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THE EUROPE**

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ABSTRACT

Scrapping Subsidies during the Financial Crisis - Evidence from the Europe*

We study the effects of the car scrapping subsidies in Europe during the financial crisis. We make use of a rich data set of all car models sold in nine European countries, observed at a monthly level during 2005-2011. 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 17.4% in countries with schemes targeted to low emission vehicles, and they prevented a 14.8% sales reduction in countries with non-targeted schemes. In contrast, the scrapping schemes only had small environmental benefits: without the schemes, average fuel consumption of new purchased cars would have been only 1.3% higher in countries with targeted schemes and 0.5% higher in countries with non-targeted schemes. We do not find evidence of crowding out due to substitution from non-eligible to eligible cars in countries with targeted schemes. Finally, we identify some competitive and trade effects from the schemes: domestic car producers benefited at the expense of foreign competitors in the countries where the schemes were not targeted.

JEL Classification: F14, H25 and L52

Keywords: automobile market, financial crisis and scrapping subsidies

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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 behaviour, 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 aimed to reduce carbon dioxide (CO₂) 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 the countries that have little or no domestic car production.

¹The 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.

²Commission 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 yield environmental benefits in the form of fuel economy savings on new purchased vehicles? Our second question is whether there were any crowding-out effects of the scrapping schemes, such as substitution from non-eligible to eligible cars, or intertemporal substitution? Our third question is whether the scrapping schemes resulted in competitive and trade effects: Did domestic firms benefit more than their foreign competitors, and did volume brands and small cars win at the expense of premium brands and large cars?

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 nine European countries: Belgium, France, Germany, Greece, 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 distinguish between targeted and non-targeted schemes. Targeted schemes provide a subsidy if the new car satisfies certain environmental eligibility criteria (mainly based on CO₂ emissions), and were adopted in for example France and Italy. Non-targeted schemes provide a subsidy regardless of the new car that is purchased. These were introduced in for example Germany 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 17.4% lower in the countries with targeted schemes, and they would have been 14.8% lower in countries with non-targeted schemes. In elasticity terms: a 1% point subsidy tends to raise car sales by 1.4% for cars under non-targeted schemes, and by 2.8% for eligible cars under targeted schemes. At the same time, the scrapping schemes only had a small effect on the average fuel consumption of new purchased cars: without the schemes, average fuel consumption would have been 1.3% higher in countries with targeted schemes and 0.5% higher in countries with non-targeted schemes. That is, the main effect of European scrapping schemes in the financial crisis was to temporarily stabilize total car sales, and their environmental benefits were very limited.

Second, there were only limited crowding out effects. In the case of targeted schemes, the sales of non-eligible cars were not affected during the period when the scheme is effective. Furthermore, intertemporal substitution effects were small. Third, the scrapping schemes

had various competitive and trade effects. Quite surprisingly, domestic car brands benefited more than foreign car brands from scrapping subsidies when the programs were non-targeted (as in Germany and the UK), but not when the programs were targeted (as in France and Italy). Premium brands gain less from subsidies than volume brands but only in the case of targeted schemes. Small cars (from the subcompact and compact segments) benefit under both targeted and non-targeted schemes, whereas large cars (from the standard and luxury market segments) only benefit under targeted schemes (i.e. when they meet the environmental eligibility criteria). The schemes may eventually impact trade flows as, for instance, they may increase imports to satisfy the increased domestic demand for cars, not produced locally.

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 the environmental benefits; (ii) no work has considered the competitive and trade effects. We discuss both contributions in turn.

First, despite a number of theoretical and policy studies related to scrapping subsidies,³ there are just a few studies that empirically investigate the economic effects of scrapping schemes. 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 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

³Theoretical 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)).

⁴The 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 (2005), 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.

⁵Cooper et al. (2010) and Copeland and Kahn (2012) estimate a time-series forecasting model to predict

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, for a rich sample of nine European countries. This enables us to systematically compare the total sales effects with the environmental 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 competitive and trade effects 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 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.

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.

⁶The 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.

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

Empirical evidence on the competitive and trade effects 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.

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 a few schemes in Europe are designed as “cash-for-scrappage”, i.e. there is no condition on the age of a replacement car or obligation to purchase a replacement car at all.¹⁰ For instance, the Greek scheme of 2009 was not conditioned on the purchase of a new car. Generally,

⁸In our discussions we focus on nine European countries: Belgium, France, Germany, Greece, 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.

⁹The 2009 US “Cash for Clunkers” Program falls under this type of scrapping incentives.

¹⁰OECD (1999) introduces this distinction between “cash-for-replacement” and “cash-for-scrappage” subsidies.

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 an old vehicle that can be 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), 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 EUR 1,000 in 2009 to EUR 750 in the first half of 2010 and to EUR 500 in the second half of 2010), while other countries end them abruptly (e.g. in Germany).

Figure 1: Timing of scrapping schemes in selected European countries

Country/Year	2005	2006	2007	2008	2009	2010	2011
Belgium							
France							
Germany							
Greece							
Italy							
Netherlands							
Portugal							
Spain							
UK							

The figure depicts scrapping schemes in nine 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 Furthermore, the 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 1). In 2009 the scrapping subsidies varied from EUR 1,000 (e.g. in France) to EUR 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 EUR 5 billion).¹²

¹¹The 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 scrapping. 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.

¹²Usually 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 spike 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)).

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

	Duration	Incentive	Old car age	Conditions on a car purchase
France	5 Dec 2007-3 Dec 2008	EUR 300	>15 years	new, max 160 g/km CO ₂
	4 Dec 2008-31 Dec 2009	EUR 1,000	>10 years	new, max 160 g/km CO ₂
	1 Jan 2010-30 June 2010	EUR 750	>10 years	new, max 155 g/km CO ₂
	1 July 2010-31 Dec 2010	EUR 500	>10 years	new, max 155 g/km CO ₂
	1 Jan 2011-31 Dec 2011	EUR 300	>15 years	new, max 150 g/km CO ₂
Germany	14 Jan 2009-31 Dec 2009	EUR 2,500	>9 years	new, min Euro 4, or used, max 1 year old
Greece	28 Sep 2009-2 Nov 2009	EUR 500-2,200 EUR 1,500-3,200	>13 years >13 years	without purchase of new car Euro 4 or 5, with purchase of new car, incentive depending on engine displacement
Italy	3 Oct 2006-31 Dec 2007	EUR 1,316 EUR 1,574	>9 years >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) 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	EUR 800	>9 years	new, max 130 g/km CO ₂
	7 Febr 2009-31 Dec 2009	EUR 900 EUR 1,500	>9 years >9 years	new, max 120 g/km CO ₂ new, min Euro 4+ max 140 g/km CO ₂ (petrol), or max 130 g/km CO ₂ (diesel), additional incentives of up to EUR 3500 for hybrid, all-electric or gas-powered new vehicles
Netherlands	29 May 2009-21 Apr 2010	EUR 750-1,000 EUR 1,000-1,750	>13 years >9 years	petrol (incentive depending on age) diesel (incentive depending on age), new car/van equipped with particular filter, new car < 8 years
Portugal	1 Jan 2005-31 Dec 2005	EUR 1,000	>10 years	new
	1 Jan 2006-31 Dec 2008	EUR 1,000	>10 years	new
		EUR 1,250	>15 years	new
	1 Jan 2009-7 Aug 2009	EUR 1,000	>10 years	new, max 140 g/km CO ₂
		EUR 1,250	>15 years	new, max 140 g/km CO ₂
	8 Aug 2009-31 Dec 2009	EUR 1,250	>8 years	new, max 140 g/km CO ₂
		EUR 1,500	>13 years	new, max 140 g/km CO ₂
	1 Jan 2010-31 Dec 2010	EUR 1,000	>10 years	new, max 130 g/km CO ₂
		EUR 1,250	>15 years	new, max 130 g/km CO ₂
Spain	11 Apr 1997-31 Dec 2006	EUR 480	>10 years	new, or used (up to 5 years old)
	1 Jan 2007-31 Dec 2007	EUR 480	>10 years	new, max 2500 cc, or used (up to 5 years old)
	4 Sept 2008-15 May 2009	EUR 2,000	>10 years	new, max 120 g/km CO ₂ , max new vehicle price EUR 30 000, or used (up to 5 years old)
	18 May 2009-31 Dec 2009	EUR 2,000	>15 years >10 years	new, max 120 g/km CO ₂ , max new vehicle price EUR 30 000, or used (up to 5 years old)
	1 Jan 2010-30 Sept 2010	EUR 2,000	>12 years >10 years >12 years	new, max 120 g/km CO ₂ , max new vehicle price EUR 30 000, or used (up to 5 years old)
UK	18 May 2009-31 Mar 2010	GBP 2,000	>10 years	new

The table summarizes scrapping schemes in nine 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).

Targeted versus non-targeted The 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 CO₂ emissions, engine displacement, or price. For instance, in France cars with CO₂ 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: 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 EUR 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, Greek scrapping scheme had a number of conditions that determined the size of incentive (e.g. from EUR 1,500 up to EUR 3,200 for cars) depending on engine displacement, which eventually

¹³For 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.

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

¹⁵Alberini 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.

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)).

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

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 economy 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,

¹⁶See, for instance, Grigolon et al. (2012) for the presentation of this economic framework in general and its discussion as related to scrapping schemes.

¹⁷See, 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.

i.e. substitution between cars, and intertemporal substitution.¹⁸

As related to the substitution between cars, first of all 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 (2012), 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. Finally, 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 the 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.

Competitive and trade effects Scrapping schemes can cause distortions of competition and trade. First, scrapping schemes can favour car producers that manufacture small sized cars that happen to comply with environmental conditions linked to the incentives or that become more appealing to consumers because the size of incentive makes smaller and cheaper cars more attractive. Consequently, the schemes may distort the market structure in terms of redistributing the market shares of different firms or across different market segments. In such a way, some weaker players in the European car industry may be supported (IHS Global Insight (2010a)).

Furthermore, scrapping schemes can impact trade flows and distort location decisions. In particular, scrapping schemes can only be attractive for certain models of a car producer. Thus, scrapping programs may result in an uneven plant utilization: some plants may be obliged to allocate workers on short-time working schemes, while other plants may have use overtime to meet the increased demand or shift labour force from one plant to another, as

¹⁸Scrapping 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 effects are beyond the scope of this paper.

reported by Eurofound (2010) and by carmakers themselves.¹⁹

Finally, if scrapping schemes are *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 CO₂ 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 CO₂ emissions per kilometer (in 2009), or in Italy a new petrol car should emit at most 140 grams CO₂ emissions per kilometer (or 130 grams CO₂ emissions per kilometer in case a diesel car is bought). Similar environmental conditions were set for schemes in Portugal and Spain.

Summary In this paper we aim to investigate the effects of scrapping schemes on total car sales and average fuel economy (“Incentive effects”), explore temporal and intertemporal substitution effects (“Crowding out effects”), quantify the competitive effects of schemes and discuss their trade implications (“Competitive and trade effects”). We especially pay attention to the role of environmental technical eligibility criteria (such as CO₂ emissions, or fuel consumption) for a new car that can be purchased under a scrapping program, and analyze whether the criteria contradict the objective of non-discriminatory nature of scrapping schemes with respect to the origin of a car producer.

3 Empirical approach

3.1 Data description

Our first dataset is a European car registration dataset from JATO. It covers nine countries: Belgium, France, Germany, Greece, 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 2005 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

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

scrapping scheme and to measure the (relative) size of the scrapping incentive. Finally, there is information on the car's brand, its country of origin, and the firm ownership.

We slightly aggregate the data and 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 CO₂ 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 1). We have collected this information from various sources. First of all, the automotive consultancy 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 nine 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 CO₂ emissions criteria, engine displacement, the 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. 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.

Table 2 provides descriptive statistics for the main variables in 2009 (when all countries in our sample, except for Belgium, introduced scrapping programs, although during different

months). We distinguish between countries with targeted schemes (left hand side) and countries with non-targeted schemes (right hand side). In the case of targeted schemes, we also distinguish between eligible cars and non-eligible cars. For targeted schemes, the eligible cars form a minority (9,764 model observations versus 15,656 observations for the non-eligible models), but they have on average much higher sales (400 versus 58 cars). The eligible cars also tend to be sold at a much lower price (average of EUR 19,400 versus EUR 44,700 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 EUR 34,813. The average relative incentives are 8.3% for eligible cars in the case of targeted schemes and 6.0% across all cars in the case of non-targeted schemes.

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

	Targeted schemes				Non-targeted schemes	
	Eligible cars		Non-eligible cars		All cars	
	<i>Mean</i>	<i>Std.dev.</i>	<i>Mean</i>	<i>Std.dev.</i>	<i>Mean</i>	<i>Std.dev.</i>
Sales (units)	400.2	905.8	58.4	146.8	245.0	799.7
Price (EUR 1,000)	19.4	8.1	44.7	44.5	34.8	38.9
CO ₂ emissions (<i>gram/km</i>)	129.1	15.0	200.5	58.4	180.6	60.2
Fuel consumption (<i>litre/100 km</i>)	5.12	0.71	8.12	2.56	7.35	2.62
Horsepower (<i>kW</i>)	71.4	21.5	134.8	71.3	116.1	68.8
Width (cm)	173.0	8.28	182.0	7.05	179.2	8.65
Length (cm)	410.4	43.1	457.3	30.3	443.2	41.6
Height (cm)	150.3	7.3	154.2	16.0	153.1	13.8
Domestic cars (0-1)	0.10	0.30	0.06	0.23	0.13	0.34
Premium cars (0-1)	0.13	0.34	0.22	0.42	0.19	0.39
Scrapping dummy (0-1)	1	0	0	0	0.63	0.48
Relative incentive (%)	8.27	4.44	0	0	5.95	6.69
# months	12		12		12	
# models	405		731		844	
# countries	4		4		4	
# observations	9,764		15,656		25,395	

The table reports means and standard deviations for our main variables in the case of targeted (left hand side) and non-targeted (right hand side) schemes in 2009. 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, Greece, 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 (see Appendix) depicts the evolution of seasonally adjusted monthly car sales in France, Germany, the Netherlands and the United Kingdom. These were the countries that introduced the scrapping programs for the first time between 2005 and 2011, in response to the financial crisis. 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. 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 (e.g. Belgium), 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 2005-2011 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 (scrapping program). We can extend this assumption to multiple countries and multiple time periods. We will control for macro-economic variables that may evolve differently across countries, such as monthly GDP and fuel prices. We will also control for other policies that were implemented during the period: 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 EUR 5,000 for cars with low CO₂ emissions and an extra charge of up to EUR 2,600 for cars with high CO₂ emissions).

Since we observe the sales and car specifications at the level of individual car models, we can further enrich the framework in various ways. First, we can account for the size of the scrapping policy incentive, which may differ depending on the car specifications. Second, we can 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 CO₂ emissions) and non-eligible cars (with high CO₂ emissions). We can also assess the intertemporal effects: anticipatory and pull-forward effects. Third, we can consider the effects of the scrapping schemes on competition and trade. Perhaps the most relevant question from a European policy perspective is whether domestic brands benefit more from scrapping subsidies than foreign brands. We can also compare different effects between volume and premium brands, or across market segments.

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/country fixed effects, and monthly time fixed effects, as well as various control variables that may vary over models/countries/time periods. One may start from the following basic specification, which focuses entirely on the incentive effects of the scrapping subsidies:

$$\begin{aligned} \log(\text{sales}_{jct}) = & \alpha_{jc} + \theta_t + \delta \text{scrap}_{jct} \\ & + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}, \end{aligned} \tag{1}$$

where j is the car model (i.e. model group/body type/fuel type, as defined above), c is the country, and t is time period (month during 2005-2011). The dependent variable is the logarithm of sales of a model in a country during a certain month. The first three terms on the right hand side are the essential parts of the difference-in-differences approach. First, α_{jc} consists of a full set of model/country fixed effects, controlling for time-invariant differences in demand across models and countries. Second, θ_t captures time fixed effects for every month during the period 2005-2011. These account for general macro-economic shocks that affect European car sales. Third, 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 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:

$$\begin{aligned} \log(\text{sales}_{jct}) = & \alpha_{jc} + \theta_t + \delta \text{scrap_pct}_{jct} \\ & + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}. \end{aligned} \tag{2}$$

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 countries. 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 economy, 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. It also includes country specific seasonal effects (monthly dummy variables per country). Finally, ε_{jct} is an error term. We account for arbitrary heteroscedasticity and serial correlation, and use clustered standard errors as emphasized by Bertrand et al. (2004) in the difference-in-differences context.

We now extend this basic framework to account for various possible crowding out as well as competitive and trade effects.

Crowding out effects Specifications (1) and (2) do not distinguish between targeted and non-targeted schemes. The treatment group thus includes all cars in countries where non-targeted schemes are active, and it includes all eligible cars in countries with targeted schemes. The control group includes all cars in countries where no scheme is active, but it also includes the non-eligible cars in countries where a targeted scheme is active (see Table 2). 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 differential impact

of targeted and non-targeted schemes, we extend (1) to the following specification:

$$\begin{aligned} \log(\text{sales}_{jct}) = & \alpha_{jc} + \theta_t + \delta_1 \text{scrap}_{jct} \times \text{NT}_{ct} + \delta_2 \text{scrap}_{jct} \times \text{T}_{ct} \\ & + \delta_3(1 - \text{scrap}_{jct}) \times \text{T}_{ct} + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}. \end{aligned} \quad (3)$$

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 CO₂ 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 $\delta_2 > \delta_1 > 0 \geq \delta_3$, 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.

Specification (3) is based on the dummy variable scrap_{jct} , which considers the effect of the scrapping scheme regardless of the size of the incentive. We also consider a specification that is based on the percentage monetary incentive variable scrap_pct_{jct} :

$$\begin{aligned} \log(\text{sales}_{jct}) = & \alpha_{jc} + \theta_t + \delta_1 \text{scrap_pct}_{jct} \times \text{NT}_{ct} + \delta_2 \text{scrap_pct}_{jct} \times \text{T}_{ct} \\ & + \delta_3(1 - \text{scrap}_{jct}) \times \text{T}_{ct} + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct}. \end{aligned} \quad (4)$$

This specification takes into account the size of the monetary incentive. We consider (3) and (4) as our base specifications: they account 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) and (4) 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) and (4) for the first month of the scheme (when it may not yet have been effective).²⁰

²⁰It is argued that no effect should be expected beyond one month (Copeland and Kahn (2012)), or at most two months (Li et al. (2013)) before a scheme is launched, especially in response to the crisis. Some authors believe that no anticipatory effect might be expected at all (for instance, Cooper et al. (2010) in the case of the US CARS Program).

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, the car sales may go down. To investigate this effect, we introduce a dummy variable for the first three months 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.²¹

Competitive and trade effects Specifications (3) and (4) assume the effects of the scrapping schemes are homogeneous across car models. In practice, the scrapping schemes may have differential effects, so that some cars obtain a competitive advantage. We focus here on the possible differential effects between domestic and foreign cars, but in our empirical analysis we also consider the differential effects between volume and premium brands, and between different car segments. We limit attention to the specification that is based on the percentage monetary incentive. To differentiate between the effects of the scrapping schemes on the sales of domestic and foreign cars, we consider the following generalization of (4):

$$\begin{aligned}
\log(\text{sales}_{jct}) = & \alpha_{jc} + \theta_t + \delta_1 \text{scrap_pct}_{jct} \times \text{NT}_{ct} + \delta_2 \text{scrap_pct}_{jct} \times \text{T}_{ct} \\
& + \delta_{1D} \text{scrap_pct}_{jct} \times \text{NT}_{ct} \times \text{DOM}_{jct} + \delta_{2D} \text{scrap_pct}_{jct} \times \text{T}_{ct} \times \text{DOM}_{jct} \\
& + \delta_3(1 - \text{scrap}_{jct}) \times \text{T}_{ct} + \delta_{3D}(1 - \text{scrap}_{jct}) \times \text{T}_{ct} \times \text{DOM}_{jct} \\
& + x_{jct}\beta + w_{ct}\gamma + \varepsilon_{jct},
\end{aligned} \tag{5}$$

where DOM_{jct} is a dummy variable equal to one if a car model j is produced by a domestic car producer in country c at period t . We define the model's domestic/foreign status based on the parent firm's nationality. Models sold under the brand of Citroën, Peugeot and Renault are defined as French cars, even though their production can take place in different locations. Similarly, Audi, BMW, Ford, Mercedes, Opel, Porsche and Volkswagen are defined as German brands. Alfa Romeo, Ferrari, Fiat and Lancia are Italian brands. Seat is a Spanish brand, and Jaguar, Land Rover, Mini and Vauxhall are British brands. Belgium, Greece, the Netherlands and Portugal do not have any domestic car brands. 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 of domestic origin: δ_{1D} refers to the additional sales effect for domestic cars under a non-targeted program; δ_{2D} refers to the additional sales effect for domestic cars that are eligible

²¹The length of the pull-forward effects investigated in the existing studies seems to be driven by the data availability. For instance, in the case of the US CARS Program Li et al. (2013), Copeland and Kahn (2012) 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.

under a targeted program; and δ_{3D} measures the additional sales effect (if any) for domestic cars that are not eligible under a targeted program.

We also use a variant of specification (5), 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. Finally, we investigate whether the effects of scrapping schemes differ across market segments. This will allow us to infer about the effect of schemes on the purchases of small, usually more fuel-efficient, and large, usually less fuel-efficient, cars.

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 competitive and trade effects, i.e. differential effects of the scrapping schemes across different models.

Incentive and crowding out effects Table 3 reports the results. Columns (1) and (4) 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 and statistically significant: the coefficient of 0.114 implies that sales go up on average by 12.1% due to the scheme.²² Column (4) 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 1.8%.

Columns (2) and (5) are based on specifications (3) and (4). These take 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} , shows that the average effect of scrapping schemes on sales is large when the schemes are targeted, i.e. a coefficient of 0.260 or an average 29.7% increase in the sales of eligible cars. The cars not eligible for purchase under targeted schemes do not suffer from the scrapping subsidies (i.e. no crowding out). Column (5), which is based on the percentage subsidy variable, yields positive sales effects in the case of both types of schemes. The effect of the percentage subsidy is however stronger

²²This is calculated as $1 - \exp(0.114)$ since a semilog sales model is estimated.

under targeted than under non-targeted schemes: a 1% increase in the subsidy raises sales of targeted cars by 2.8% whereas under non-targeted schemes a 1% increase in the subsidy raises sales of all cars by 1.4%. As before, we do not find any significant crowding out effect.

Table 3: Incentive and crowding out effects of scrapping schemes

	Scrapping dummy			Relative incentive		
	(1)	(2)	(3)	(4)	(5)	(6)
scrap	0.114 (8.164)			1.834 (12.070)		
scrap \times NT*		0.017 (1.273)	0.021 (1.490)		1.368 (8.666)	1.416 (8.801)
scrap \times T*		0.260 (13.334)	0.266 (13.211)		2.789 (10.712)	2.886 (10.639)
(1 - scrap) \times T		-0.006 (-0.411)	-0.005 (-0.337)		0.007 (0.449)	0.009 (0.532)
scrap - first month			-0.117 (-9.425)			-0.152 (-12.681)
scrap \times NT - 3 months after			-0.052 (-3.255)			-0.034 (-2.097)
scrap \times T - 3 months after			0.158 (5.229)			0.161 (5.154)
(1 - scrap) \times T - 3 months after			-0.072 (-2.968)			-0.070 (-2.868)
# months (θ_t)	84	84	84	84	84	84
# models	1,300	1,300	1,300	1,300	1,300	1,300
# countries	9	9	9	9	9	9
# groups (model/country effects α_{jc})	8,761	8,761	8,761	8,761	8,761	8,761
# observations	383,566	383,566	383,566	383,566	383,566	383,566
R-squared	0.263	0.265	0.265	0.268	0.269	0.269

The table reports the parameter estimates and t-statistics (in parenthesis). Column (1) refers to specification (1), columns (2) and (3) refer to specification (3); column (4) refers to specification (2), and columns (5) and (6) refer to specification (4). 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 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 (specifications (1) and (3)), or a percentage monetary incentive in the right hand side of the table (specifications (2) and (4)).

The results in columns (2) and (5) thus show that the targeted programs do not cause any

crowding out because of a substitution effect: they do not tend to increase sales of eligible cars at the expense of the sales of non-eligible cars. The substitution effect is a crowding out effect during the scheme. We now extend the analysis to account for possible intertemporal crowding out effects.

We investigate two types of intertemporal effects: anticipatory (before-subsidy) and pull-forward (after-subsidy). 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 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.

Columns (3) and (6) of Table 3 show the results. The scrapping effects during the scheme change only slightly compared with the previous specifications that do not include anticipatory and pull-forward effects. As related to the anticipatory effects, the effect of the dummy variable for the first month of the scheme is negative and significant. This shows that the first month of the scheme is not yet part of the treatment period of the scrapping scheme, which stems from the lag between car purchase orders and car registrations. Hence, there is a negative anticipatory effect, but the effect is only one month, and its magnitude is relatively small, equivalent to about one third of the monthly effect during the scheme.

As related to the pull-forward effects, the effect of post-subsidy dummy variable is negative and statistically significant in the case of non-targeted schemes and for non-eligible cars in the case of targeted schemes. The effect on the sales of eligible cars in the case of targeted schemes is positive and statistically significant, which might be explained by the extended period for car registrations. In this case, although the schemes expire, their positive effect can be felt over a longer period of time. Note that we do not observe any post-subsidy period in the case of French targeted scheme. 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).

We have performed some counterfactuals to quantify the impact of scrapping schemes on total car sales and average fuel economy of new cars (see Table 4). We find that European car sales (in countries with scrapping policies) would have been 15.9% lower in 2009 absent the schemes. The sales would have been 17.4% lower in countries with targeted schemes

(and 21.1% for the eligible cars). Sales would have been 14.8% lower in countries with non-targeted schemes. Although scrapping policies thus stabilized sales in all countries, their individual performance varies. For instance, in Germany, with its non-targeted scheme, around 640 thousand cars (or 17.6% of total German car sales in 2009) would not have been purchased without the scheme. In Germany, around 1.6 million cars were sold with a scrapping incentive. That is, 40.8% of cars purchased with a scrapping subsidy, were such that otherwise would not have been purchased. In France, with a targeted scheme, 15.9% of cars would not have been purchased absent the subsidy in 2009.

We have also investigated how the schemes affected the sales-weighted average fuel consumption of new cars. We find a beneficial but small environmental impact because consumers substitute to more fuel efficient cars in response to the schemes. In countries with non-targeted schemes, average fuel consumption would have been only 0.5% higher in the absence of the schemes; in countries with targeted schemes that were explicitly targeted to low emission vehicles, average fuel consumption would have been 1.3% higher without the schemes, which is still only a modest effect compared with the large total sales impact of the schemes.²³ The effects are also quite heterogenous across countries. The targeted scheme improved average fuel economy by up 2.3% in Spain. In contrast, the targeted scheme in France improved average fuel economy by 0.6%, which is the same as in Germany which had a non-targeted scheme.

²³The improvement in average fuel economy of 1.3% is entirely due to a relative demand increase for the eligible cars, which have lower fuel consumption than the non-eligible cars. The sales-weighted average fuel economy change of eligible cars is negligible (0.07%), which shows there was indeed very limited substitution within the group of eligible cars.

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

Country	Total car sales		Average fuel consumption	
	<i>actual (million)</i>	<i>% change</i>	<i>actual (liter/100 km)</i>	<i>% change</i>
<i>Non-targeted schemes</i>				
Germany	3.63	-17.64	5.99	0.56
Greece	0.21	-0.93	6.43	0.07
Netherlands	0.42	-4.40	5.89	0.29
UK	1.96	-13.28	5.81	0.60
Total non-targeted	6.22	-14.80	5.95	0.54
<i>Targeted schemes</i>				
France	2.19	-15.94	5.09	0.59
Italy	1.66	-18.07	5.43	1.75
Portugal	0.16	-12.35	5.20	0.62
Spain	0.95	-20.29	5.49	2.30
Total targeted	4.96	-17.37	5.28	1.25
<i>eligible cars</i>	<i>4.05</i>	<i>-21.14</i>	<i>4.97</i>	<i>0.07</i>
<i>non-eligible cars</i>	<i>0.91</i>	<i>-0.69</i>	<i>6.67</i>	<i>0.00</i>
Total (excl. Belgium)	11.18	-15.94	5.65	0.92

The table reports the actual total sales and average fuel consumption as well as 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 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, Greece, the Netherlands and the United Kingdom, whereas countries with targeted schemes include France, Italy, Portugal and Spain.

To sum up, we find a considerable impact of the scrapping schemes on total car sales. In contrast, environmental benefits are very small as the average fuel economy of purchased new cars improves only little. Consequently, the main impact of scrapping schemes is on the total sales. There is no evidence for crowding out through the substitution effect between eligible and non-eligible cars during the targeted schemes, although we find some evidence for small intertemporal substitution effects.²⁴

²⁴Our considerable sales impact 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 (2012), Mian and Sufi (2012), Li et al. (2013)). There is also some evidence on the sales effects of scrapping schemes

Competitive and trade effects We now extend the framework to consider the competitive effects of the scrapping schemes, i.e. the differential impact of scrapping schemes between domestic and foreign car producers, between premium and volume brands, and between the various market segments. As discussed above, we limit attention to the specification where the scrapping scheme is measured as a percentage subsidy.

Table 5 reports the results. Column (1) follows specification (5), and considers whether scrapping programs have a different sales effect on domestic and foreign firms. This enables us to assess whether the scrapping schemes are designed to support domestic car production, especially so-called “national champions”. Interestingly, the non-targeted schemes have a stronger impact on domestic than on foreign brands: a 1 percent non-targeted subsidy raises sales of foreign brands by 1.2%, and it raises the sales of domestic brands by an additional 1.5%. Hence, the non-targeted schemes (introduced in important car-producing countries Germany and the United Kingdom) may still protect domestic manufacturers, even though they were designed very broadly and without any restrictive eligibility conditions. This may be due to some unobserved characteristics of the schemes.

in the past. For instance, Licandro and Sampayo (2005) 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.

Table 5: Competitive effects of scrapping schemes: domestic versus foreign car brands, premium versus volume cars

	Domestic vs foreign (1)	Premium vs volume (2)
scrap_pct \times NT	1.208 (6.779)	1.416 (8.550)
scrap_pct \times T	2.826 (10.625)	2.932 (10.956)
scrap_pct \times NT \times X	1.451 (3.617)	-0.545 (-1.052)
scrap_pct \times T \times X	-0.656 (-0.659)	-1.892 (-2.002)
(1 - scrap) \times T	0.011 (0.733)	-0.004 (-0.200)
(1 - scrap) \times T \times X	-0.078 (-0.893)	0.043 (1.028)
# months (θ_t)	84	84
# models	1,300	1,300
# countries	9	9
# groups (model/country effects α_{jc})	8,761	8,761
# observations	383,566	383,566
R-squared	0.269	0.269

The table reports the parameter estimates and t-statistics (in parenthesis) for specification (5). 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 dummies (or respectively, relative size) for green rebates in Belgium and France are included but not reported. ‘X’ stands for “DOM” (domestic brand dummy) in (1), and for “PREMIUM” (premium brand dummy) in (2).

In contrast, the targeted schemes do not have a differential impact on domestic and foreign car brands. Hence, domestic brands do not receive any extra stimulus under targeted schemes, but they may of course benefit more if they are more likely to fall under the eligibility criteria, set by the governments. To assess this, we computed the overall effects of targeted schemes on total domestic and foreign sales. The major car-producing countries with targeted schemes are France, Italy and Spain. We find that domestic firms do not benefit more than foreign firms.

In particular, our counterfactuals (Table 6) show that total sales of domestic cars would have been 25.2% lower without non-targeted schemes, whereas total sales of foreign cars

would have been only 13.6% lower. Therefore, non-targeted schemes have a larger stimulating effect on domestic car purchases. For instance, in the United Kingdom sales of domestic cars would have been 20.4% lower absent the program, and only 12.2% lower for foreign cars. In contrast, in the case of targeted schemes, sales of domestic cars would have been 14.4% lower absent the schemes, and 17.0% lower for foreign cars. Therefore, both domestic and foreign brands benefited from the targeted schemes. For instance, in France foreign brands could have benefited only slightly more than domestic brands through scrapping incentives: sales of domestic cars would have been 13.0% lower absent the subsidies, whereas sales of foreign cars would have been 15.4% lower.

Table 6: Impact of removing scrapping schemes on domestic and foreign brands (2009)

Country	Domestic brands		Foreign brands	
	<i>actual (million)</i>	<i>% change</i>	<i>actual (million)</i>	<i>% change</i>
<i>Non-targeted schemes</i>				
Germany	2.10	-25.97	1.52	-19.61
Greece			0.21	-0.83
Netherlands			0.42	-3.91
UK	0.33	-20.37	1.64	-12.21
Total non-targeted	2.43	-25.22	3.79	-13.63
Total (Germany+UK)	2.43	-25.22	3.16	-15.78
<i>Targeted schemes</i>				
France	1.19	-12.99	1.00	-15.42
Italy	0.46	-17.13	1.20	-16.66
Portugal			0.16	-12.59
Spain	0.08	-19.88	0.86	-20.13
Total targeted	1.74	-14.43	3.22	-17.00
<i>Eligible cars</i>	1.63	-19.83	2.42	-22.02
<i>Non-eligible cars</i>	0.11	-0.69	0.80	-0.69
Total (France, Italy+Spain)	1.74	-14.43	3.06	-17.23
Total (excl. Belgium)	4.17	-16.02	7.01	-15.89

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 (5). The left hand side of the table presents the findings for domestic brands, while the right hand side of the table reports the findings for foreign brands. Countries with non-targeted schemes include Germany, Greece, the Netherlands and the United Kingdom, whereas countries with targeted schemes include France, Italy, Portugal and Spain.

Scrapping schemes can thus have adverse effects on competition since they might benefit

domestic car producers, but only indirectly in the case of non-targeted schemes. The environmental eligibility criteria in the case of targeted schemes, contrary to *a priori* expectations, may however not involve any serious competitive concerns.²⁵

Because of the differential impact on domestic and foreign car sales, scrapping schemes may exercise not only competitive effects, but also affect trade flows. The increased demand for foreign car brands, not produced locally, or the increased demand for domestic car brands that cannot be satisfied based on the existing country's capacities, can have an effect on trade flows. For instance, they may stimulate higher imports to meet the country's internal demand, and/or increase exports to meet the increased demand abroad. There is some evidence that car imports increased into Germany during the 2009 scrapping scheme because most small and economical cars are either produced by foreign car producers, or they are not manufactured in Germany (IHS Global Insight (2010b)). Especially Korean, French and Italian car makers could profit from this trend.²⁶

Column (2) of Table 5 follows a variant of specification (5), and considers whether the scrapping programs have a different effect on volume and premium producers. We find evidence for a lower stimulus effect on premium cars in the case of targeted scrapping programs: a 1 percent targeted subsidy raises demand by 2.9% for volume brands and by only 1.0% for premium brands. Since there are no environmental eligibility conditions in the case of non-targeted schemes (these conditions could target in particular smaller and more fuel-efficient cars that usually volume car manufacturers produce), both premium and volume brands can profit from the scrapping subsidies. Recall that 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. Our counterfactuals also confirm that both premium and volume car brands benefited from the scrapping subsidies, however premium brands profited to a much lower extent.

Finally, we investigate the effects of scrapping schemes on sales across market segments. As we can see in Table 7, subcompact and compact cars benefited both in the case of

²⁵This 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)).

²⁶In 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)).

targeted and non-targeted schemes. There is no effect on the sales of cars belonging to the intermediate market segment. Standard, luxury and sports cars benefit only in the case of targeted schemes, while SUVs might benefit only in the case of non-targeted schemes. Compact vans and MPVs profit also in the case of both targeted and non-targeted schemes, but the effect under the targeted programs is larger. Most probably, large cars can still profit from the targeted schemes if they meet the program eligibility criteria, despite a price disadvantage compared to small lower-priced cars.

Table 7: Competitive effects of scrapping schemes: market segments

	subcompact (1)	compact (2)	intermediate (3)	standard (4)	luxury (5)	van (6)	MPV (7)	SUV (8)	sports (9)
scrap \times NT	1.365 (5.945)	1.526 (3.770)	-0.719 (-1.339)	-0.331 (-0.429)	-0.670 (-0.821)	0.759 (1.597)	1.536 (1.779)	0.916 (1.775)	-0.395 (-0.629)
scrap \times T	1.558 (5.562)	1.819 (3.748)	1.843 (1.353)	5.100 (2.915)	5.685 (1.633)	2.440 (3.128)	5.855 (4.728)	-0.177 (-0.056)	3.313 (2.099)
(1 - scrap) \times T	-0.011 (-0.161)	0.006 (0.118)	-0.047 (-1.033)	0.063 (1.264)	0.063 (2.326)	-0.094 (-1.678)	0.053 (0.980)	0.060 (1.834)	0.056 (2.434)
# months (θ_t)	84	84	84	84	84	84	84	84	84
# models	198	205	126	94	108	88	58	189	234
# countries	9	9	9	9	9	9	9	9	9
# groups (model/country effects α_{jc})	1,307	1,308	894	662	703	661	386	1,264	1,576
# observations	65,029	59,932	41,981	24,634	31,541	29,779	18,259	55,662	56,749
R-squared	0.214	0.273	0.338	0.385	0.336	0.340	0.398	0.313	0.321

The table reports the parameter estimates and t-statistics (in parenthesis) for various market segments (based on the relative incentive). 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 dummies (or respectively, relative size) for green rebates in Belgium and France are included but not reported.

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 yielding environmental benefits in the form of fuel economy savings for new vehicles. We also studied the presence of any crowding out effects of the scrapping schemes, and their competitive and trade effects.

For our purpose, we have collected a unique model-level monthly dataset on the European car market and scrapping schemes. We apply a difference-in-differences approach, with fixed effects in a panel data context, and exploit variation of scrapping programs at country level to identify the impact of scrapping programs on car sales. The country difference-in-differences approach is well-suited in our context: various European countries have introduced or phased out their scrapping subsidies at different points in time, or some countries have not introduced any scrapping scheme at all. This estimation strategy can 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. Targeted schemes did not cause any substitution between different types of cars: eligible cars do not benefit at the expense of non-eligible cars. In contrast, the environmental benefits of the scrapping schemes were very modest, in the sense that they improved the average fuel economy of new cars to a low extent. 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, but not as a long-term instrument to generate environmental benefits.²⁷

As related to “competitive and trade effects”, we found that the “green” eligibility criteria in the case of targeted schemes (e.g. in the form of CO₂ emissions) did not cause any serious competitive bias. Although the primary objective of these criteria may be to protect “national champions”, foreign competitors could benefit from the schemes as well, and domestic cars did not gain more than foreign brands. In contrast, non-targeted schemes stimulated higher purchases of domestic car brands. Furthermore, premium car brands still gained from the targeted scrapping subsidies, although to a lesser extent than volume brands. They did not face any extra disadvantage from being a premium brand in the case of non-targeted schemes. Consumers can still buy premium cars if they are attractive to them because of a price advantage due to the fixed scrapping premium. Finally, scrapping subsidies had dif-

²⁷We 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 CO₂ emissions and the possibility to reach multiple objectives with a single policy.

ferent sales effects across market segments, and not only small but also large cars benefited from the scrapping programs.

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, contrary to *a priori* expectations, 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.

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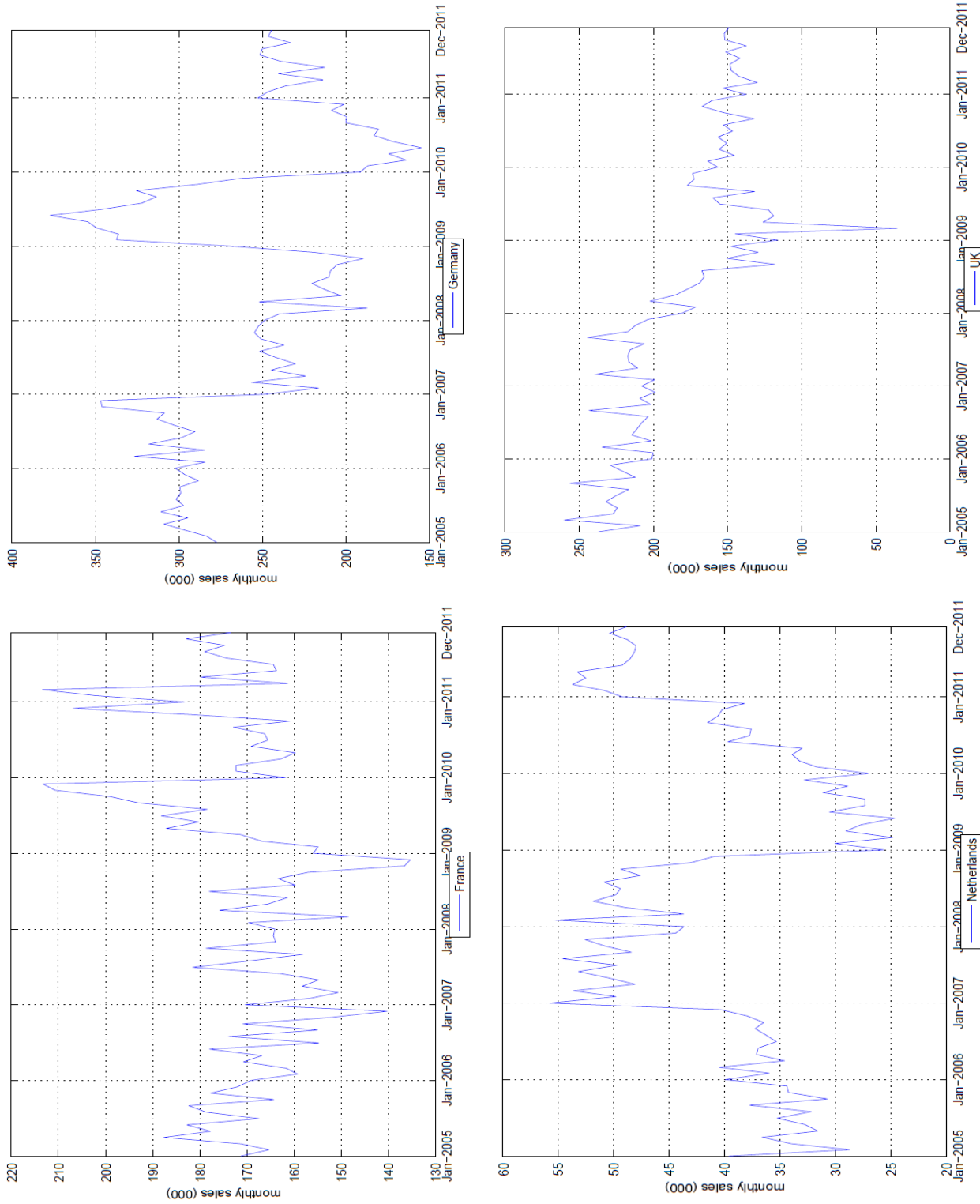
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6 Appendix

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



The figure depicts seasonally adjusted monthly car sales in several European countries: France, Germany, the Netherlands, and the United Kingdom. Duration of the crisis scheme in France: 1 Jan 2009-31 Dec 2010. Duration of the scheme in Germany: 14 Jan 2009-31 Dec 2009. Duration of the scheme in the Netherlands: 29 May 2009-21 Apr 2010. Duration of the scheme in the United Kingdom: 18 May 2009-31 Mar 2010. The official duration of a scheme is given.