that do not include anticipatory and pull-forward effects. The effect of the dummy variable for the first month of the scheme is negative and significant for France, the UK, Portugal and Spain and insignificant for Germany and Italy: mixed evidence on the presence of anticipatory effects could be explained by the difficulty that consumers have in forecasting the start of the scrapping schemes as suggested in Cooper et al. (2010) for the US CARS Program. In countries where the dummy is negative and significant the magnitude is relatively small, equivalent to less than one third

Table 4: Impact of removing scrapping schemes on total sales and fuel economy (2009)

Country	Total car sales		Average fuel consumption		Cost per unit of sale
	actual (million)	*% change*	*actual (liter/100 km)*	*% change*	€
Non-targeted schemes					
Germany	3.53	-40.1%	5.99	1.5%	5,929
Netherlands	0.41	-8.5%	5.88	0.6%	6,251
UK	1.92	-13.1%	5.80	0.4%	10,748
Total non-targeted	5.86	-29.0%	5.92	0.7%	
Targeted schemes					
France	2.08	-40.0%	5.08	3.8%	2,112
of which eligible	1.96	-44.4%	4.94	0.4%	
of which non-eligible	0.12	31.9%	7.49	0.0%	
Italy	1.61	-30.3%	5.43	3.3%	2,923
of which eligible	1.15	-41.1%	4.93	0.6%	
of which non-eligible	0.47	-3.6%	6.26	0.1%	
Portugal	0.15	-33.2%	5.18	2.8%	2,474
of which eligible	0.13	-41.5%	4.91	0.5%	
of which non-eligible	0.03	6.6%	6.47	0.0%	
Spain	0.92	-9.3%	5.49	2.0%	1,965
of which eligible	0.64	-18.5%	4.96	0.1%	
of which non-eligible	0.28	11.6%	6.69	0.0%	
Total targeted	4.77	-30.5%	5.28	3.6%	
Total eligible	3.87	-39.1%	4.94	0.0%	
Total non-eligible	0.90	6.3%	6.57	0.7%	
Total (excl. Belgium)	10.63	-29.7%	5.64	2.0%	

The table reports the actual total sales and average fuel consumption (liter/100km) as well as the estimated changes in these variables due to scrapping schemes based on the estimates reported in Table 3 and Table A.3, column (2) for each country. The left hand side of the table presents the findings for total car sales, while the right hand side of the table reports the findings for (sales-weighted) average fuel consumption. Countries with non-targeted schemes include Germany, the Netherlands and the UK, whereas countries with targeted schemes include France, Italy, Portugal and Spain.

of the monthly effect during the scheme.[29] Figure 2 may suggest an anticipation effect even for the month before the policy is introduced, so we exclude the observations related to the month before the scheme: our results are robust to this specification (see Table A.7 in Appendix).[30]

As related to the pull-forward effects, we cannot comment on the French case as we do not observe any post-subsidy period. The effect of the post-subsidy dummy variable is negative and statistically significant for Germany. The coefficient -0.265 implies that sales would have been 30.4% higher during the first three months of 2010, after the end of the scrapping scheme. The post-subsidy dummy variable is positive and statistically significant for eligible cars (0.277) and negative for non-eligible cars (-0.260) in Italy: the coefficients imply that overall sales would have been 8.9% lower during the first three months of 2010 absent the scheme. The positive coefficient for sales of eligible cars is not intuitive, but may be explained by the extended period for car registrations: although the schemes expire, their positive effect can be felt over a longer period of time. The post-subsidy effects generally appear to be declining across countries when we look at the post-subsidy dummy of cumulative sales after five months, although the longer than three months' post-scheme period may also be contaminated by other influences (see for instance Mian and Sufi (2012) for related discussion). The length of the pull-forward effects investigated in the existing studies seems to be driven by data availability: for instance, in the case of the US CARS Program Li et al. (2013), Copeland and Kahn (2011) define 4 months as a relevant post-subsidy period, whereas Mian and Sufi (2012) conclude that car sales might be pulled forward by 7 to 10 months. Because of the lack of consensus on the timing of intertemporal substitution and the possibility that extended periods for car registration differing across countries may bias our main results in Table 3, we check the robustness of our estimates of the impact of scrapping schemes by simply excluding all the observations after the end of the scrapping scheme (3 months and 5 months after): see Appendix, Table A.8. Reassuringly, the estimates on effect of scrapping schemes are robust to the alternative specifications.

To sum up, we find heterogeneous and considerable impact of the scrapping schemes on total car sales. For some countries, we find evidence of crowding out through the substitution effect between eligible and more fuel efficient cars and non-eligible cars during the targeted

[29] Empirical evidence from other studies shows that no effect should be expected beyond one month (Copeland and Kahn (2011)), or at most two months (Li et al. (2013)) before a scheme is launched, especially in response to the crisis.

[30] As an additional robustness check, we run the specification reported in Table 5 and control both for the month before the scheme was introduced and the first month of the scheme. Contrary to what Figure 2 suggests, the coefficient of the dummy before the scheme is introduced is positive in most countries except for the UK and Spain. Again, our results are robust as the other coefficients are not impacted by the additional control.

Table 5: Intertemporal effects of scrapping schemes

	Germany		France		Italy	
	3 months	5 months	3 months	5 months	3 months	5 months
scrap_pct × NT	3.833	3.834			3.705	3.729
	(6.234)	(6.235)			(5.945)	(5.979)
scrap_pct × T			9.122	9.122	5.363	5.394
			(6.105)	(6.105)	(9.409)	(9.420)
$(1 - \text{scrap}) \times$ T			-0.276	-0.276	0.040	0.039
			(-4.369)	(-4.369)	(1.030)	(0.995)
scrap - first month	0.004	0.009	-0.335	-0.335	-0.025	-0.024
	(0.054)	(0.115)	(-9.226)	(-9.226)	(-1.043)	(-0.979)
scrap X NT 3/5 months after	-0.265	-0.233				
	(-9.027)	(-7.761)				
scrap X T 3/5months after					0.277	0.239
					(3.717)	(3.224)
(1-scrap) X T 3/5 months after					-0.260	-0.264
					(-6.121)	(-6.427)
# models	1,250	1,250	1,191	1,191	1,230	1,230
# countries	2	2	2	2	2	2
# model/month fixed effects α_{jt}	14,415	14,415	13,612	13,612	13,940	13,940
# country/year fixed effects θ_{ct}	28	28	28	28	28	28
# observations	178,301	178,301	165,756	165,756	166,250	166,250
R-squared	0.416	0.416	0.287	0.287	0.296	0.296

The table reports the parameter estimates and t-statistics (in parenthesis). All results are based on specification (3), with the extension to account for anticipatory and post-subsidy effects. The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

schemes. As a result, the average fuel consumption of purchased new cars improves, but only under targeted schemes. We do not find evidence of significant anticipatory effects for the most important countries of our sample, while pull-forward effects are clearly identified and sizeable only in Germany. Our considerable impact on sales of the scrapping schemes seems to be in line with the recent estimates of the sales effect of scrapping schemes introduced in response to the financial crisis, found in other studies. For instance, Mian and Sufi (2012) find that about half of the vehicles that were purchased under the US CARS Program were such that would otherwise not have been purchased. The US studies find however higher intertemporal effects, which makes the overall performance of the program rather bleak. The car sales decreased in the months before and especially after the program (Copeland and Kahn (2011), Mian and Sufi (2012), Li et al. (2013)). There is also some evidence on the sales effects of scrapping schemes in the past. For instance, Licandro and Sampayo (2006) quantify a transitory increase of 16% in car sales following the introduction of 1997 Spanish scrapping subsidy and a permanent increase of about 1.2% in car sales in the long run. Schiraldi (2011) finds that the Italian "cash-for-replacement" schemes increased sales by 97% in 1997 and by 51% in 1998. Adda and Cooper (2000) also report the bursts in car sales following the introduction of French scrapping subsidies in 1994 and 1996.

Effects on domestic production We now extend the framework to consider the differential impact of scrapping schemes between domestically and non-domestically assembled cars. As discussed above, we limit our attention to the specification in which the scrapping scheme is measured as a percentage subsidy and to the separate estimation on country pairs to identify country-specific effects.

Table 6 reports the results for Germany, France and Italy (for the other countries, see Table A.9 in Appendix). All columns follow specification (4) and consider whether scrapping programs have a different sales effect on domestically and non-domestically produced cars. This enables us to assess whether the scrapping schemes are designed to support domestic car production. Interestingly, the non-targeted schemes have a strong positive impact on domestic production: a 1 percent non-targeted subsidy raises sales of non-domestically produced cars by 4.3%, and raises sales of domestic brands by an additional 3.5%. Hence, the German non-targeted scheme may still protect domestic manufacturers, even though it was designed very broadly and without any *de facto* restrictive eligibility conditions. We also observe a positive effect of scrapping programs on domestic production for the other two countries that introduced non-targeted schemes: the Netherlands and the UK.

Our estimates suggest that the French targeted program did not have a differential impact on domestic producers (the coefficient is insignificant) but domestically assembled cars received an extra stimulus under the targeted scheme of another major country in our sample, Italy.

To assess the possibility that the environmental eligibility criteria can raise competitive concerns, we computed the overall effects of targeted schemes on total domestic and foreign sales. Table 7 reports the results. Total sales of domestic cars would have been 49.0% lower without non-targeted schemes, whereas total sales of foreign cars would have been 30.9% lower. Under targeted schemes, domestic firms benefit only slightly more than foreign firms: absent the scheme, sales of domestic cars would have been 31.4% lower, while sales of non-domestic cars 29.5% lower. Therefore, non-targeted schemes have a larger stimulating effect on domestic car purchases, although there is considerable variation across countries. For instance, in the United Kingdom sales of domestic cars would have been 30.4% lower absent the program, and only 11.9% lower for foreign cars.

Under targeted schemes one would expect that domestically produced cars should be favoured as most of them are also eligible for scrapping subsidies. But the effect is heterogeneous across countries and the overall slight advantage on domestic production is mainly driven by the results found in Italy, in which sales of domestic cars would have been 58.3% lower absent the subsidies, whereas sales of foreign cars would have been only 26.7% lower. In France, foreign brands have benefited more than domestic brands through scrapping incentives: sales of domestic cars would have been 19.0% lower absent the subsidies, whereas sales of foreign cars would have been 42.4% lower, even if the vast majority of the cars produced in France was eligible to obtain the incentive. In conclusion, contrary to *a priori* expectations, the environmental eligibility criteria may involve some competitive concerns only in the case of Italy.[31]

[31] This is also confirmed in the case of the US CARS targeted Program: Japanese car producers Toyota, Honda and Nissan profited disproportionately more from the program than other car producers. This might be related to the fact that Japanese cars are more fuel-efficient than US cars (Li et al. (2013)). Furthermore, it may also be attributed to the bankruptcy proceedings or restructuring processes that US domestic car producers were involved into in the summer of 2009 (Cooper et al. (2010)). The financial troubles could have increased the reluctance of US consumers to buy cars from the ailing domestic producers due to after-sales service concerns (see for instance, Hortaçsu et al. (2010)).

Table 6: Competitive effects of scrapping schemes: domestic versus non-domestic production

	Germany	France	Italy
scrap_pct × NT	4.334		3.258
	(8.992)		(5.003)
scrap_pct × T		9.512	4.651
		(6.060)	(8.181)
scrap_pct × NT×Domestic Prod.	3.515		5.001
	(3.532)		(2.602)
scrap_pct × T×Domestic Prod.		-4.937	7.758
		(-1.685)	(5.669)
$(1 - \text{scrap}) \times$ T		-0.218	0.009
		(-3.506)	(0.248)
$(1 - \text{scrap}) \times$ T×Domestic Prod.		-0.436	0.350
		(-3.295)	(3.077)
Domestic Production (0-1)	0.842	0.852	1.163
	(7.116)	(10.541)	(9.651)
# models	1,250	1,191	1,230
# countries	2	2	2
# model/month fixed effects α_{jt}	14,415	13,612	13,940
# country/year fixed effects θ_{ct}	28	28	28
# observations	178,301	165,756	166,250
R-squared	0.433	0.307	0.325

The table reports the parameter estimates and t-statistics (in parenthesis) for specification (4) including interactions with the domestic production dummy, separately estimated for each country. The dependent variable is the logarithm of car model sales. Car characteristics, country-specific model, country-specific monthly (for seasonal adjustment), and year-monthly fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table 7: Impact of removing scrapping schemes on domestic and non-domestic production (2009)

	Domestic production		Foreign production	
Country	*actual (million)*	*% change*	*actual (million)*	*% change*
Non-targeted schemes				
Germany	1.51	-52.9%	2.02	-50.6%
Netherlands	0.00	-21.2%	0.40	-8.4%
UK	0.32	-30.4%	1.61	-11.9%
Total non-targeted	1.83	-49.0%	4.03	-30.9%
Targeted schemes				
France	0.55	-19.0%	1.53	-42.4%
of which eligible	*0.53*	*-23.1%*	*1.43*	*-47.2%*
of which non-eligible	*0.02*	*92.4%*	*0.10*	*24.4%*
Italy	0.27	-58.3%	1.34	-26.7%
of which eligible	*0.19*	*-73.5%*	*0.82*	*-43.2%*
of which non-eligible	*0.08*	*-21.7%*	*0.52*	*-0.7%*
Portugal	0.00	-10.0%	0.15	-33.0%
of which eligible	*0.00*	*-28.6%*	*0.13*	*-41.2%*
of which non-eligible	*0.00*	*-5.4%*	*0.03*	*7.6%*
Spain	0.19	-28.6%	0.73	-6.8%
of which eligible	*0.16*	*-32.8%*	*0.48*	*-16.5%*
of which non-eligible	*0.03*	*-4.6%*	*0.25*	*11.4%*
Total targeted	1.01	-31.4%	3.76	-29.5%
Total eligible	*0.88*	*-35.8%*	*2.85*	*-40.6%*
Total non-eligible	*0.13*	*-0.6%*	*0.90*	*5.8%*
Total (excl. Belgium)	2.84	-42.7%	7.79	-30.2%

The table reports the actual total sales of domestic and foreign cars and the estimated changes in these variables due to scrapping schemes based on the counterfactuals for specification (4). The left hand side of the table presents the findings for domestically produced cars, while the right hand side of the table reports the findings for cars of foreign production. Countries with non-targeted schemes include Germany, the Netherlands and the United Kingdom, whereas countries with targeted schemes include France, Italy, Portugal and Spain.

Because of the differential impact on domestic and foreign car sales, scrapping schemes may also cause imbalances in production. The increased demand for foreign car brands, not produced locally, or the increased demand for domestic car brands that cannot be satisfied because of capacity constraints can have an effect on trade flows. Increased internal demand may stimulate higher imports, while increased demand from abroad may increase exports. There is some evidence that car imports increased into Germany during the 2009 scrapping scheme because most small and economical cars were either produced by foreign car producers, or they were not manufactured in Germany (IHS Global Insight (2010b)).[32] We use our data on plant capacity to investigate possible production imbalances and compare the capacity level by plant with actual production and counterfactual production absent the scrapping schemes. In 2009, only two plants out of 66 in the countries of interest saw a rise in production due to the scrapping schemes above the capacity level that would not have occurred absent the schemes: that could have caused additional imports to satisfy local demand. Those plants are Poissy in France and Swindon in the UK.[33] We run the same exercise and checked the plants for which 90% of the capacity level was saturated because of the schemes: in addition to the two plants mentioned above, we find that two German plants were affected by production imbalances: Cologne, producing the Ford Fiesta, and Wolfsburg, producing the VW Golf and VW Tiguan. In sum, we find only some limited evidence that the schemes caused severe production imbalances and saturated plant capacity with the need to increase imports to satisfy the increased domestic demand for cars, not produced locally.

Effects on average quality of newly purchased cars With a purchase subsidy such as a scrapping scheme, consumers may be more likely to substitute towards more expensive cars: we investigate this potential effect by looking at the effect of scrapping subsidies on the quality of cars purchased. In particular, we follow a variant of specification (4), and considers whether the scrapping programs have a different effect on volume and premium producers.

Table 8 and Table A.10 in Appendix present the results. In France, we find that a 1 percent targeted subsidy raises demand by 8.2% for volume brands while decreasing sales of premium brands by 11.4%. Since there are no environmental eligibility conditions in the case of non-targeted schemes, both premium and volume brands can profit from the scrapping subsidies: this is indeed confirmed by our estimates under the German targeted scheme. Our premium brand definition includes Audi, BMW, Mercedes and some small luxury car brands (for instance, Bentley, Cadillac). Audi, BMW and Mercedes are distinguished German premium car brands, and the German scheme was designed very broadly, most probably so that these premium car producers could have a chance to benefit from the scheme as well. Counterfactuals based on our estimates confirm that, under non-targeted schemes, both premium and volume car brands benefited from the scrapping subsidies, while premium brands profited to a much lower extent or did not profit under targeted schemes. Finally, we investigate the effects of scrapping schemes on the characteristics of the car fleet in each

[32] In the US, half of the incremental car demand due to the 2009 CARS Program was satisfied by non-North American as well as Canadian and Mexican imports (Cooper et al. (2010)).

[33] In 2009, Poissy produced the Peugeot 208, Peugeot 1007 and Citroen DS3. Swindon produced the Honda Civic and Honda CR-V.

country, focusing in particular on horsepower and size. As we can see in Table 9, targeted schemes tend to affect the horsepower and size of the fleet of volume models more than non-targeted schemes: absent the scheme the average horsepower of volume models would have been 6.7% higher in France and 7.5% higher in Italy. The effect is slightly smaller in Germany (6.5%) and much smaller in the UK (1.3%). Similar results are found for size. In contrast, under targeted schemes the characteristics of the premium fleet appear unaffected, while non-targeted schemes significantly affect the size and horsepower of premium cars.

Table 8: Competitive effects of scrapping schemes: premium versus volume cars

	Germany	France	Italy
scrap_pct × NT	4.297		3.888
	(9.077)		(5.989)
scrap_pct × T		8.156	5.240
		(5.474)	(9.191)
scrap_pct × NT×Premium	4.482		-2.292
	(3.437)		(-0.704)
scrap_pct × T×Premium		-11.374	1.196
		(-2.855)	(0.612)
$(1-\text{scrap})\times$ T		-0.410	0.015
		(-5.324)	(0.331)
$(1-\text{scrap})\times$ T×Premium		0.159	0.059
		(2.212)	(0.883)
# models	1,250	1,191	1,230
# countries	2	2	2
# model/month fixed effects α_{jt}	14,415	13,612	13,940
# country/year fixed effects θ_{ct}	28	28	28
# observations	178,301	165,756	166,250
R-squared	0.416	0.287	0.295

The table reports the parameter estimates and t-statistics (in parenthesis) for specification (4) including interactions with the premium brand dummy, separately estimated for each country. The dependent variable is the logarithm of car model sales. Car characteristics, country-specific model, country-specific monthly (for seasonal adjustment), and year-monthly fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table 9: Impact of removing scrapping schemes on volume and premium brands (2009)

	Volume Models		Premium Models	
	Average horsepower			
Country	*actual (kW)*	*% change*	*actual (kW)*	*% change*
Non-targeted schemes				
Germany	68.22	6.5%	116.94	5.7%
Netherlands	70.94	1.3%	111.40	0.1%
UK	71.20	1.3%	120.77	5.7%
Average non-targeted	69.43	4.2%	117.86	3.8%
Targeted schemes				
France	64.88	6.7%	113.28	1.3%
Italy	64.54	7.5%	121.23	0.9%
Portugal	67.80	6.6%	116.27	2.6%
Spain	74.42	2.5%	111.10	1.5%
Average targeted	66.66	6.6%	116.12	0.8%
	Average size			
Country	*actual* (m^2)	*% change*	*actual* (m^2)	*% change*
Non-targeted schemes				
Germany	7.18	2.6%	8.22	1.3%
Netherlands	7.09	0.7%	8.33	0.0%
UK	7.22	0.7%	8.31	0.3%
Average non-targeted	7.19	1.6%	8.25	1.0%
Targeted schemes				
France	7.09	2.9%	8.18	0.3%
Italy	6.86	3.3%	8.27	0.3%
Portugal	7.30	3.0%	8.31	0.6%
Spain	7.49	0.9%	8.20	0.5%
Average targeted	7.10	2.8%	8.23	0.3%

The table reports the actual average horsepower and size as well as the estimated changes in these variables due to scrapping schemes based on the estimates reported in Table 8 and Table A.10. The left hand side of the table presents the findings for volume brands, while the right hand side of the table reports the findings for premium brands. Countries with non-targeted schemes include Germany, the Netherlands and the United Kingdom, whereas countries with targeted schemes include France, Italy, Portugal and Spain.

Effects on prices It would be interesting to investigate whether the incentive were fully "passed through" to consumers by the dealers. To answer the question, we would need information on transaction prices, but we only observe list prices. We investigated the question with the available information by regressing the logarithm of the deflated net-of-incentive car prices on the percent subsidy variable (scrap_pct) and the usual set of fixed effects and macro-control variables. The coefficient of scrap_pct indicates the extent by which the scrapping incentives reduced the new car prices. Table A.11 in Appendix reports the results. We find that consumers obtained at least 100% of the subsidy: for Germany the coefficient is estimated at -1 (full pass-through), while for France and Italy the coefficient is estimated slightly lower than -1, thus indicating even some over pass-through. The effect on the non-eligible cars is practically zero. These results should be interpreted with some caution since discounting could be lower during scrapping policies so that pass-through is incomplete; or manufacturers could adopt heterogeneous discounting policies that could lead to biases in our estimates even after the vast set of controls we employ. Our results of full pass-on are line with the finding of Busse et al. (2012).

5 Conclusion

The last financial and economic crisis has been accompanied by the worsening of consumer confidence and degradation of households' access to finance. In addition, there was uncertainty about future economic prospects. These factors led to a short-term decline in the demand for cars. To stimulate new car purchases, a number of European countries have introduced scrapping programs. In our study we have investigated the impact of the scrapping schemes that were adopted during the recent economic crisis. In particular, we studied the incentive effects of the scrapping schemes, in terms of stimulating (or at least stabilizing) total demand, and demand for more fuel-efficient cars. We also studied the presence of any crowding out effects of the scrapping schemes, and the effect of scrapping schemes on domestic production.

For our purpose, we have collected a unique model-level monthly dataset on the European car market and scrapping schemes. We have applied a difference-in-differences approach for each country pair, keeping Belgium as control group, and with fixed effects in a panel data context. We exploited variation of scrapping programs to identify the impact of scrapping programs on car sales while accounting for heterogeneity in the effects of scrapping programs across countries and identify country-specific effects of the scrapping schemes. Our estimation strategy help us to alleviate the potential endogeneity problem that may be characteristic for time-series country-specific studies on scrapping policy evaluation (i.e. both sales and scrapping schemes may be driven by some third variable, e.g. worsening macroeconomic conditions).

As related to the "incentive and crowding out effects", we found that scrapping schemes have substantially stimulated car purchases. This prevented a large decline in sales in 2009 due to the last economic downturn. Targeted schemes had stronger effects on car sales than non-targeted schemes, especially on the sales of eligible cars. In addition, targeted schemes caused substitution between different types of cars in France and Spain: eligible cars benefited at the expense of non-eligible cars in those countries. Because eligible cars tend to be more fuel efficient, targeted scrapping schemes had significant environmental benefits in the form of improved fuel consumption, while the environmental benefits of the scrapping schemes were very modest under non-targeted schemes. In sum, the scrapping schemes that were introduced in response to the crisis can be viewed as a short-term instrument to stabilize car demand and thus to counteract the financial crisis and economic downturn. They may work as a long-term instrument to stimulate the demand for more fuel-efficient cars and generate environmental benefits, but only when subsidies are designed to target low-emission vehicles.[34]

As related to the effects on competition and production, we found that the "green" eligibility criteria in the case of targeted schemes (e.g. in the form of CO_2 emissions) did not cause any serious competitive bias apart from the case of Italy, in which cars domestically produced received an extra stimulus with respect to cars produced abroad. Domestic cars gained more than foreign brands in the case of non-targeted schemes. Furthermore, premium car brands lost some market shares from the targeted scrapping subsidies, although to a small extent, while they did no face any extra disadvantage from being a premium brand in the case of non-targeted schemes: consumers could still buy premium cars attractive to them because of a price advantage due to the fixed scrapping premium.

In general, our empirical analysis and findings fit well into the economic framework that we have implemented to assess scrapping subsidies, following the so called "balancing test" of positive and negative effects applied by the European Commission in the case of state aid. In European state aid terms, scrapping schemes are a public support instrument that does not constitute state aid if the schemes are non-discriminatory, i.e. open to all undertakings or fall under the *de minimis* regulation. Hence, they are not subject to the notification requirement and the economic assessment by the European Commission. Our findings generally support, apart from the case of Italy, the presumed *ex ante* non-discriminatory nature of scrapping schemes. Our *ex post* evaluation of European scrapping schemes in the financial crisis has been very informative in this respect, and the Commission can pursue such evaluations in the future to guide its public support policy.

Our paper offers several directions for future research, especially related to the enEf-

[34] We cannot empirically quantify the trade-offs, if there exist any, between economic and environmental targets of scrapping programs in the sense, discussed by Li and Wei (2013) for the US CARS Program. The authors argue that environmental benefits are the costs of economic stimulus, in the sense that the sales effects would have been larger in the absence of any program eligibility criteria. Li et al. (2013) doubt both the environmental impact of the program due to the high implied costs of reducing gasoline consumption and CO_2 emissions and the possibility to reach multiple objectives with a single policy.

fecvironmental impact of scrapping subsidies. In our analysis, we study only one aspect of their possible environmental effects, i.e. whether the fuel efficiency of new purchased cars has improved compared to what would have been without the scrapping subsidies. The total fuel consumption benefit of scrapping policies should also include the fuel consumption savings on scrapped cars that should be contrasted with those on the purchased new cars. This exercise would require information on the characteristics of scrapped cars. A deeper environmental analysis might also address other than CO_2 types of pollutant emissions, or consider the full life circle of a car, starting from the amount of energy used to build a car up to the amount of energy used to dismantle it, and estimate related CO_2 emissions. The careful analysis of environmental costs and benefits of scrapping policies may be a focus of another major study. Finally, our empirical analysis has focused on the short-term sales and fuel consumption effects of scrapping policies. A more complete analysis would involve an equilibrium model of the automobile market, including both new and used car markets, to study the dynamic effects of scrapping programs.

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A Appendix. Additional Tables

Table A.1: Design features of scrapping schemes in selected European countries

	Duration	Incentive	Age retired car	Conditions on car purchase
France				
	5 Dec 2007-3 Dec 2008	€300	>15 years	new, max 160 g/km CO_2
	4 Dec 2008-31 Dec 2009	€1,000	>10 years	new, max 160 g/km CO_2
	1 Jan 2010-30 June 2010	€750	>10 years	new, max 155 g/km CO_2
	1 July 2010-31 Dec 2010	€500	>10 years	new, max 155 g/km CO_2
	1 Jan 2011-31 Dec 2011	€300	>15 years	new, max 150 g/km CO_2
Germany				
	14 Jan 2009-31 Dec 2009	€2,500	>9 years	new, min Euro 4, or used, max 1 year old
Italy				
	1 Jan - 31 Jan 1998	€775	>10 years	new
	1 Feb-31 July 1998	€516-646	>10 years	new, max 10liter/100km
	1 Jul 2002-31Dec 2002	€262.39 + 7.74*hp	>10 years	new, max 85 horsepower
	3 Oct 2006-31 Dec 2007	€1,316	>9 years	new, Euro 4&5, up to 100 kw, max 140 g/km CO_2 (petrol), or max 130 g/km CO_2 (diesel)
		€1,574	>9 years	new, Euro 4&5, more than 100 kw, max 140 g/km CO_2 (petrol), or max 130 g/km CO_2 (diesel)
	1 Jan 2008-31 Dec 2008	€800	>9 years	new, max 130 g/km CO_2
		€900	>9 years	new, max 120 g/km CO_2
	7 Febr 2009-31 Dec 2009	€1,500	>9 years	new, min Euro 4+ max 140 g/km CO_2 (petrol), or max 130 g/km CO_2 (diesel), additional incentives up to € 3500 for hybrid, all-electric or gas new cars
Netherlands				
	29 May 2009-21 Apr 2010	€750-1,000	>13 years	petrol (incentive depending on age)
		€1,000-1,750	>9 years	diesel (incentive depending on age), new car/van with particulate filter, new car< 8 years
Portugal				
	1 Jan 2000-31 Dec 2004	€750	>10 years	new
	1 Jan 2005-31 Dec 2005	€1,000	>10 years	new
	1 Jan 2006-31 Dec 2008	€1,000	>10 years	new
		€1,250	>15 years	new
	1 Jan 2009-7 Aug 2009	€1,000	>10 years	new, max 140 g/km CO_2
		€1,250	>15 years	new, max 140 g/km CO_2
	8 Aug 2009-31 Dec 2009	€1,250	>8 years	new, max 140 g/km CO_2
		€1,500	>13 years	new, max 140 g/km CO_2
	1 Jan 2010-31 Dec 2010	€1,000	>10 years	new, max 130 g/km CO_2
		€1,250	>15 years	new, max 130 g/km CO_2
Spain				
	11 Apr 1997-31 Dec 2006	€480	>10 years	new, or used (up to 5 years old)
	1 Jan 2007-31 Dec 2007	€480	>10 years	new, max 2500 cc, or used (up to 5 years old)
	4 Sept 2008-15 May 2009	€2,000	>10 years	new, max 120 g/km CO_2, max new vehicle price €30 000
			>15 years	or used (up to 5 years old)
	18 May 2009-31 Dec 2009	€ 2,000	>10 years	new, max 120 g/km CO_2, max new vehicle price € 30 000,
			>12 years	or used (up to 5 years old)
	1 Jan 2010-30 Sept 2010	€2,000	>10 years	new, max 120 g/km CO_2, max new vehicle price €30 000
			>12 years	or used (up to 5 years old)
UK				
	18 May 2009-31 Mar 2010	£2,000	>10 years	new

The table summarizes scrapping schemes in eight European countries based on IHS Global Insight, ACEA and various national sources. We describe the characteristics of schemes that are the most relevant for our empirical analysis and that are related to passenger cars only. Spanish (2008-2010) and British scrapping incentives include a mandatory incentive on the part of car manufacturers. The official duration of a scheme is given (i.e. not taking into account the extended period for registration, usually up to three months).

Table A.2: Descriptive statistics for European scrapping schemes (2009)

	The Netherlands Non-targeted All cars	UK Non-targeted All cars	Portugal Targeted Eligible	Portugal Targeted Non-eligible	Spain Targeted Eligible	Spain Targeted Non-eligible
	Mean	Mean	Mean	Mean	Mean	Mean
Sales (units)	67.3	285.7	59.2	11.6	279.2	55.4
Price (€1,000)	38.2	30.2	22.3	51.0	17.0	40.5
CO_2 emissions (gram/km)	173.8	180.3	125.2	183.1	127.8	198.7
Fuel consumption (liter/100km)	7.06	7.33	4.94	7.34	5.06	8.07
Horsepower (kW)	107.7	119.6	69.9	125.4	68.4	129.0
Width (cm)	179.0	179.4	173.1	181.7	172.1	181.4
Length (cm)	444.1	443.8	409.0	456.9	408.8	456.9
Height (cm)	153.6	152.0	150.4	152.7	150.4	154.3
Domestic. Prod. (0-1)	0.01	0.11	0.01	0.03	0.11	0.05
Premium cars (0-1)	0.27	0.32	0.15	0.38	0.07	0.36
Scrapping dum (0-1)	0.57	0.67	1.00	0.00	1.00	0.00
Rel. incentive (%)	2.40	7.89	5.81	0.00	12.91	0.00
# models	676	644	216	354	267	634
# countries	1	1	1	1	1	1
# observations	6,051	6,736	2,142	2,280	2,291	5,112

The table reports means by country for our main variables for non-targeted schemes (The Netherlands and the UK) and targeted schemes (Portugal and Spain) in 2009. In the case of targeted schemes we distinguish between eligible and non-eligible cars. Belgium does not have any scrapping scheme, so it is not presented in the table. The variables are expressed as averages per model. Prices are retail prices (i.e. after VAT and other taxes).

Table A.3: Incentive and crowding out effects of scrapping schemes: by country

	Netherlands	UK	Portugal	Spain
scrap_pct $\times$ NT	2.780	1.334	9.734	13.781
	(3.306)	(4.687)	(6.106)	(4.178)
scrap_pct $\times$ T			9.483	1.669
			(3.965)	(3.964)
$(1 - \text{scrap}) \times$ T			-0.064	-0.110
			(-0.446)	(-3.024)
scrap_pct $\times$ NT $=$ scrap_pct $\times$ T			0.02	13.40
Prob $>$ F-stat			(0.9006)	(0.0003)
# models	1,213	1,271	1,181	1,245
# countries	2	2	2	2
# model/month fixed effects α_{jt}	13,668	14,570	13,234	14,077
# country/year fixed effects θ_{ct}	28	28	28	28
# observations	162,721	164,649	141,136	168,835
R-squared	0.138	0.384	0.301	0.259

The table reports the parameter estimates and t-statistics (in parenthesis). Results are based on specification (3). The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.4: Incentive and crowding out effects of scrapping schemes before and after the 2008-2009 crisis: by country

	Italy	Portugal	Spain
scrap_pct pre 2008	4.919	9.160	11.218
	(8.245)	(5.583)	(3.749)
scrap_pct post 2008	4.983	10.785	2.322
	(5.491)	(8.450)	(5.426)
scrap_pct pre 2008 = scrap_pct post 2008	0.01	1.31	9.21
Prob > F-stat	(0.9401)	(0.2523)	(0.0025)
# models	1,230	1,181	1,245
# countries	2	2	2
# model/month fixed effects α_{jt}	13,940	13,234	14,077
# country/year fixed effects θ_{ct}	28	28	28
# observations	166,250	141,136	168,835
R-squared	0.295	0.301	0.258

The table reports the parameter estimates and t-statistics (in parenthesis). Results are based on specification (2) with the percent monetary incentive interacted with a dummy for before and after the 2008 crisis. The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.5: Robustness check on null sales - Incentive and crowding out effects of scrapping schemes by country

	Germany	France	Italy
scrap_pct × NT	4.777		3.017
	(10.360)		(3.937)
scrap_pct × T		9.616	4.255
		(5.535)	(7.474)
$(1 - \text{scrap}) \times$ T		-0.321	0.018
		(-4.136)	(0.374)
# models	1250	1191	1230
# countries	2	2	2
# model/month fixed effects α_{jt}	10886	9515	9483
# country/year fixed effects θ_{ct}	28	28	28
# observations	110,957	95,666	93,731
R-squared	0.337	0.319	0.295

The table reports the parameter estimates and t-statistics (in parenthesis). Results are based on specification (3) where we omit all the models presenting null sales. The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.6: Intertemporal effects of scrapping schemes

	Netherlands		UK		Portugal		Spain	
	3 months	5 months	3 months	5 months	3 months	5 months	3 months	5 months
scrap_pct $\times$ NT	2.821	3.544	1.515	1.307	10.034	10.136	13.895	13.952
	(3.090)	(3.694)	(5.013)	(4.197)	(6.050)	(6.092)	(4.214)	(4.229)
scrap_pct $\times$ T					9.575	9.614	2.034	1.629
					(3.989)	(4.003)	(3.586)	(3.351)
$(1 - \text{scrap}) \times$ T					-0.073	-0.082	-0.070	-0.123
					(-0.513)	(-0.573)	(-1.270)	(-2.711)
scrap - first month	0.015	0.007	-0.197	-0.196	-0.151	-0.155	-0.138	-0.102
	(0.409)	(0.192)	(-5.241)	(-5.186)	(-2.040)	(-2.082)	(-2.700)	(-2.193)
scrap X NT 3/5 months after	0.022	0.163	0.090	-0.090				
	(0.667)	(4.587)	(3.185)	(-3.232)				
scrap X T 3/5 months after					0.395	0.385	0.269	0.150
					(6.600)	(6.742)	(3.525)	(2.803)
(1-scrap) X T 3/5 months after					-0.362	-0.409	-0.053	-0.202
					(-6.039)	(-7.211)	(-0.764)	(-4.724)
# models	1,213	1,213	1,271	1,271	1,181	1,181	1,245	1,245
# countries	2	2	2	2	2	2	2	2
# model/month fixed effects α_{jt}	13,668	13,668	14,570	14,570	13,234	13,234	14,077	14,077
# country/year fixed effects θ_{ct}	28	28	28	28	28	28	28	28
# observations	162,721	162,721	164,649	164,649	141,136	141,136	168,835	168,835
R-squared	0.138	0.138	0.384	0.384	0.302	0.302	0.259	0.259

The table reports the parameter estimates and t-statistics (in parenthesis). All results are based on specification (3), with the extension to account for anticipatory and post-subsidy effects. The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.7: Robustness check I - Intertemporal substitution effects of scrapping schemes by country: drop observations before the scheme starts

	Germany			France			Italy		
	base	3 months	5 months	base	3 months	5 months	base	3 months	5 months
scrap_pct × NT	3.797	3.841	3.837				3.838	3.725	3.735
	(7.709)	(7.722)	(7.626)				(6.060)	(5.987)	(6.002)
scrap_pct × T				9.099	9.122	9.122	5.461	5.356	5.406
				(6.089)	(6.106)	(6.106)	(9.229)	(9.431)	(9.436)
$(1 - \text{scrap}) \times$ T				-0.276	-0.277	-0.277	0.055	0.038	0.039
				(-4.363)	(-4.381)	(-4.381)	(1.332)	(1.025)	(1.033)
scrap - first month		0.005	0.009		-0.340	-0.340		-0.025	-0.023
		(0.059)	(0.119)		(-9.365)	(-9.365)		(-1.010)	(-0.948)
scrap X NT 3/5 months after		-0.262	-0.231						
		(-8.928)	(-7.712)						
scrap X T 3/5months after								0.286	-0.264
								(3.789)	(-6.406)
(1-scrap) X T 3/5 months after								-0.258	-0.264
								(-6.021)	(-6.406)
# models	1,250	1,250	1,250	1,191	1,191	1,191	1,230	1,230	1,230
# countries	2	2	2	2	2	2	2	2	2
# model/month fixed effects α_{jt}	14,411	14,411	14,411	13,612	13,612	13,612	13,937	13,937	13,937
# country/year fixed effects θ_{ct}	28	28	28	28	28	28	28	28	28
# observations	177,649	177,649	177,649	165,194	165,194	165,194	164,675	164,675	164,675
R-squared	0.415	0.418	0.420	0.286	0.286	0.286	0.295	0.297	0.299

The table reports the parameter estimates and t-statistics (in parenthesis). All results are based on specification (3), with the two following extensions: (i) exclude all the observations related to the month before the scheme is introduced (columns base, 3 months, 5 months); (ii) account for anticipatory and post-subsidy effects (columns 3 months and 4 months). The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.8: Robustness check II - Intertemporal substitution effects of scrapping schemes by country: drop observations after the scheme ends

	Germany			France			Italy		
	no drop	drop 3 m.	drop 5 m.	no drop	drop 3 m.	drop 5 m.	no drop	drop 3 m.	drop 5 m.
scrap_pct × NT	3.795	3.841	3.837				3.691	3.725	3.735
	(7.740)	(7.722)	(7.626)				(5.952)	(5.987)	(6.002)
scrap_pct × T				9.122	9.122	9.122	5.278	5.356	5.406
				(6.106)	(6.106)	(6.106)	(9.400)	(9.431)	(9.436)
$(1-\text{scrap}) \times$ T				-0.277	-0.277	-0.277	0.037	0.038	0.039
				(-4.381)	(-4.381)	(-4.381)	(0.996)	(1.025)	(1.033)
								(-6.021)	(-6.406)
# models	1,250	1,250	1,250	1,191	1,191	1,191	1,230	1,230	1,230
# countries	2	2	2	2	2	2	2	2	2
# model/month fixed effects α_{jt}	14,415	14,381	14,415	13,612	13,612	13,612	13,940	13,928	13,922
# country/year fixed effects θ_{ct}	28	28	28	28	28	28	28	28	28
# observations	178,301	176,332	175,016	165,756	165,756	165,756	166,250	164,547	163,425
R-squared	0.415	0.418	0.420	0.286	0.286	0.286	0.295	0.297	0.299

The table reports the parameter estimates and t-statistics (in parenthesis). All results are based on specification (3), with the extensions: (i) exclude all the observations related to 3 months after the end of the scheme (drop 3 m.); (i) exclude all the observations related to 5 months after the end of the scheme (drop 5 m.). The dependent variable is the logarithm of car model sales. Car characteristics, model/month and country/year fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.9: Competitive effects of scrapping schemes: domestic versus non-domestic production

	Netherlands	UK	Portugal	Spain
scrap_pct × NT	2.734	1.174	9.671	10.853
	(3.182)	(3.872)	(6.088)	(3.192)
scrap_pct × T			9.395	1.469
			(3.914)	(3.336)
scrap_pct × NT×Domestic Prod.	6.555	2.981	-5.089	8.534
	(1.376)	(3.087)	(-0.373)	(1.937)
scrap_pct × T×Domestic Prod.			1.077	1.756
			(0.254)	(1.082)
$(1 - \text{scrap}) \times$ T			-0.073	-0.108
			(-0.509)	(-2.928)
$(1 - \text{scrap}) \times$ T×Domestic Prod.			0.128	0.155
			(0.363)	(0.736)
Domestic Production (0-1)	-0.310	0.231	0.154	0.191
	(-1.676)	(2.082)	(1.235)	(1.528)
# models	1,213	1,271	1,181	1,245
# countries	2	2	2	2
# model/month fixed effects α_{jt}	13,668	14,570	13,234	14,077
# country/year fixed effects θ_{ct}	28	28	28	28
# observations	162,721	164,649	141,136	168,835
R-squared	0.140	0.386	0.301	0.262

The table reports the parameter estimates and t-statistics (in parenthesis) for specification (4) including interactions with the domestic production dummy, separately estimated for each country. The dependent variable is the logarithm of car model sales. Car characteristics, country-specific model, country-specific monthly (for seasonal adjustment), and year-monthly fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.10: Competitive effects of scrapping schemes: premium versus volume cars

	Netherlands	UK	Portugal	Spain
scrap_pct × NT	2.851	1.318	10.766	15.426
	(3.249)	(4.547)	(6.426)	(4.564)
scrap_pct × T			9.647	1.723
			(3.498)	(4.065)
scrap_pct × NT×Premium	-2.308	1.416	6.797	7.936
	(-0.704)	(1.491)	(2.590)	(1.215)
scrap_pct × T×Premium			1.362	-1.782
			(0.313)	(-0.718)
$(1 - \text{scrap}) \times$ T			-0.106	-0.054
			(-0.571)	(-1.091)
$(1 - \text{scrap}) \times$ T×Premium			0.154	-0.142
			(1.549)	(-2.038)
# models	1,213	1,271	1,181	1,245
# countries	2	2	2	2
# model/month fixed effects α_{jt}		14,570	13,234	14,077
# country/year fixed effects θ_{ct}	28	28	28	28
# observations		164,649	141,136	168,835
R-squared	0.139	0.384	0.301	0.260

The table reports the parameter estimates and t-statistics (in parenthesis) for specification (4) including interactions with the premium brand dummy, separately estimated for each country. The dependent variable is the logarithm of car model sales. Car characteristics, country-specific model, country-specific monthly (for seasonal adjustment), and year-monthly fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.

Table A.11: Effect of scrapping schemes on prices

	Germany	France	Italy
scrap_pct × NT	-1.078		-1.204
	(-31.839)		(-36.183)
scrap_pct × T		-1.581	-1.197
		(-13.818)	(-40.726)
$(1 - \text{scrap}) \times$ T		-0.020	-0.005
		(-4.288)	(-2.464)
# models	1,250	1,191	1,230
# countries	2	2	2
# model/month fixed effects α_{jt}	14,415	13,612	13,940
# country/year fixed effects θ_{ct}	28	28	28
# observations	178,301	165,756	166,250
R-squared	0.614	0.551	0.560

The table reports the parameter estimates and t-statistics (in parenthesis) for a regression of the logarithm of the deflated net-of-incentive car prices on the percent subsidy variable (scrap_pct), separately estimated for each country. Car characteristics, country-specific model, country-specific monthly (for seasonal adjustment), and year-monthly fixed effects as well as macroeconomic controls (income per capita, unemployment, consumer confidence, and fuel prices) and relative size for green rebates in Belgium and France are included but not reported.