Bailing on the Car That Was Not Bailed Out: Bounding Consumer Reactions to Financial Distress

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We examine how consumers react to the financial distress of durable goods manufacturers by studying the Swedish new car market. We employ a difference-in-differences matching methodology whereby we compare sales of carmaker Saab with those of a control group of substitute products. To account for possible substitution between products in the treatment and control groups, we propose and apply bounds to our difference-in-differences matching estimator. We then refine the bounds and provide conditions under which they depend only on product elasticities. We find that there was a significant decrease in the sales of Saab following its filing for administration.

1. Introduction

In a number of industries such as the automobile industry, both warranties and post-sales assistance are prevalent and of such great importance to consumers that these are yet another dimension over which carmakers differentiate their products (Cars.com, 2011a, b). As a result, whenever a company producing automobiles, or any other durable good, faces financial difficulties—bankruptcy in the extreme case—one might expect consumers to shy away from its products due to risks associated with the company ceasing to exist and post-sales services tied to the product becoming worthless (as modeled in, e.g., Titman, 1984).

The importance of post-sales services to consumers make the auto industry well suited for studying how consumers perceive and react to the financial difficulties of carmakers. The studies by Hammond (2013a) and Hortaçsu et al. (2013) have made use of these features and, perhaps unsurprisingly, found that that financial distress of a carmaker does affect the secondary car market; on average, consumers are no longer willing to pay as much for a used car produced by a carmaker that starts experiencing financial difficulties.

Nikita Koptyug gratefully acknowledges financial support from the Foundation of Banking Research, the Jan Wallander and Tom Hedelius Foundation and the Marianne and Marcus Wallenberg Foundation. We thank Tobias Olsson at Vroom Stockholm for making data available and participants at the EARIE, Jornadas de Economia Industrial, IIOC, MOITA Workshop, SBE, and SSE (Empirical Micro Workshop, Economics and Finance Lunch Seminars) for comments. We are also indebted to Laurent Bach, Áureo De Paula, Bob Hammond, Erik Lindqvist, Anindya Sen as well as our discussants Céline Bonnet, Rodrigo Moita, Leonard Nakamura, and Frank Verboven for comments. Lastly, we are grateful to the editor, coeditor, and an anonymous referee for useful comments and suggestions.

To study how consumers react to financial difficulties and distress on the primary market, one has to establish among other things whether it is a carmaker's financial health that is affecting consumer behavior or vice versa. In this study, we aim to resolve the issue of reverse causality by focusing on the effects of Swedish carmaker Saab's financial distress and filing for administration on the Swedish new passenger car market.[1] Saab, originally a domestic Swedish carmaker whose products were praised by their admirers for the fine engineering and characteristic design, was facing financial ills due to the parent company's General Motors' (GM) own financial problems of late 2008.[2] Following the financial aid package provided by the U.S. Government to bail out GM in late 2008, it eventually became clear that Saab would not benefit from a rescue of its parent company. The terms of the emergency loan granted to GM were such that the money was to be used to save American jobs and other funds would have to be used to keep Saab operational (SvD, 2008b). Due to these circumstances, we argue that Saab's financial situation was not a concern for potential buyers until GM started experiencing its own financial troubles. Having lost the backing of GM in early 2009 after a strategic review, the financial difficulties facing Saab led the company to file for administration in February 2009. It was only months later that GM agreed on Saab's sale to a new owner with the financial backing of both the Swedish Government and the European Investment Bank (EIB). As a result, once a binding deal regarding the sale of Saab to Koenigsegg Group was signed in August 2009, Saab's administration came to an end.

Empirical Strategy. We use vehicle registration-based data to study purchases of new Saab cars by private individuals in Sweden during the years 2006–2009. By doing so, we contribute to a better overall understanding of how consumers react to financial distress and on the impact of financial distress on a company.[3]

In our analysis, we take advantage of a key institutional setting of the Swedish new car market: Sweden being a small market, car dealers keep low inventory levels, so consumers typically *order* a car a few months in advance. This means that as long as Saab was producing cars, it would have been possible to order a car as before. Further, this results in very few episodes of sales or rebates from the part of carmakers or dealers, making the list prices, we observe a much improved approximation to transaction prices than in most markets, for example, the United States. As a result, we are able to make use of both price and quantity information in our analysis.

Our identification relies on the credible exogeneity of GM's financial health to Saab product market performance but not to its financial one. That is, prior to filing for administration, Saab could count on the financial backing of GM, a large multinational conglomerate that did on several occasions inject funds into its subsidiary. However, this situation changed abruptly once GM applied for financial assistance from the U.S. government, which set as a precondition that U.S. funds are only used to keep U.S. jobs and could not be used to support Saab or other foreign brands.

To identify and quantify the impact of Saab's financial distress on consumer purchasing behavior, we use a difference-in-differences (DD) matching estimator whereby we compare the sales of Saab, the treatment group, to those of comparable cars on

1. Saab is known among car enthusiasts for (among other things) launching the first mainstream turbocharged car ever sold, the Saab 99 (Popular Mechanics, 2008).

2. As detailed below, supply-side-related concerns were not a major concern in Saab's case.

3. Although companies and the Swedish government purchase a significant share of new cars in Sweden, they do not necessarily have the same objectives as consumers when purchasing automobiles. For instance, the Swedish government has a mandate to buy environmentally friendly vehicles for non-emergency services.

the Swedish market, the control group. We propose constructing our control group by matching Saab products to a set of close competitors according to observable product characteristics.[4] More importantly, we propose a way to estimate treatment effects when both treated and untreated subjects are likely to be affected by the treatment. To do so, we propose economically-motivated bounds for the DD estimator we consider. The motivation for the bounds comes from the fact that our control group for Saab products consists of close substitutes to the treated subjects. The fact that there may be substitution from Saab products to the control group renders standard methods used in the treatment effects literature unfit for our purposes (see Angrist and Pischke, 2010, and Nevo and Whinston, 2010, for a closely related exchange). For instance, in our application, substitution from the treatment to control group results in standard DD estimates being *biased upward* (in absolute terms), that is, any consumer reaction to Saab's financial ills is likely to be *overstated* by the standard DD estimator. To account for this, we propose bounds for our DD matching estimator by assuming that the true effect lies between no—and perfect substitution between treatment and control groups.

One concern raised by our empirical strategy—the matching procedure in particular—regards how the size and composition of the control group affect the bounds we propose. That is, the method might give researchers excessive leeway, so that in the extreme case, the choice of the control group may determine the bounds to the DD effect. To address such concern, we provide conditions under which our bounds are either not substantially, or not at all, influenced by the choice of control group. First, a *homogeneity condition* whereby cross-price elasticities between the treated subject and products within a market segment are similar. Second, a *dominance condition* according to which the own-price elasticity of the treated subject dominates cross-price elasticities between itself and products in the same market segment, which, in turn, dominate cross-price elasticities between the treated subject and products in other market segments. Third, a *symmetry condition* whereby products in the treatment and control groups have sales of similar magnitudes. Under these conditions, the bounds become a function of own- and within-group cross-price elasticities of the marketed products. Such conditions are consistent with empirical findings for differentiated product markets (see online Appendix B for an illustration) and allow the method to be applied within Industrial Organization and Antitrust settings.

Although one could think that the assumptions we impose would result in uninformative (i.e., overly wide) bounds, we show in our application that even without refining the bounds, we obtain results pointing to a significant effect of Saab's financial distress on its sales.

Main Findings. In contrast to previous findings for the used car market, we find limited evidence that prices of the Saab brand as a whole responded to its financial distress. As a result, we focus primarily on its sales. Doing so, we find ample evidence that consumers react to Saab's financial troubles; our most conservative results point to consumer reactions corresponding to a decrease of over 200 units sold by the Saab brand, as compared to the control group, a sizable 50% and 56% effect if compared to unconditional average sales of Saab which amount to 470 units per month. Given the ample evidence of the existence of a home-bias in both the International Trade and

4. We also provide robustness checks using the synthetic matching methods of Abadie and Gardeazabal (2003).

Industrial Organization literature, especially for the auto industry, see, for instance, Goldberg and Verboven (2001, 2005), one could think that such effects might be stronger for foreign brands operating in a given market. All in all, our estimates for the new car market are one order of magnitude larger than those previously obtained in the literature looking at the used car market.

The strength of our results leads us to explore alternative explanations for our findings. First, we focus on additional reasons—above and beyond the finance channel—that are likely to drive consumer reactions. In addition to documenting that findings are unlikely to be driven by supply effects, we show that our results survive a number of robustness tests, including accounting for increased promotional activity of competing brands, news coverage, technological laggardness of Saab products, and different treatment periods. In particular, our results are also obtained using different control groups.

Second, we consider the external validity of our results. The Swedish market is broadly comparable to other European markets (see, e.g., table 1 of Huse and Lucinda, 2014, for details). For instance, ACEA (2015) reports that new passenger car registrations in Sweden are 32 vehicles/1,000 inhabitants, roughly between those of Germany and France (38 and 27 vehicles/1,000 inhabitants, respectively). Moreover, we have also considered the effect of financial distress on the sales of Opel products, the best-selling GM brand in Sweden. Our results suggest that any differences in the results of Opel and Saab are due to their different status in GM's restructured brand portfolio.

Contribution. We contribute to a rich literature investigating the costs of financial distress and its effects on the product market and firm performance. On the theoretical front, Titman (1984)'s results point to the major role played by decreases in demand as a result of financial distress. On the empirical front, there are conflicting views regarding how distressed companies respond, typically focusing on prices; while the studies of Chevalier (1995) and Matsa (2011) document that supermarket increase prices when in financial distress, Busse (2002) finds that firms in worse financial condition are more likely to start price wars in her study of the airline industry. More recently, Hammond (2013a) and Hortaçsu et al. (2013) examine the used car market and find evidence of (single-digit) price reactions as a consequence of financial distress of a company. Our results suggest that the main channel whereby market participants react to financial distress is quantities, very much in the spirit of Titman (1984). Such reaction is significant both statistically and—at a roughly 50% reduction in sales—economically. The limited evidence of price reactions in the case of the Saab brand to countervail the substantial decrease in quantities allows to estimate the loss in revenues of the distressed company, in contrast to previous literature.

Methodologically, we provide bounds derived using economic assumptions in a setting when standard reduced-form methods are unfit for use (Nevo and Whinston, 2010). Initially, such bounds are obtained assuming that there is either no or full substitution between treatment and control groups. They can be, moreover, refined by assuming that substitution patterns between products are well-behaved and consistent with empirical findings for many differentiated products markets.

The paper is organized as follows. Section 2 provides an overview of the market. Section 3 describes the data. Section 4 outlines the empirical strategy and Section 5 presents the results. Section 6 details various robustness tests.

Table I. Annual Market Shares and Sales of Selected Brands, 2006–2009

		Sales Rank						
	Year	(1) Volvo	(2) Toyota	(3) Peugeot	(4) Volkswagen	(5) Ford	. . .	(10) Saab
Panel A: Market Shares	2006	15.38%	9.38%	9.45%	7.63%	5.93%	. . .	5.25%
	2007	17.42%	9.47%	9.32%	7.15%	5.80%	. . .	4.11%
	2008	12.44%	10.99%	8.48%	8.35%	5.48%	. . .	3.74%
	2009	14.77%	12.29%	5.69%	6.88%	5.69%	. . .	1.66%
	2006–2009	15.20%	10.34%	8.46%	7.50%	5.74%	. . .	3.87%
Panel B: Sales	2006	21,468	13,091	13,198	10,648	8,281	. . .	7,330
	2007	26,345	14,323	14,104	10,814	8,779	. . .	6,218
	2008	14,144	12,492	9,642	9,493	6,233	. . .	4,247
	2009	14,414	11,999	5,549	6,718	5,554	. . .	1,619
	2006–2009	76,371	51,905	42,493	37,673	28,847		19,414

Notes: Annual market shares and sales volumes of the five most frequently purchased car brands in Sweden together with tenth best selling brand for 2006–2009, Saab. Panel A: Annual market shares of the five most frequently purchased car brands in Sweden together with 10th best-selling brand Saab; Panel B: Annual sales volume of the five most frequently purchased car brands in Sweden together with the 10th best-selling brand Saab.

2. Market

2.1. Overview

Hosting two carmakers, Sweden is highly dependent on the automobile industry, which is key to employment, investments, exports, and R&D in the country. In fact, out of a population of roughly 9 million, some 120,000 are employed by the automobile industry that is responsible for over 10% of Swedish exports (BIL Sweden, 2010). Moreover, Sweden is the second and first market for local brands Volvo and Saab, respectively (BIL Sweden, 2010). Having originated in Sweden, Volvo and Saab were taken over by U.S. carmakers, thus becoming brands within global car conglomerates Ford and GM, respectively.

Although Volvo has been regularly on the top spot, commanding a market share of about 15% over the years, Saab has consistently been the 10th top selling brand in the Swedish market prior to administration, with a market share in the range 4–5%. This is consistent with previous evidence of a home-bias whereby consumers tend to favor domestic car brands (Goldberg and Verboven, 2001). Other major carmakers in terms of sales include Toyota, Peugeot, Volkswagen, and Ford, as reported in Table I. Overall, the Swedish new car market is comparable to those of other European countries albeit having a preference for more powerful, heavier cars (see, e.g., Huse and Lucinda, 2014).

Car sales in the Swedish market peaked in 2007 and depressed considerably in June 2009 with the global recession.[5] Even within the Swedish market, Saab had sold just over 6,000 units annually in the years prior to 2009 at which point sales declined more than for the other brands with Saab sales having fallen by 65%.

Throughout the years, Saab has produced few models that are praised by their admirers for the fine engineering and characteristic design. Its size was one of its major hurdles, as the brand was unable to explore economies of scale well known to exist in the

5. This period coincided with the Green Car Rebate (GCR) between 2007 and 2009, which provided a transfer of 10,000 SEK (roughly USD 1,500) for consumers purchasing an environmentally friendly ("green") car. See Huse (2014) for a detailed description of the GCR.

Table II.
Descriptive Statistics

	Year	Fuel Economy (l/100 km)	List Price (SEK)	Weight (kg)	Engine Power (HP)	Engine Size (cm^3)	CO_2 Emission (g/km)
Panel A: All Vehicles excl. Saab	2006	7.08	184,612***	1,361***	121**	1,724*	171*
	2007	6.75**	192,696***	1,380***	127***	1,732***	165*
	2008	6.45***	184,001***	1,344***	120***	1,630***	157***
	2009	6.15***	191,630***	1,370***	122***	1,623***	151***
Panel B: Control Vehicles	2006	7.39	221,898	1,486	140	1,876	180
	2007	7.10	226,679	1,497*	147	1,900	175
	2008	7.31	234,628	1,501*	148***	1,893**	178
	2009	7.63	243,914	1,515	150***	1,927	184
Panel C: Saab Vehicles	2006	7.76	228,029	1,517	147	1,870	188
	2007	7.88	241,819	1,549	168	1,942	193
	2008	8.02	249,122	1,560	178	1,970	195
	2009	7.63	246,135	1,559	178	1,968	185

Notes: Annual sales-weighted characteristics of newly registered cars in Sweden from 2006 to 2009. Panel A: Annual sales-weighted characteristics of newly registered cars in Sweden excl. Saab; Panel B: Annual sales-weighted characteristics of newly registered cars in Sweden that are included in the control groups; Panel C: Annual sales-weighted characteristics of newly registered Saab manufactured cars in Sweden. Statistical significance of tests of differences in means between non-Saab and Saab cars is denoted by * for each characteristic and relevant year, and is given at the 10% (*), 5% (**), and 1% (***) significance levels. For instance, in 2008, the null of equality of sales-weighted engine power between Saab (178 HP) and the control group (148 HP) is rejected at the 1% significance level.

automobile industry. Coupled with the fact that GM never fully integrated Saab into its portfolio of brands, the growing feeling over the years was that Saab was beginning to lag behind its competitors due to high development costs combined with low production levels.

Table II compares a number of characteristics of Saab vehicles against those of other brands for years 2006–2009, providing difference-in-means tests between Saab and non-Saab vehicles.[6] Typically, Saab models are less fuel-efficient, more expensive, heavier, and more powerful than the average car sold in Sweden for each year in the sample. Notably, there are few statistically significant differences between Saab and control group vehicles. However, Saab does stand out in terms of horse power, producing significantly more powerful cars than those of the control groups. In particular, although (sales-weighted) CO_2 emissions in the Swedish market followed a downward trend during the sample period, the effect was much less pronounced among Saab models, hinting that the brand was lagging in terms of technological development—-although the observed differences are not statistically significant. Comparing the sales-weighted characteristics of Saab to those of closely competing models, we see that the average improvements that can be observed for the market as a whole are no longer as obvious for this subsample of vehicles. For instance, although fuel economy has been slightly better for competing models, no clear improvements in fuel economy have been made in comparison to the Saab products when looking at the entire sample period.

2.2. Saab Automobile

Saab Automobile became a fully owned subsidiary of GM Europe in 2000, when GM purchased a 50% stake in Saab from Investor AB for USD 125 million (Investor AB, 2000)

6. Although we have sales data since 2005, we look only at data starting from 2006 due to the construction of the control groups. See Section 5.2 for details.

after 10 years of joint ownership. Saab was one of a total of 12 other brands owned by GM, but in 2008, it accounted for sales of roughly 100,000 units (Saab History, 2008) out of a total of 8.5 million units sold by GM worldwide (General Motors, 2009). As a result, it is highly unlikely that Saab may have played any role in GM's financial situation.

What is perhaps more striking is that, out of the 20 years of GM ownership, Saab only generated a profit in 2, with GM consistently injecting money into its subsidiary (Dagens Industri, 2009c).[7] That is, even if Saab arguably lacked the sales volume of close competitors such as Audi and BMW in global terms, it was consistently among the top 10 best-selling brand in its main market (see Table I). More importantly, Saab could very much count on continuous funding provided by GM to finance its operations. Thus, despite a less-than-stellar performance in the product market, it is unrealistic to think about the Saab brand as being in financial distress.[8]

Things were to change dramatically for Saab following the U.S. financial package to rescue GM and Chrysler. When GM appealed for emergency aid to remain solvent in late 2008, the U.S. government's willingness to aid the automobile industry initially sparked hope for Saab whose future was becoming increasingly uncertain. However, GM made it clear that financial aid would not be provided to its European operations (Dagens Industri, 2008). That is, the terms of the emergency loan granted to GM were such that the money would be used to save American jobs and instead that other funds would have to be used to keep Saab going (SvD, 2008b), at least until a strategic global overview had been conducted.

In early 2009, GM announced that Saab was to become a more independent company, in what was seen as a first step in preparing Saab for a future divestiture and a possible precondition for receiving financial aid from the Swedish government (Dagens Industri, 2009a). On February 12th, 2009, GM asked the Swedish government to back a SEK 5 billion loan from the European Investment Bank (SvD, 2009a).[9] Without the backing of either the Swedish government or GM, Saab was forced into filing for an emergency loan at the EIB on its own (TT News Agency, 2008, 2009a). On February 17th, 2009, GM presented its restructuring plan to the U.S. Congress with Saab no longer being a part of its future strategy (SvD, 2009b). On February 18th, GM announced plans to sell Saab and that if Saab were to remain solvent until a sale was completed, the company would require emergency loans from the Swedish government (TT News Agency, 2009b)

On February 20th, 2009, Saab officially filed for administration.[10] While under administration, it was expected that Saab would continue to operate, although there were concerns that sales would be depreciated further if worried consumers were to stop buying Saab products altogether. Production was interrupted for only one week, that

7. Although justifications may have differed from one year to the next, GM did regularly inject funds into Saab. For instance, GM justified stepping in during August 2005 due to a weakening of the U.S. dollar, high development costs, and increased price competition from other brands (SvD, 2008a).

8. This suggests that Saab was in economic distress during a longer period but that any additional drop in performance due to GM's inability to continue to provide funding to Saab is primarily due to financial distress and not economic distress.

9. This amounts to approximately USD 600 million at the then prevailing exchange rate of 8.42 SEK/USD.

10. In Sweden, a company may file for bankruptcy or administration. Administration, legally speaking, is available for companies that are very likely to fail to fulfill their financial obligations in the short term but are deemed to have future potential. To be granted the related legal status, a company must apply with a court that may or may not grant administration status for up to one year. If a company is allowed to enter into administration, it is legally allowed to delay honoring legal obligations while at the same time being legally protected from debt collectors. Furthermore, during administration, a company cannot be forced into bankruptcy. The period of administration ends after the court deems the company financially capable of continuing to operate.

is, until February 27th, when Saab was able to obtain liquid funds and pay outstanding fees (TT News Agency, 2009c).[11] GM started honoring credit lines open on Saab's behalf on March 2nd, 2009, as it entered administration. As a result, key suppliers were able to resume operations and supply Saab with the necessary components to keep production open (Dagens Industri, 2009b).

Despite the rumored interest of a number of companies, it took until May 29, 2009 to find Saab a potential buyer—Swedish sports carmaker Koenigsegg, which went on to sign an intent to purchase Saab on June 15 (TT News Agency, 2009d). Part of the deal was an expected government-backed loan of USD 600 million from the EIB and a strategic partnership with GM whereby it would supply Saab with engines and transmission systems (Saab AB, 2009). On August 17, 2009, GM and Koenigsegg Group, a consortium led by Koenigsegg, signed a binding deal regarding the sale of Saab. As a result, on August 19, 2009, Saab officially filed for an end to administration, which was granted on August 21st (TT News Agency, 2009e).

3. Data

We combine administrative-based registration data with publicly-available car characteristics. The details are as follows.

Vehicle Characteristics. Product characteristics for years 2005–2009 are obtained from the consumer guide, the New Car Guide (Nybilsguiden), issued by the Swedish Consumer Agency (Konsumentverket). For every car model available on the Swedish market, the information includes characteristics such as fuel type, engine power and displacement, number of cylinders, number of doors, gearbox type, weight, fuel economy,[12] CO_2 emissions, vehicle tax, and list prices. List prices, sticker prices or MSRPs (manufacturer's suggested retail prices) are set by manufacturers and are typically constant across geographic markets within a model-year. Given the difficulty in obtaining transaction prices, MSRPs have commonly been used in the literature, see, for example, Huse and Lucinda (2014) for a recent study of the Swedish market. Importantly, since Sweden is a small market, car dealers keep low inventory levels, so consumers typically order a car a few months in advance, which results in few episodes of sales or rebates from the part of carmakers or dealers, making the list prices we observe a much improved approximation to transaction prices than in most markets, for example, the United States.

Vehicle Registrations. Car registration data was provided by *Vroom Stockholm*, a consulting company. The data on privately-owned vehicles is recorded at the monthly frequency from January 2005 to December 2009.[13] An observation is a combination of

11. Anecdotal evidence also suggests that a large number of suppliers manufacturing components for Saab vehicles were poorly diversified in that many produced components were only suitable for use in Saab vehicles. This suggests that some smaller manufacturers may have gone out of business because suppliers could not easily switch from supplying Saab with parts to another manufacturer. Despite this, we have found no accounts to suggest that Saab had difficulty in finding suppliers for manufacturing parts leading to supply problems of either the Saab 9-3 or 9-5.

12. Fuel economy is measured in terms of city, highway, and mixed driving, with testing conducted under a EU-determined driving cycle and expressed in liters per 100 km, or 100 m^3/km for gas (compressed natural gas) cars. CO_2 emissions are measured in gCO_2/km under EU-determined driving conditions and mixed driving.

13. Legally, the registration of a motor vehicle with the Swedish Transport Agency (Transportstyrelsen) must take place within 10 working days of a change in vehicle ownership.

year, brand, model, engine size, fuel type (thus more disaggregated than the typical market level data set) and market segment.

Sweden being a small market, car dealers keep very low inventory levels, so much so that typically one has to order a car a few months in advance and make a deposit (anecdotal evidence is that delivery times are from four weeks to four months). This results in very few episodes of sales or rebates from the part of carmakers and/or dealers. Moreover, if anything, we can expect transaction prices to be *lower* than list prices, for example, due to fire selling or retailer discounting, thus *underestimating* the treatment effect.

Combining vehicle datasets. Given the different levels of aggregation, we merge characteristics and registration datasets by month-brand-model-fuel type and attribute the sales of all versions of a given model to its baseline characteristic specification.

Demand shifters. We consider a number of alternative demand shifters; First, we include an indicator for the GCR period (from April 2007 to June 2009), since certain vehicles were eligible for a rebate. Second, we consider a measure of consumer confidence from the National Institute for Economic Research (Konjunkturinstitutet). Consumer confidence is a leading indicator for the purchase of durable products, see Ludvigson (2004) for a survey and Friberg and Huse (2012) for an application to the demand for new automobiles. Finally, we include controls for new versions of existing products, so as to account for redesign, facelifts, etc., of models in the control group, which are likely demand shifters. In order to determine which models within a control group have had a facelift or redesign, we proceeded by looking at photos in carmakers' web sites and specialized magazines.

4. Bounding the Treatment Effect

We are interested in estimating whether consumers react to the financial distress of Saab. To establish a causal link between consumer behavior and Saab's financial health, we rely on the particular institutional setting of the market, whereby any measurable impact is, in fact, caused by the financial distress of Saab and not the prior behavior of consumers or suppliers, that is, causality runs from the company's financial side toward the product market—something we discuss in more detail when defining the treatment period.

In order to identify and quantify the impact of Saab's financial distress on consumer purchasing behavior, we use a DD matching estimator. DD is commonly used to estimate the impact of a treatment or event on a predetermined treatment group or individual. The effect of the treatment is obtained by comparing the outcomes of the treated group with that of a carefully selected control group. The difference in post-treatment outcomes between the two groups measures the differential impact of the treatment itself. Although one may indeed find differences in post-treatment outcomes between the treated and untreated (control) groups, the underlying cause of any such difference may be due to factors other than the treatment itself. To minimize the chance of factors other than Saab's financial distress being responsible for changes in consumer behavior, we construct control groups at the level of year-model-fuel type, for example, a 2008 Saab 9-3 running on diesel, using matching techniques.

Given our particular setting, one valid concern is that since elements of the control group are close competitors to those in the treatment group, there is a potential mismeasurement in the effect of the treatment. This relates to an ongoing debate regarding the use of treatment effects methods in Industrial Organization—especially merger analysis—see Angrist and Pischke (2010) and Nevo and Whinston (2010). One criticism of DD methods comes from the fact that treatment may affect not only the treatment group but also the control group. This effect is of special concern in a setting of strategic interactions among players. In our case, unlike the studies of Hammond (2013a) and Hortaçsu et al. (2013), we focus on quantities instead of prices; whenever the sales of the treated group decrease those of the control group are likely to react in the opposite direction as consumers substitute from treatment group elements to control group elements. This reaction will be an indirect treatment effect of the treatment on treated with a less than proportional increase occurring if some of the consumers opting not to buy an element of the treatment group also choose not to purchase an element of the control group. Hammond (2013b) faces a similar issue when studying the effect of automobile recalls on vehicle resale values: the fact that Toyota recalled some vehicles due to safety concerns may have had a positive impact on competing brands' resale values, as current Toyota users replace their vehicle or potential Toyota buyers switch to competing brands. Alternatively, there may have been a negative spillover as consumers may have switched to domestic brands altogether.

4.1. Bounds and the Indirect Treatment Effect

Although we cannot be sure of the extent of the indirect treatment effect or substitution looking only at aggregate data, we are able to say something about the true treatment effect if we are willing to consider the two most extreme scenarios regarding substitution from the treatment to control group. That is, that either all of the consumers that switch away from the treatment group substitute to the control group, or that none of the consumers substitute to the control group. Together, these two extremes will bound the true estimate, regardless of the true level of substitution.[14] In our case, the observed control group sales are a combination of sales to consumers who would have purchased an element from the control group regardless of treatment being applied to the treatment group and the consumers who decide to purchase an element in the control group as a consequence of treatment.[15]

Setup. Assume a two-period DD specification given by

$$y_{it} = \theta_i + \mu_t + T_t G_i \delta + u_{it}, \tag{1}$$

where $\theta_i = \theta + G_i\phi$ and $\mu_t = T_t\mu$.

The parameter θ measures the control group mean pretreatment, μ measures the difference in control group means between pre- and post-treatment periods, and ϕ measures the difference in means between treatment and control group pre-treatment. The time periods are denoted by $t = 1, 2$, y_{it} is the true outcome variable of both the untreated and treated groups, which are indexed by $i = c, \tau$, and G_i takes on a value of one if the observation is a treated subject and zero otherwise, whereas T_t takes on a value of one for observations falling within the treatment period and zero otherwise. The coefficient of interest is given by δ and measures the treatment effect. Further, assume that treatment is exogenous, that is, treatment is uncorrelated with the error term u_{it}.

14. For a rigorous analysis of the bounding of treatment effects in the presence of contaminated or corrupted data, see Horowitz and Manski (1995), who show how to construct bounds for models in which one observes data that are composed of a true observation plus some noise.

15. Related strategies have been pursued by Sallee (2011), who uses bounded treatment effects to measure the incidence of tax credits for the Toyota Prius.

ASSUMPTION A1: *The true post-treatment outcome variable for the control group is potentially biased by an indirect treatment effect d given by the number of consumers having substituted from the treatment group. Formally, let us rewrite the model in (1) as*

$$y_{it}^{*} = \theta_i + \mu_t + T_t(G_i\delta + (1 - G_i)d) + u_{it}, \tag{2}$$

or more compactly as

$$y_{it}^{*} = \theta_i + \mu_t^{*} + T_tG_i\delta^{*} + u_{it}, \tag{3}$$

where $\delta^{*} = (\delta - d)$, $\mu_t^{*} = (\mu_t + T_td)$ and following treatment, the control group outcome variable absorbs some unobservable nonrandom value d.

This assumption states that the sales of the control group we observe may be biased because consumers who would have bought a Saab product switched to a vehicle belonging to the control group. If we look at the expected outcome for the control group posttreatment, we have

$$\begin{aligned} E\left[y_{it}^{*}|G_i = 0, T_t = 1\right] &= E[y_{it}|G_i = 0, T_t = 1] + d \\ &= \theta_c + \mu_2 + d, \end{aligned}$$

where we see the outcome is biased by the indirect treatment effect d. Furthermore, we see that the OLS estimate of the treatment effect as given in (3) will be $\delta^{*} = \delta - d$, that is, the estimated treatment effect δ^{*} will be a biased estimate of the true treatment effect δ. The coefficient μ_t^{*} will analogously be biased but as this coefficient is not the main focus of our study, we will only mention that bounds can also be derived for this coefficient in much the same way as we do below for the treatment effect δ.

In our application, we expect d to be positive because we believe that there is likely to be a positive substitution effect away from Saab to the control group. That is, we believe that the sales of the control group will be higher than they would otherwise have been, absent Saab's filing for administration.

Without loss of generality, let us also assume that the true treatment effect δ is nonpositive, $\delta \leq 0$. That is, we are assuming ex-ante that Saab's sales are going to fall due to its filing for administration. This assumption allows us to bound the indirect treatment effect d in a natural and intuitive way, as will become clear with the next assumption.

ASSUMPTION A2: *The indirect treatment effect d is bounded, $\Delta_L \leq d \leq \Delta_U$, in particular, $0 \leq d \leq -\delta$.*

Assumption A2 seems natural if, for instance, the object of interest is quantities or market shares; in this case, the indirect treatment effect can be bound by zero and, say, total sales. Implicit in this assumption are assumptions regarding substitution to the outside good: on the one extreme, we say that the average drop in Saab sales is entirely absorbed into the outside good ($d = 0$), whereas on the other extreme, we say that no consumer chooses the outside good ($d = -\delta$).[16]

16. The outside good is, for example, a car model outside of the closest competitors of Saab used to form the control group, or to postpone the purchase of a car into the non-foreseeable future. Although Huse and Lucinda (2014) provide structural evidence that the share of the outside good did not change during the period of the GCR, which encompasses that of Saab's administration, we prefer to be conservative and further control for a number of demand shifters likely to affect demand more locally, see Section 3.

Assumption A3: *The control group consists of $K \geq 1$ equally-weighted individuals. This implies that the outcome of the control group, y_{ct}, is the equally-weighted average of the K individuals' outcomes, y_{kt}. Formally, assume $y_{ct} = \frac{1}{K}\sum_k y_{kt}$. Within the control group, assume that each element k absorbs d_k units from the treatment group in the post-treatment period, with $d = \sum_k d_k$. Formally, with an equally weighted control group, the biased outcome is given by*

$$y^*_{ct} = \frac{1}{K}(y_{1t} + T_t d_1 + \ldots + y_{kt} + T_t d_k) = \frac{1}{K}\sum_k y_{kt} + \frac{1}{K}T_t \sum_k d_k$$

$$= y_{ct} + \frac{1}{K}T_t d = y_{ct} + T_t d^*,$$

which consists of the average of all individual control group elements, y_{ct}, pre-treatment (when $T_t = 0$), and the average of these outcomes, y_{ct}, together with the average of the indirect treatment effect given by $d^* = \frac{1}{K}d$, post-treatment (when $T_t = 1$). This comes from the fact that although the control group elements absorb d units in sum, the group as a whole absorbs on average $d^* = \frac{1}{K}d$. Assumption A3 is illustrated by the following example.

Example: *In our setting, the control group consists of Saab's close competitors with the control group outcome being a simple average of each of the competitors' outcomes. For instance, if Volvo sells 100 units of its V70 and 150 units of its V50 posttreatment, a control group consisting only of these two models will have an average outcome of 125 units. If we assume that Saab loses 10 units in sales posttreatment that are fully absorbed by the V70 and the V50, for instance, with all 10 units being absorbed by the V70, the control group outcome will instead be 130—the average of 110 and 150. That is, the control group outcome is the sum of the true outcome $y_{ct} = 125$ and the average of the total number of units absorbed by the V70 and the V50 post treatment, namely, $d^* = \frac{10}{2} = 5$.*

As established above, the estimated treatment effect is given by $\delta^* = \delta - d$, where d is the indirect treatment effect. If we use a control group of equally weighted individuals, then from Assumption A3, we see that the indirect treatment effect is instead $d^* = \frac{1}{K}d$ giving the estimated treatment effect as $\delta^* = \delta - \frac{1}{K}d$. From this relationship, we see that $\delta \cong \delta^*$ as K, the number of control group elements, grows large, that is, the bias vanishes as K increases. However, it is also important to emphasize the trade-offs involved in choosing the size of the control group, because an overly large control group would consist of subjects that will no longer be substitutes of those in the treatment group. In our setting, the more models we include in the control group, the more likely we are to include vehicles that can no longer be seen as close substitutes to Saab vehicles. In the most extreme case, one could include all models available on the market, whereas in the other case, one could include only one. As discussed below, under mild conditions, one obtains that the bounds depend on the own-price elasticity of the treatment group and the cross-price elasticities between elements of the treatment and control groups. This is intuitive because the indirect treatment effect is the result of the substitutability between elements in the treatment and control groups. Before, Proposition 1 below derives more general properties of the bounds.

Proposition 1: *Let Assumptions A1 and A2 hold. Then, the true treatment effect δ is bounded. Formally,*

$$\delta^* + \Delta_L \leq \delta \leq \delta^* + \Delta_U, \tag{4}$$

Proof: See online Appendix. □

This proposition states that although we do not know the true treatment effect δ, we can nevertheless say something about its magnitude if we are willing to make assumptions about the bounds of the indirect treatment effect d. For instance, if we assume that there is no bias, that is, $\Delta_L = \Delta_U = 0$, then the estimated treatment effect δ^* is going to be equal to the true treatment effect δ. If, on the other hand, we have a strictly positive bias ($\Delta_U > \Delta_L > 0$), Proposition 1 tells us that given a nonpositive treatment effect, $\delta \leq 0$, we will underestimate the true treatment effect by at least Δ_L and at most Δ_U.

Corollary 1 (Bounded EW Estimator): *Let assumptions A1, A2, and A3 hold. Then, the true treatment effect is bounded by*

$$\delta^* \leq \delta \leq \frac{K}{K+1}\delta^*. \tag{5}$$

Alternatively, for any constant level of substitution $\lambda \in [0, 1]$, *the true treatment effect is given by* $\delta = \frac{K}{K+\lambda}\delta^*$.

Proof: See online Appendix. □

Although Proposition 1 makes the general statement that we are able to find bounds on the true treatment effect δ even in the presence of an indirect treatment effect d, Corollary 1 provides specific bounds for the true treatment effect δ given our assumptions on the bounds of the indirect treatment effect d. The lower bound is simply the case when there is no indirect treatment effect and the true treatment effect δ equals the estimated treatment effect δ^*. Given our previous assumption that the outcome of the control group is an average of the control group individuals' outcomes, the upper bound is a function of how many elements we include in our control group with the interval narrowing as the number of control group elements K increases. However, we need not assume that there is either perfect or no substitution, assuming instead that substitution is given by some fixed fraction $\lambda \in [0, 1]$ of the true treatment effect. Although less conservative, such an assumption would allow us to fully recover the true treatment effect through the relationship given by $\delta = \frac{K}{K+\lambda}\delta^*$.

Corollary 2 (Bounded EW Estimator Variance): *For any constant fraction* $\lambda \in [0, 1]$ *of consumers in the treatment group switching to the control group and constant size of the control group* $K \geq 1$, *the variance of the treatment effect estimator can be written as*

$$Var(\hat{\delta}) = \left[\frac{K}{K+\lambda}\right]^2 Var(\hat{\delta^*}). \tag{6}$$

Proof: See online Appendix. □

One implication of an indirect treatment effect is that the variance of the estimated coefficient δ^* will also be incorrect, as seen from (6). The result of Corollary 2 parallels that of Corollary 1 in that if we were to assume, or know, the true fraction λ of consumers substituting from the treatment to the control group, we would be able to correct the variance of the estimate in order to do correct inference.

Corollary 3 (Standardized EW Estimator): *The standardized estimate of the treatment effect remains unchanged by the bias* d, *that is,*

$$\frac{\hat{\delta^*}}{\sqrt{Var(\hat{\delta^*})}} = \frac{\hat{\delta}}{\sqrt{Var(\hat{\delta})}}. \tag{7}$$

Proof: See online Appendix. □

Corollary 3 states that although there may be an indirect treatment effect that over—or underestimates the true treatment effect, because the indirect treatment effect merely inflates the estimate and its variance, the two effects exactly cancel out leaving T-statistics unchanged. Although we construct 95% confidence intervals using block bootstrapping to avoid small sample issues of heteroskedasticity and autocorrelation corrected estimators of standard errors, Corollary 3 states that we could have used regular T-statistics we had a robust estimate of the coefficient standard errors. [17]

4.2. Refining the Bounds

Our analysis so far has obtained bounds without imposing much economic structure, the exception being the existence of an outside good. In what follows, we will make assumptions on substitution patterns between products in order to obtain bounds that satisfy two conditions. First, the bounds should be more informative than those obtained above.[18] Second, the bounds should not depend on the size of the control group. That is, to the extent possible, the bounds should be determined by the data rather than by the researcher.

Our analysis relies on bounding the substitution parameter between treatment and control groups, λ, known in the literature as the diversion ratio and widely used in antitrust analysis (Shapiro, 1996; Werden, 1998). Assuming without loss of generality that K' elements of the control group are in the same market segment as the treated subject and K'' in other market segments (so $K' + K'' = K$), one can write

$$\lambda := \frac{\Delta q_C}{\Delta q_T} = -\frac{\varepsilon_{CT}}{\varepsilon_{TT}}\frac{q_C}{q_T} = -\sum_{i=1}^{K}\frac{\varepsilon_{iT}}{\varepsilon_{TT}}\frac{q_i}{q_T} = -\frac{\sum_i^{K'}\varepsilon_{iT}q_i}{\varepsilon_{TT}q_T} - \frac{\sum_i^{K''}\varepsilon_{iT}q_i}{\varepsilon_{TT}q_T},$$

where q_T and q_C are total sales of treatment and control groups, ε_{iT} is the cross-price elasticity between the treatment group and element i of the control group, ε_{TT} is the own-price elasticity of the treatment group, and ε_{CT} is the cross-price elasticity of the control group with respect to prices of the treatment group.[19]

To investigate how the substitution parameter changes as a function of the size and the composition of the control group, we need the following assumptions.

Assumption E1 (Dominance): *The own-price elasticity of the treatment group dominates the sum of the cross-price elasticities between elements of the treatment and control groups:*

$$|\varepsilon_{TT}| \geq \sum_{i=1, i\neq T}^{K} \varepsilon_{iT}.$$

Assumption E1, which applies only to elements of the treatment and control groups, is implied by an elasticity matrix with a dominant diagonal.[20] Intuitively, it holds if consumers decide not to purchase any product given that treatment occurred.

17. Our choice of the block bootstrap is expected to improve on standard bootstrap methods such as in Horowitz and Manski (2000) due to its accounting of potential autocorrelation in the data.
18. Recall that $\lambda \in [0, 1]$ and $\lambda = 0$ is the standard DD case.
19. We assume throughout that the treatment group has a single element for the sake of tractability.
20. The dominant diagonal condition is given by $|\varepsilon_{jj}| \geq \sum_{j\neq i} |\varepsilon_{ji}|, \forall i, j = 1, \ldots, J$, where $J\,(> K)$ is the number of inside products, that is, all products on the market.

In our application, this amounts to a consumer not purchasing a new vehicle due to the financial ills of Saab, for instance.

Assumption E2 (Substitutability): *Let the cross-price elasticities between a product and its substitutes in the same market segment dominate its cross-price elasticities with respect to products in other market segments. Moreover, let the latter be negligible, in the sense that substitution is mostly within a market segment. Since K' elements of the control group are in the same market segment and K'' elements of the control group are in other market segments, one can write*

$$\sum_{i=1,i\neq T}^{K} \varepsilon_{iT} = \sum_{i=1,i\neq T}^{K'} \varepsilon_{iT} + \sum_{i=1,i\neq T}^{K''} \varepsilon_{iT} \approx \sum_{i=1,i\neq T}^{K'} \varepsilon_{iT}.$$

Assumption A2 posits the existence of different market segments, which is typical of differentiated products markets such as the automobile industry. What is more, while the closer the substitution between two products, the higher their cross-price elasticities, Assumption E2 requires that there is virtually no substitution between products in different market segments. Economically, this is consistent with the fact that consumers choose among products that are somewhat similar in characteristics space. In particular, it is consistent with estimates coming from (one-level) nested logit demand models, where cross-price effects within a nest are substantially larger than cross-price effects between nests, which are often negligible. [21]

Assumption E3 (Homogeneity): *Assume the market under consideration is segmented, with homogenous cross-price elasticities within and across market segments denoted by ε_H and ε_L, respectively, with the homogeneous elasticities satisfying* [22]

$$\sum_{i=1,i\neq T}^{K} \varepsilon_{iT} \leq K'\varepsilon_H + K''\varepsilon_L.$$

Homogeneity of the elasticities is not crucial, but facilitates obtaining analytical results. Examples of functions satisfying the inequality in Assumption E3 are averages or maxima of the elasticities within a segment. Assumption A3 could be further generalized by assuming richer patterns (consistent with, say, a multilevel nested logit model), but this is unlikely to add much in terms of insight. [23,24]

Assumption E4 (Symmetry): *Products in the control and treatment groups have sales of similar magnitudes, $q_i \approx q_T \approx \tilde{q}, \forall i \in CG$.*

Assumption E4 is also made for the sake of tractability. Alternatively, one could assume that sales of the treated product are a scaled version of the typical element of the control group, but this would add little in terms of insight.

21. In online Appendix B, we report estimates of nested logit specifications that are consistent with the above assumption, see Table B1. For instance, in Specification 5, the average within-nest (cross-nest) cross-price elasticity is 0.06 (0.01) with standard deviation 0.12 (0.01).

22. Formally, ε_H denotes the cross-price elasticity between the treatment group and elements of the control group in the same market segment as those in the treatment group, whereas ε_L denotes the cross-price elasticity between the treatment group and elements of the control group in different market segments.

23. For instance, a two-level nested logit model would have cross-price elasticities within a subgroup, between different subgroups of the same groups, and between different groups.

24. Table B1 in online Appendix B reports findings consistent with the assumption of homogeneity, that is, cross-price elasticities within a segment have the same magnitude and are typically clustered around their mean.

In what follows, we bound the substitution parameter λ using the above assumptions, and then provide the associated bounds to the DD effect.

Proposition 2: *Let assumptions E1–E4 hold. Then,*

$$\lambda \leq -K' \frac{\varepsilon_H}{\varepsilon_{TT}} \leq 1.$$

From Proposition 2, the diversion ratio λ is affected only by the number of products in the control group in the same market segment as the product in the treatment group, in addition to the corresponding own- and cross-price elasticities. Interestingly, $\frac{\partial \lambda}{\partial K} = -\frac{\varepsilon_H}{\varepsilon_{TT}} > 0$ meaning that even if λ never reaches 1, it increases—at a rate determined by the ratio of own- and cross-price elasticities—with the number of within-nest elements belonging to the control group, K'.

Corollary 4: *Let the assumptions in Proposition 2 hold. Moreover, let the elements in the control group and the market segment of the treated subject coincide ($K' = K$). Then, the DD effect can be bounded as follows:*[25]

$$\delta^* \leq \delta \leq \frac{\varepsilon_{TT}}{\varepsilon_{TT} - \varepsilon_H} \delta^*,$$

where δ^* is the naive (OLS) DD estimate.

Within the framework of a one-level nested logit model, the assumptions above imply that those products in the control group are within the same nest as the product in the treatment group. From Corollary 4, once one assumes that $K' = K$, a sensible assumption if one is to believe that the control group should only contain elements in the same market segment as the treated subject, the relation between the biased DD estimate and the true one depends on own- and cross-price elasticities.[26] Alternatively, given the naive (OLS) DD estimates δ^*, the upper bound of the true DD effect is obtained by multiplying the naive estimate by a term consisting of price elasticities.

5. Empirical Analysis

5.1. Treatment Period

The DD estimator quantifies the effect of a treatment—Saab's financial distress in our application—on an outcome by comparing the average change over time in such outcome for treatment and control groups. This definition of treatment poses a problem of defining a specific point in time when the treatment was administered to the treatment

25. We have also derived results where we replace E1–E3 with a stronger dominance condition (E1′), $\rho|\varepsilon_{TT}| \geq \sum_{i=1, i\neq T}^{K} \varepsilon_{iT}$, $\rho \in (0, 1]$. Under E1′ and E4, we obtain $\lambda \leq \rho$, that is, the diversion ratio is majorated by the dominance parameter, ρ. This implies that $\delta \in [\delta^*, \frac{K}{K+\rho}\delta^*]$, that is, as in the previous section, the bound narrows as the size of the control group grows large. While the bounds still depend on the size of the control group, the result allows comparing the relative importance of the dominance parameter and the size of the control group, with a stronger dominance parameter (lower ρ) resulting in a narrower interval for the DD effect. Moreover, comparing the latter result with the one in the text stresses the price to be paid in terms of assumptions to obtain bounds that do not depend on the size of the control group. The results are available from the authors upon request.

26. Note, however, that the cross-price elasticity ε_H likely changes with the size of the control group if it is not the case that $K' = K$. For instance, by leaving out of the control group one element of the same market segment as the treated subject, one would be affecting the cross-price elasticity; arguably, this impact is more likely to be felt if ε_H is taken to be the average cross-price elasticity than the maximum cross-price elasticity.

group. Financial distress is generally not something that occurs instantaneously, being rather the consequence of poor financial conditions of a company over a certain, often prolonged, period of time. Not all companies with a poor financial situation can be construed as financially distressed. Instead, only once a certain threshold is crossed, can a company realistically be defined as being financially distressed One such threshold, if a little extreme, is the filing of a company for bankruptcy or administration; once a company files for bankruptcy or administration, as Saab did in February 2009, little doubt can remain as to whether the company is in financial distress or not. Alternatively, one could argue that what really triggers financial distress in Saab's case are GM's financial troubles, which were made public in November 2008 or when GM officially applied for emergency financial aid in December 2008.

The end of treatment for Saab is less of a controversy: having filed for administration, Saab was not liquidated but continued to operate under administration until the Swedish Courts ruled it was out of administration on August 21, 2009.[27]

In what follows, we define the treatment period to start when GM's financial problems become public, that is November 2008, and to end in August 2009. This treatment window yields the more conservative estimates of the treatment. In particular, our reported estimates are more conservative than those resulting from a treatment period starting in February 2009.

One natural concern is that Saab' s poor sales performance started due to Saab' s own financial issues that either did, or did not, influence GM' s financial situation. However, recall from Section 2 that it is highly unlikely that any financial issues Saab may have had would have affected GM, mainly due to Saab being much smaller. Moreover, Saab only turned a profit on 2 out of the 20 years under GM ownership, thus consistently counting on GM's funds during this period. That is, despite its sub-par operating performance, one cannot claim that Saab was in financial distress.

Another concern is that there were other events during, or around, the treatment period that may have had a direct impact on Saab sales. We have tried to capture any event, which we have not mentioned directly, by collectively combining news into indices and using these as additional control variables in our robustness checks. We believe that this allows us to directly control for any events that occurred to Saab before or after treatment which may have had additional impacts on the sales of Saab.

5.2. Constructing Control Groups

Choosing a suitable control group with which to compare the outcome of the treated group is largely dependent on the treatment group. In the current setting, the treatment group is the carmaker Saab (and its products), whereas the treatment is that of being in financial distress.

To quantify the impact of Saab's financial distress, we need to construct a control group for each of Saab's products. Since consumers wish to purchase a car based on a fairly specific set of needs, an adequate control group should consist of vehicles catering to the same consumer needs as Saab models. That is, a control group should contain

27. This means that the Court that had access to all of Saab's internal financial information, and granted Saab its legal administration status also deemed the company healthy enough to continue operating. Not only did the court deem Saab strong enough to continue operating but the ruling was arguably credible enough to restore buyers' confidence in the brand.

models that are close competitors to a given Saab product in characteristic space (design, market segment, engine size, etc.) and evolve in a similar manner over time.[28,29]

One extreme case is to include only the single closest competitor of a given product in the control group. However, this would leave the control group potentially exposed to idiosyncratic events related to the very model included in it. On the other hand, having too many models in the control group would wash out the effects local to the market category a given Saab model belongs to.[30] In other words, there is a clear trade-off regarding the size/composition of the control group.

To construct control groups, we consider a market with J products and K characteristics denoted by χ_{kj}, $j = 1, .., J; k = 1, \ldots, K$, typically assumed exogenous in the demand literature. To make characteristics of different magnitudes comparable, we standardize each characteristic, denoted as χ_{1j}^{0}, subtracting its mean and dividing the demeaned characteristic by its standard deviation. For product j, the vector of standardized product characteristics is given by $\chi_j^0 = (\chi_{1j}^0, \ldots, \chi_{Kj}^0)'$. With the above notation set, we need to define a distance between products i and j in characteristic space to identify the closest competitors of each Saab product. One intuitive and convenient measure is the (weighted) Euclidean distance defined as $\partial_{ij} = [(\chi_i^0 - \chi_j^0)' W^{-1} (\chi_i^0 - \chi_j^0)]^{1/2}$ where W is a weighting matrix potentially allowing for different weights according to the relevance of characteristics.[31] Essentially, product i will be identified as a close competitor of the treated (Saab) product j whenever the distance between these two products is less than or equal to a threshold level ∂^*. In our setting, we choose ∂^* such that each Saab product has a control group consisting of 10 competing products. A similar approach is used by Ashenfelter and Hosken (2008) in their study of consumer goods prices following mergers whereby the authors construct control groups out of "private label," or store brand, products that are closest in characteristic space to the products owned by merging parties.[32]

Control Group Composition. We construct control groups for both gasoline and diesel versions of Saab's two models, the 9-3 and the 9-5.[33] To make it into the control group, competitors have to be in the same market segment, run on the same fuel, and be close to a specific Saab model in terms of its technical characteristics.[34] Control groups are rebalanced every year using data from the previous year only, so as to avoid forward-

28. We make sure that no models from other brands owned by GM are included in any of the control groups used.

29. Matching only on observable characteristics, however, means that those which are unobserved are not directly accounted for. If unobservable characteristics consist primarily of brand—or model—reputation, then these are unlikely to vary greatly over time (as pointed out in, for example, Nevo, 2001).

30. A further technical complication is that if you rebalance control groups annually with only a few elements, any differences in the magnitudes of sales may cause jumps in the sales.

31. Here, we use an equal weighting scheme when calculating the Euclidean distances between different products.

32. The above strategy relates to two approaches commonly used in economics, namely, the distance metric (DM, see Pinkse et al., 2002) and the matching estimator (Cochran and Rubin, 1973; Rosenbaum and Rubin, 1983; Abadie and Gardeazabal, 2003). DM essentially views products as a unique combination of characteristics, so substitution patterns across products are spatially determined, that is, are determined by the relative proximity between products in characteristic space. This allows replacing a multidimensional set of characteristics with a summary statistic thereof, thus bypassing curse of dimensionality issues.

33. Due to the small number of models available and the common technology (the Otto cycle engine), we coded vehicles able to operate on both gasoline and ethanol as gasoline. This is consistent with the empirically observed fact that substitution occurs mostly between gasoline and gasoline/ethanol cars, see Huse and Lucinda (2014) for additional evidence of this substitution.

34. More precisely, within a market segment, for example, sedan, and fuel, for example, diesel, we use continuous variables such as engine power (horsepower, HP), engine size (cubic centimeters, cm^3), weight (kilograms, kg), emissions (gCO_2/km), mixed fuel economy (l/100 km), and list price (SEK).

Table III.
Control Group Elements Disaggregated by Year, Model, and Fuel Type

		Saab 9-3		Saab 9-5	
	Year	2008	2009	2008	2009
Panel A:	1	Audi A4	Alfa Romeo 159	Alfa Romeo 159	Alfa Romeo 159
Gasoline	2	Dodge Avenger	Dodge Avenger	Audi A4	Audi A6
	3	Honda Accord	Honda Accord	Audi A6	Dodge Avenger
	4	Kia Magentis	Kia Magentis	Dodge Avenger	Honda Accord
	5	Mazda 6	Peugeot 407	Hyundai Sonata	Hyundai Sonata
	6	Renault Laguna	Skoda Superb	Mazda 6	Kia Magentis
	7	Skoda Superb	Subaru Legacy	Skoda Superb	Peugeot 407
	8	Toyota Avensis	Toyota Avensis	Subaru Forester	Skoda Superb
	9	Volkswagen Jetta	Volkswagen Jetta	Subaru Legacy	Subaru Legacy
	10	Volkswagen Passat	Volkswagen Passat	Volkswagen Passat	Volkswagen Passat
Panel B:	1	Audi A4	Alfa Romeo 159	Alfa Romeo 159	Alfa Romeo 159
Diesel	2	Dodge Avenger	Audi A4	Audi A4	Audi A6
	3	Honda Accord	Honda Accord	Audi A6	Dodge Avenger
	4	Kia Magentis	Kia Magentis	Dodge Avenger	Hyundai Sonata
	5	Mazda 6	Mazda 6	Hyundai Sonata	Jaguar X-Type
	6	Peugeot 407	Peugeot 407	Kia Magentis	Kia Magentis
	7	Renault Laguna	Subaru Legacy	Lexus Is	Lexus Is
	8	Toyota Avensis	Toyota Avensis	Peugeot 607	Skoda Superb
	9	Volkswagen Jetta	Volkswagen Jetta	Skoda Superb	Subaru Legacy
	10	Volkswagen Passat	Volvo S80	Volkswagen Passat	Volvo S80

Notes: Control group elements disaggregated by year, model (Saab 9-3 and 9-5) and fuel type. A single control group is separately constructed for each of the two Saab car models as well as for each year from 2006 to 2009 and each fuel type. Elements of the control group are chosen to be as close as possible in characteristics space to the characteristics of any given Saab car model. Each control group contains 10 other cars chosen from all possible cars available on the Swedish market between 2005 and 2009. Only models available in a previous year are allowed to be included into a control group. Panel A: Control group for Saab's gasoline models; Panel B: Control group for Saab's diesel models.

looking biases and account for product entry and exit—see Table III for the control groups of models 9-3 and 9-5.[35] As discussed in online Appendix D, results are robust to changes in the size and composition of the control group. While we report results using equally-weighted elements of the control group, sales-weighted elements yield similar qualitative results. Although there exists some degree of attrition in the control groups, it amounts to a small share of the models from year to year. As a further robustness check, we perform the main analysis with control groups that are not rebalanced, but instead retain their 2006 composition throughout the entire sample period, with similar results.

Control groups for the Saab 9-3 and Saab 9-5 versions are displayed in Table III. As reported in Panel A, the main competitors of the Saab 9-3 running on gasoline across the years are the Skoda Superb, the Toyota Avensis, and the VW Jetta. Other close competitors include models such as the Audi A4 and the Mazda 6. The results for the diesel version of the Saab 9-3 differ only slightly from those of the gasoline one; besides the models above, the Honda Accord, the Kia Magentis, and the Peugeot 407 also often appear as competitors to the model.

35. Although using characteristics from the same period rather than lagged ones does somewhat change the composition of the control groups, the results remain qualitatively very similar. Using models from the previous (as opposed to current) year arguably reflects more accurately the information set available to competitors when deciding about their own product lines for a given year, thus being preferred in our analysis.

Being larger than the Saab 9-3, it is no surprise that some of the models in the control group of the Saab 9-5 are also slightly larger than those in the control groups for model 9-3. For instance, besides the Skoda Superb, which also appears as a close competitor to the Saab 9-3, now models such as the Audi A6 (which is larger than the Audi A4) and the Hyundai Sonata also appear as close competitors to the Saab 9-5.[36,37]

Our approach is also closely related to the synthetic matching technique of Abadie and Gardeazabal (2003), who propose constructing a control group with elements weighted in a way to provide the best possible match between the treatment and control groups, pre-treatment. Although we apply these synthetic matching methods in Section 6.1, we conduct our main analysis using control groups constructed as described above for the following reasons. First, recall that the car market witnesses a high number of products at any given point in time and episodes of entry, exit, and facelift of products, all of which are likely to alter the consumer's perception of a product. Second, the demand for automobiles often manifests itself through shifts in demand for particular market segments, for example, minivans and SUVs; thus, we believe that our weighting scheme is more likely to capture changing trends within the industry as a whole, rather than the trends of the individual control group elements.

5.3. A First Look at the Data: Identification

To assess the appropriateness of the DD analysis, we argue that absent treatment, the sales of Saab, and the control group would have evolved in a similar manner. Formally, this amounts to testing the parallel trends assumption between treatment and control groups. First, notice that despite the noisiness, the sales of the Saab brand tend to follow the same pattern as that of the control group in the years prior to its filing for administration, as displayed in Panel A of Figure 1. In particular, the seasonal patterns are well pronounced for both groups. Starting from early 2009, Saab's sales are strongly affected, whereas those of the control group follow an upward trend. Despite its magnitude, this discrepancy is short-lived—as early as mid-2009, the sales of Saab once again follow very closely those of the control group, in what coincides with the signature of Saab's purchase intent by Koenigsegg.[38]

When decomposing the Saab brand figures at the model level, it becomes apparent that the behavior of Saab is driven mostly by its best-selling 9-3 model. In particular, although less pronounced for the 9-5 model, the pre-administration sales of both models follow closely those of their control groups, with sales of both models typically below the 100-unit threshold for most of the administration period. Moreover, for all panels in Figure 1, the sales of the treatment group are notably more volatile than those of the control groups. The smoothness in the sales of the control group is a direct consequence of the averaging of the sales of a number of products. However, we still fail to reject

36. In our analysis, we have not allowed products of any GM brand to enter the control group, but did not constrain the presence of models produced by Chrysler. As a result, one Dodge (a subsidiary of Chrysler) product enters the control group. As a robustness check, we also perform our analysis excluding it from the control group, with marginal changes to the results.

37. Although the control groups contain cars that may differ somewhat from a Saab product, there are very few statistically significant differences between the average Saab and average control group vehicle as reported in Table II.

38. Although one could argue that this period also coincides with the end of the GCR, a policy that arguably benefited Saab due to its emphasis on gasoline/ethanol flexible fuel vehicles, a segment where Saab operated, its importance as compared to the end of administration is of second order. In fact, Huse and Lucinda (2014) show that Swedish and high-end German brands did not benefit from the GCR. Nevertheless, our conservative choice is to still explicitly control for the GCR in our empirical specifications.

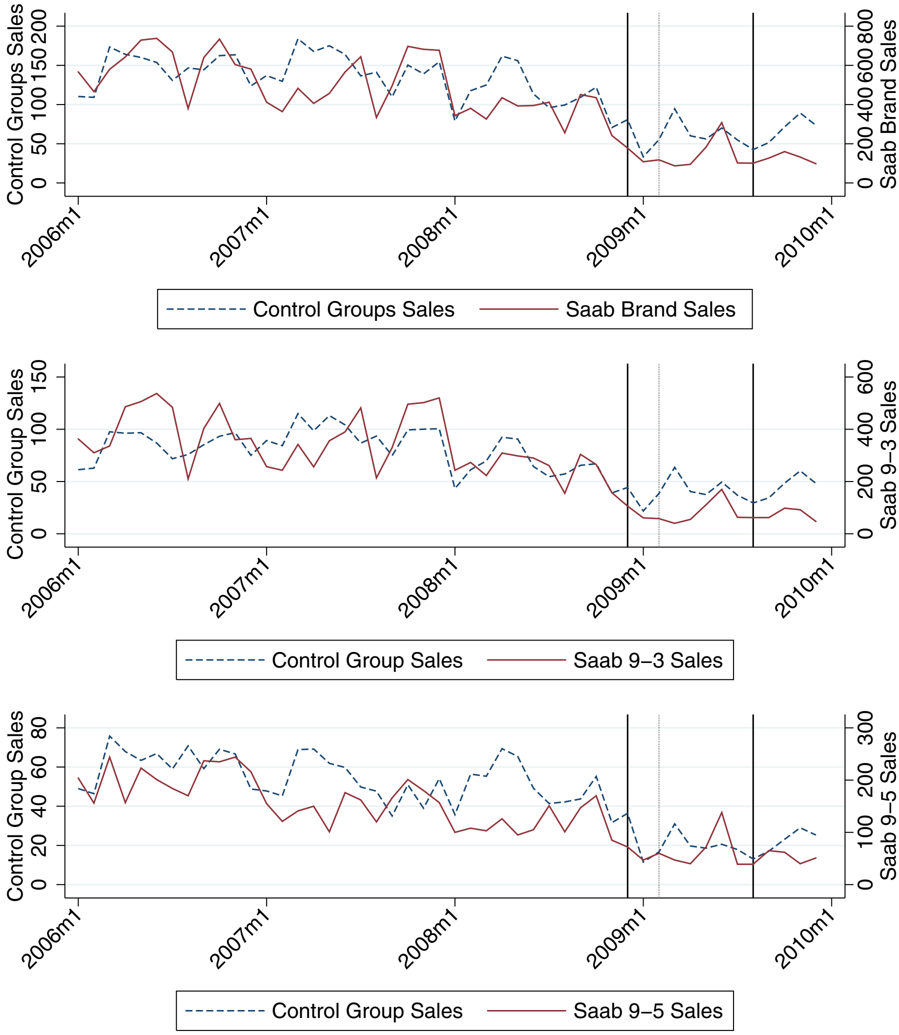

FIGURE 1. SALES OF SAAB AND OF ITS CONTROL GROUP

Note: Sales of Saab and of its control group at the monthly frequency from January 2006 to December 2009. Solid vertical lines indicate the treatment period, which begins in November 2008 and ends in August 2009. The start of the treatment period coincides with the financial problems of Saab's parent company General Motors becoming public. The end of the treatment period coincides with a Swedish court ending Saab's administration status. Dashed vertical lines indicate Saab's administration filing in February 2009. Panel 1a (top): Sales of Saab brand and annually rebalanced control group; Panel 1b (middle): Sales of Saab 9-3 and annually rebalanced control group; Panel 1c (bottom): Sales of Saab 9-5 and annually rebalanced control group.

the null hypothesis of parallel trends between sales of treatment and control groups in the pretreatment period, the key identifying assumption in the DD setting. In order to check whether this assumption is satisfied, we estimate a triple difference specification to assess the parallel trends assumption. More specifically, we interact a time trend with the treatment group and a dummy for the pretreatment period.

Table IV reports results for the Saab brand in column 1, for the Saab 9-3 in column 2, and for the Saab 9-5 in column 3. For each case, we consider the specification with

Table IV.
Results for Triple Difference Specifications

	(1)	(2)	(3)
Dependent Variable	Saab Brand Sales	Saab 9-3 Sales	Saab 9-5 Sales
Sample Period	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12
Trend × Treatment × Pretreatment Period	**−5.27**	**−3.49**	**−1.79**
	[−2602.76, 2145.29]	[−957.63, 1525.33]	[−518.56, 703.84]
GCR FE	X	X	X
Consumer Confidence	X	X	X
Month × Introductions FE:s	X	X	X
Observations	96	96	96
R-squared	0.93	0.91	0.92

Notes: Results for triple difference specifications to test the parallel trends assumption. The coefficient of interest is a triple interaction term between a time trend and dummies for the treatment group and the pretreatment period. Specification 1 shows the parallel trends test for the Saab 9-3, Specification 2 for the Saab 9-5, and Specification 3 for Saab as a brand. The 95% heteroskedasticity-robust confidence intervals are reported within square brackets. The null of parallel trends is not rejected for any of (1)–(3).

the full set of controls, that is, the GCR indicator, the consumer confidence measure, and the interaction of product introduction and month fixed effects. Additionally, in Section 6.1, we provide robustness checks using synthetically constructed groups as in Abadie and Gardeazabal (2003) whereby sales of the treatment group are replicated as closely as possible using the weighted sales of all other models. In this setting, the treatment and control group sales are very closely related pretreatment but fall for Saab in the treatment period. All these results lend support to the finding that, absent treatment, the sales of Saab and the control groups would have evolved in a similar manner, thus lending credence to the DD analysis we perform.

5.4. Results

To quantify consumer response to Saab's financial distress, we estimate DD regressions using sales as the dependent variable. We estimate such regressions both for the Saab brand as a whole and for its products separately.

Table V reports results for the Saab sales as compared to the control groups defined above, both for Saab as a brand as well as for the Saab 9-3 and the Saab 9-5 separately. To construct the overall brand-level control group, we first construct control groups for each individual Saab model-fuel combination, as noted above, and then aggregate these into a single-brand-level control group. Our benchmark specification is given by

$$y_{it}^{*} = \theta_i + \mu_t^{*} + T_t G_i \delta^{*} + x_{it}^{'}\beta + u_{it}, \tag{8}$$

where $t = 1, \ldots, T$ are time periods, y_{it}^{*} are sales of treated (the Saab brand, a Saab 9-3, or a Saab 9-5 model, depending on the specification) and untreated groups, and G_i takes on a value of one if the observation is a treated subject and zero otherwise, whereas T_t takes on a value of one for observations falling within the treatment period between November 2008 and August 2009 and zero otherwise, and x_{it} is a set of controls including fixed effects for the GCR, month interacted with the number of new car models introduced a given year as well as a consumer confidence index.[39] The DD estimator is given by δ^{*} and the model is estimated using ordinary least squares.

39. One reason to include month fixed effects is to account for potential difference between list and transaction prices.

Table V.
Results of Difference-in-Differences Specifications

	(1)	(2)	(3)
Dependent Variable	Saab Brand Sales	Saab 9-3 Sales	Saab 9-5 Sales
Sample Period	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12
Bounded Treatment Effect: $[\underline{\delta}, \bar{\delta}]$	**[−261.06, −237.33]**	**[−204.30, −185.73]**	**[−57.17, −51.97]**
	[−438.46, −142.22]	[−305.19, −101.82]	[−105.40, −23.94]
GCR FE	X	X	X
Consumer Confidence	X	X	X
Month × Introductions FE:s	X	X	X
Observations	96	96	96
R-squared	0.766	0.757	0.716

Notes: Results of Difference-in-Differences specifications described in Section 4 comparing the sales of the Saab brand (1), and its two products (2) and (3), to the sales of the relevant, annually-rebalanced control group in order to measure the effect of financial distress on Saab sales. The treatment window is defined to be between November 2008 and August 2009. The start of the treatment period coincides with the financial problems of Saab's parent company General Motors becoming public. The end of the treatment period coincides with a Swedish court ending Saab's administration status. Each specification contains a vector of additional control variables including fixed effects for the Green Car Rebate, month interacted with the number of new car models introduced a given year as well as a consumer confidence index. The estimated lower and upper bounds for the true treatment effectδ are given by$[\underline{\delta}, \bar{\delta}]$ above in bold. Below each coefficient and the estimated treatment effect bounds, 95% block bootstrapped confidence intervals are provided.

Columns 1–3 in Table V report results that differ with respect to treatment group used. DD coefficients are negative and significant throughout. The table shows the upper and lower bounds, $\bar{\delta}$ and $\underline{\delta}$, respectively, which correspond to the estimated end points of the inequality given by equation (5). If we are to assume perfect substitution, that is, $\lambda = 1$, then the true treatment effect would be correctly estimated by $\bar{\delta}$, whereas, if $\lambda = 0$, or no substitution, then the true treatment effect would instead be correctly estimated by $\underline{\delta}$.[40] The confidence intervals reported are 95% block bootstrapped confidence intervals obtained by block bootstrapping 500 samples. We choose block bootstrapping in order to account for potential serial correlation in the errors terms, something earlier applications of the DD applications were criticized for not doing (Bertrand et al., 2004). Although another alternative would be to use some form of standard errors corrected for heteroskedasticity and autocorrelation in the residuals, it has been suggested that these perform poorly in small samples. See online Appendix D for additional details and robustness checks.

Column 1 reports results of the specification for sales of the Saab brand as a whole. The treatment effect is bounded between −261.06 and −237.33 units, and is statistically significant at the 95% significance level. Given unconditional average monthly sales of 470 units between 2005 and late 2008, these results suggest a drop in the sales of Saab products of between 50% and 56%.

Columns 2 and 3 report a more disaggregated analysis focusing on Saab models 9-3 and 9-5, respectively. Since the 9-3 was Saab's best-selling product during the sample period, it is not surprising that it suffers the bulk of consumer reactions: while column 2 estimates are in the range of a 150–200 unit reduction in sales, those in column 3 are closer to a 50 unit decrease. Column 2 estimates for the Saab 9-3 suggest a treatment effect in the range between −204.30 and −185.73 units—a drop of between 61% and 67% given unconditional average monthly sales of 304 units between 2005 and late 2008.

40. By Proposition 2, the refined bounds may be narrower than the bounds assuming perfect or no substitution, as the nature of demand may significantly restrict the possible values of λ. To be conservative, however, we choose not to present the refined bounds.

The DD results for model 9-5, reported in column 3 of Table V, follow a path similar to that of the Saab 9-3 with a treatment effect bounded between −57.17 and −51.97 units. Given unconditional average monthly sales of 151 units between 2005 and late 2008, these results suggest a drop in the sales of Saab products of between 34% and 38%. A lower decline in the sales Saab 9-5 may be due to the Saab 9-5 being even older than the Saab 9-3 in terms of technology and because of this having a more loyal following from consumers.

All in all, consumer responses are not only statistically but also economically significant with the bounds providing evidence that, even in the worst case of full substitution toward the control group, consumers did react to the financial ills of Saab.

5.5. Supply Effects

One important challenge faced in the analysis of the effects of financial distress on firm performance is disentangling demand from supply effects. For instance, in the automobile industry, a firm in financial difficulties may fire employees or cut production in order to improve revenues or better utilize production capacity. Even if the producer's actions were to remain the same, the dealers who sell the cars on to consumers may choose to stop transacting the cars because of the risk that at some point, consumers stop purchasing the car altogether and the dealer is left with an initially expensive asset that becomes worthless. Further, suppliers of parts used in manufacturing may choose to stop supplying to firms in financial distress making it more and more difficult to keep production levels constant. All of these scenarios would potentially affect the supply of cars available for purchase and lead to a drop in sales—not because consumers do not want to buy the car but because they simply cannot.

In Sweden, unlike for example in the United States, dealers do not keep a large inventory with consumers instead having to order the exact vehicle they want to buy. This means that as long as Saab continued producing cars, consumers would still be able to go to a dealer and order the car that they wanted to buy with the dealer not being exposed to the risk of initially having to buy the vehicle and then being unable to sell it at a later point in time.[41]

Moreover, despite production at Saab being halted during the period it was under administration, this happened for only a single week in February 2009. Production was halted as Saab was unable to pay Swedish customs import duties for parts arriving from overseas suppliers. As soon as Saab had obtained liquid funds to pay the import duties, production resumed with no other interruptions taking place in 2009.[42,43] Additionally, we have found no evidence that inventories of already manufactured Saab cars dwindled and were unable to cover demand. Furthermore, as seen from Figure 1, both the Saab 9-3 and 9-5 saw sales improving slightly toward the summer of 2009 with, for instance, the sales of the Saab 9-5 reaching levels better than those seen in early 2008. This suggests that there was enough of a supply to satisfy consumers once their demand improved.

41. See Huse and Lucinda (2014) for a more detailed description on the ordering of cars in Sweden.

42. Although it was noted in the Swedish media that certain smaller suppliers did end up going bankrupt, we found no further evidence regarding issues with Saab not being able to manufacture cars because suppliers had stopped supplying parts.

43. As an additional robustness check, we test whether the list prices of Saab vehicles changed as compared to control group. These are included in online Appendix D.

Analysis of Vehicle Prices. To support the above analysis, we perform a DD analysis comparing the list prices of Saab cars to those of a control group to assess whether there was any reaction in prices from the part of Saab.[44] Table VI reports separate results for Saab as a brand and for its models 9-3 and 9-5 using two different control groups.[45] First, we use the standard control groups described above for the sake of consistency with the remaining of our analysis. Second, we perform a robustness check whereby we construct control groups containing all products in the same market segment as the Saab products.

The results in Table VI document a lack of response in prices for Saab as a whole and for model 9-3, see columns 1 and 2, respectively. However, the same does not hold for model 9-5, see column 3. The reason why the significance of the price reactions for Saab 9-5 do not translate into price reactions for Saab as a whole is the small share of sales commanded by model 9-5 within the Saab brand. These results, hold also for our alternative definition of control group, compare columns 1 and 4, 2 and 5, and 3 and 6.

Our interpretation of the above findings is as follows. In the case of the Saab 9-3, its supply curve is largely flat—inelastic to changes in quantities—due to the very fact that such model was the leading product of the Saab brand. In contrast, the supply curve of the already dated Saab 9-5 was upward-sloping, with the company accepting to lower its price in order to make up for, say, the lack of technology improvements and the dated layout.[46]

The fact that we find no significant difference between Saab prices and the prices of other cars may be due to prices being mismeasured, leading to an underestimated effect. We do not believe that our results are driven by attenuation bias but rather that the results correctly reflect that Saab' s list prices did not change significantly as compared to that of other cars.

All in all, the reactions we document—no statistical evidence of price reactions for the Saab brand as a whole coupled with a roughly 50% reduction in sales—show the large economic impact of financial distress on the revenues (and thus profits) of a company.

6. Robustness

This section reports selected robustness tests used to assess the maintained assumptions of the analysis above. Online Appendix D reports results of a number of additional robustness checks.

6.1. Synthetic Control Groups

We examine whether our main results are robust to constructing a control group according to the synthetic matching methodology of Abadie and Gardeazabal (2003).

The synthetic control method allows estimating the effect of a treatment when a single unit (Saab, in our case) is exposed to such treatment. It consists of a data-driven methodology to construct synthetic control units based on a convex combination of untreated units that approximates the characteristics of the treated unit. For instance, in

44. Since vehicles are effectively ordered in the Swedish market, there is little room for bargaining upon the purchase of a new vehicle, making list prices (Manufacturer Recommended Sale Prices, RMSPs) a good proxy for actual transaction prices in the new vehicle market, see Huse and Lucinda (2014) for details.
45. Recall that that model 9-3 is the best-selling Saab product, commanding about 80% of the brand sales.
46. See online Appendix D for a discussion of the technological lagardness of Saab's products.

Table VI.
Results of Difference-in-Differences Specifications for Prices

	Control Groups Cars			All Cars within Segment		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Saab Brand Prices	Saab 9-3 Prices	Saab 9-5 Prices	Saab Brand Prices	Saab 9-3 Prices	Saab 9-5 Prices
Sample Period	2006–2009	2006–2009	2006–2009	2006–2009	2006–2009	2006–2009
Treatment × Post	**−13,043**	**−4,742**	**−19,767**	**−10,865**	**−2,421**	**−19,310**
	[−27,570, 14,842]	[−30,186, 20,702]	[−28,269, −11,265]	[−23,625, 1,894]	[−23,045, 18,203]	[−26,566, −12,054]
Year FE:s	X	X	X	X	X	X
Fuel Type FE:s	X	X	X	X	X	X
Observations	141	96	95	582	570	570
R-squared	0.938	0.906	0.974	0.980	0.980	0.980

Notes: Results of Difference-in-Differences specifications for prices of Saab cars against prices of control group cars. Results are for prices of Saab brand as a whole (1), the Saab 9-3 (2), and the Saab 9-5 (3) as compared to the relevant control group and for prices of Saab brand as a whole (4), the Saab 9-3 (5), and the Saab 9-5 (6) as compared to the prices of all vehicles available within the same segment. All specifications include year and fuel type fixed effects. The 95% robust confidence intervals given in parenthesis.

the case of Saab, one would intuitively expect that the synthetic control group would consist of vehicle models that closely compete with Saab, due to their reputation or observable characteristics such as size. Such models would be weighted in a way that the combination mimics as closely as possible the behavior of Saab sales pre-treatment in order to conduct inference for the post-treatment period.

Despite being somewhat similar, a few key distinctions exist between the construction of control groups presented in Section 5, and that presented in Abadie and Gardeazabal (2003). Whereas we construct control groups by matching Saab products to close competitors using only car characteristics, restricting these to the 10 closest competitors, the method of Abadie and Gardeazabal (2003) allows choosing the control group so as to synthetically match both the sales and car characteristics of the control group as closely as possible to that of the treatment group in the pretreatment period.

We conduct the robustness check by constructing three types of synthetic control groups, namely (i) using only car characteristics; (ii) using only car sales; and (iii) using both car characteristics and sales in order to make these results comparable to the ones presented in the main analysis—see online Appendix C for details. Furthermore, we also redo the exercise for another GM brand, Opel, in order to determine whether other GM brands also experienced similar effects of financial distress as those observed in Saab.

Results of Synthetic Matching. We construct synthetic control groups based on each of the three methods described above focusing on Saab's most popular model, the Saab 9-3. The matching is carried out using all 90 competing products available before 2009 that were within the same market segments, excluding other Saab products.[47] As the control group elements are no longer weighted equally, and as there is a much larger number of control group elements, we shall assume that substitution between the treatment and control group is not an issue and estimate a DD specification without taking substitution into account.

From specifications 1 and 2 in Table VII, we see that when comparing the sales of the Saab 9-3 to those of a synthetic control group constructed using only standardized and equally important product characteristics, the results are very similar to the main results where we construct control groups using proximity in characteristic space as the criterion for choosing the elements of the control group. Perhaps, this is unsurprising as there are only a few differences in how the two control groups are constructed; the methodology of Abadie and Gardeazabal (2003) assigns weight by replicating the characteristics of the treated product as closely as possible from the entire universe of competing products, whereas the methodology presented in this paper equally weights the elements that are closest in characteristic space.

As seen from the top panel of Figure 2, the synthetic control group does not perfectly replicate the sales of treated products in the pre-treatment period as information regarding sales is excluded in the construction of the synthetic control group. As a direct comparison, the bottom panel of Figure 2 shows sales for the Saab 9-3 and a synthetic control group that is constructed in order to replicate the sales of the Saab 9-3 in the pre-treatment period. We see that the sales of the Saab 9-3 and the sales of the synthetic control group are very similar in the pre-treatment period, diverging significantly in the post-treatment period. This is confirmed by the regression results presented in specifications 3–5 of Table VII, from which we can conclude that there are no statistically significant

47. As with the main results, other GM brands are not allowed to be part of the control group.

Table VII.
Results of Difference-in-Differences Specifications Based on Synthetic Matching

	Saab 9-3				Opel Astra	
	(1)	(2)	(3)	(4)	(5)	(6)
Control Group Sales	Baseline	Synth. Chars. Only	Synth. Sales Only	Synth. Chars. + Sales	Synth. Chars. Only	Synth. Sales Only
Sample Period	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12
Treatment × Post: δ	**−202.28**	**−221.44**	**−92.24**	**−202.92**	**−127.72**	**−48.11**
	[−280.31, −124.26]	[−296.94, −145.94]	[−172.39, −12.08]	[−277.91, −127.94]	[−171.53, −83.91]	[−94.71, −1.51]
GCR FE	X	X	X	X	X	X
Consumer Confidence	X	X	X	X	X	X
Month × Introductions FE:s	X	X	X	X	X	X
Observations	96	96	96	96	96	96
R-squared	0.764	0.759	0.650	0.706	0.823	0.784

Notes: Results of Difference-in-Differences specifications described in Section 6 where control groups are constructed according to the synthetic matching method of Abadie and Gardeazabal (2003) matched on car characteristics, sales and both. The specification is given by $y_{it} = \theta_i + \mu_t + T_t G_i \delta + x_{it}^{'} \beta + u_{it}$ comparing the sales of the Saab 9-3 (specifications 1–4, with specification 1 using the baseline control group for the Saab 9-3 as described in the main text) and Opel Astra (specifications 5 and 6) to the sales of the relevant, control group in order to measure the effect of financial distress on Saab and Opel sales. The treatment window is defined to be between November 2008 and August 2009. The start of the treatment period coincides with the financial problems of Saab's parent company General Motors becoming public. The end of the treatment period coincides with a Swedish court ending Saab's administration status. Each specification contains a vector of additional control variables including fixed effects for the Green Car Rebate, month interacted with the number of new car models introduced a given year as well as a consumer confidence index. The treatment effect may be affected by an indirect treatment effect as described in Section 4 but is disregarded in this case as control groups are synthetically constructed. Below each coefficient and the estimated treatment effect, 95% heteroskedasticity-robust confidence intervals are provided.

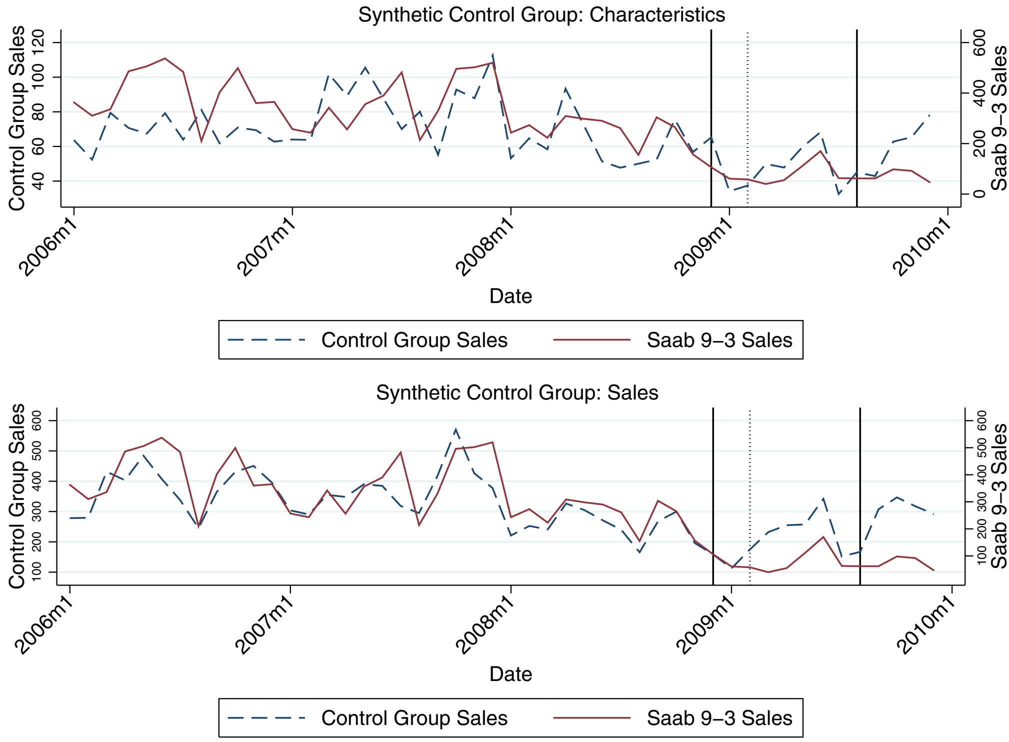

FIGURE 2. SALES OF SAAB AND OF ITS CONTROL GROUP BASED ON SYNTHETIC MATCHING

Note: Sales of Saab and of its control group at the monthly frequency from January 2006 to December 2009. Solid vertical lines indicate the treatment period, which begins in November 2008 and ends in August 2009. The start of the treatment period coincides with the financial problems of Saab's parent company General Motors becoming public. The end of the treatment period coincides with a Swedish court ending Saab's administration status. Dotted vertical lines indicate Saab's administration filing in February 2009. Panel 2a (top): Sales of Saab 9-3 and synthetic control group constructed as in Abadie and Gardeazabal (2003) by matching on standardized product characteristics; Panel 2b (bottom): Sales of Saab 9-3 and synthetic control group constructed by matching only on product sales.

pretreatment differences in outcomes between the treatment group and the control group but that there is a significant difference in post-treatment outcomes.[48]

Distress of Other General Motors Brands. We also perform the synthetic matching exercise using another GM brand, Opel, the best-selling GM brand in Sweden. Similarly to Saab, Opel may itself have experienced a decline in sales due to the financial distress of GM. Whereas Saab's future was uncertain, largely due to GM's announcement that Saab was to be made independent and that it would no longer be a part of GM, Opel was to remain an integral part of GM as part of a slimmer GM. Despite this, as GM's future as whole was uncertain in late 2008, this uncertainty may have affected the sales of Opel. However, if consumers were to have stopped buying Opel cars due to uncertainty of the

48. As before, we cannot reject the parallel trends assumption pretreatment.

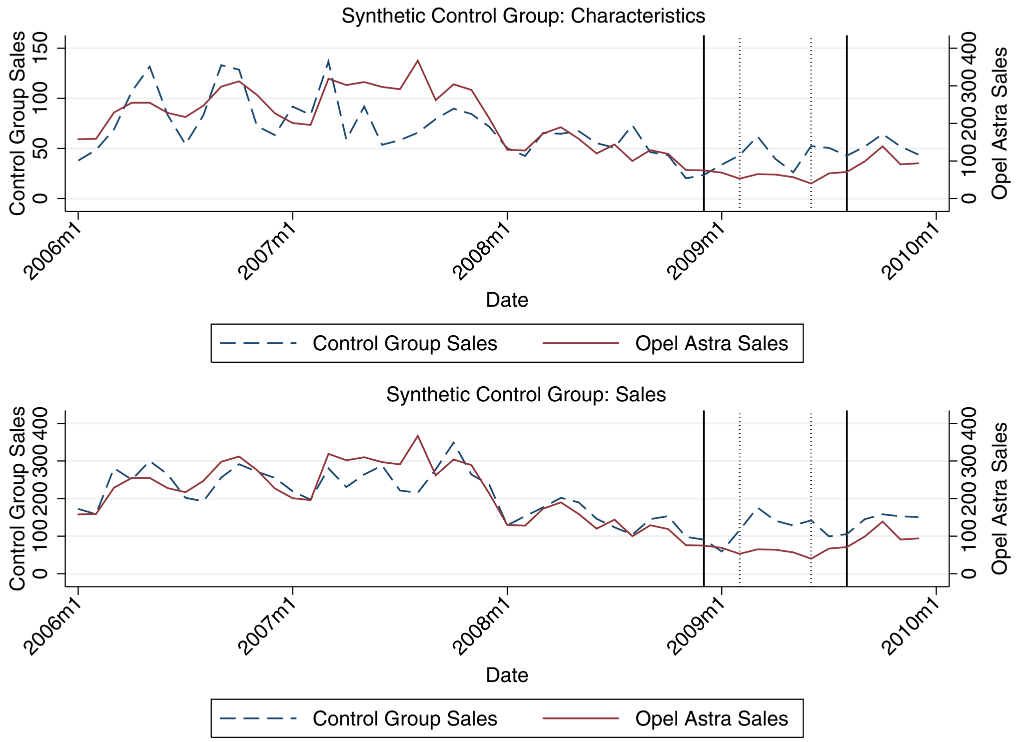

FIGURE 3. SALES OF OPEL ASTRA AND ITS CONTROL GROUP

Note: Sales of Opel Astra and sales of relevant control group at a monthly frequency from January 2006 to December 2009. Solid vertical lines indicate treatment period beginning from November 2008 and ending in August 2009, respectively. The start of the treatment period coincides with the financial problems of Saab's parent company General Motors becoming public. The end of the treatment period coincides with a Swedish court ending Saab's administration status. The first dotted vertical line indicates Saab's administration filing in February 2009, whereas second dotted vertical line indicates GM's bailout in June 2009. Panel 3a (top): Sales of Opel Astra and synthetic control group constructed as in Abadie and Gardeazabal (2003) by matching only on standardized product characteristics; Panel 3b (bottom): Sales of Opel Astra and synthetic control group constructed by matching only on product sales.

financial situation of GM, we should expect the effect to have at least partly disappeared with the effective bailout of GM in June 2009.[49]

Looking at specifications 5 and 6 in Table VII, we see that sales of Opel's best-selling model, the Opel Astra, do also decline as compared to their synthetic control groups. However, what is more important, see Figure 3, sales of the Opel Astra recover almost immediately following the bailout of GM. The above findings are consistent with our line of reasoning in several dimensions. First, Saab was not the only brand to suffer a decline in sales due to GM's failing financial health. That is, consumers do react to the perception that a company is in ill financial health.

49. For the sake of comparison, we will assign the same treatment window for Opel as that of Saab. Restricting the treatment window to coincide with GM's financial distress—that is, November 2008–June 2009—strengthens the results.

Second, the effects were different for Opel and Saab due to their differential status in GM's restructured brand portfolio—while Saab was to be made independent, Opel was to remain one of GM's core brands.

Finally, the fact that Opel sales rebound so markedly from June 2009 suggests that supply was not a large factor driving the decline in Opel sales. That is, the effect was in most part demand-driven. This fact lends additional credibility to our arguments that the decline in Saab sales was not caused by supply effects but rather demand effects.

6.2. Negative Spillovers

In this paper, we focus on positive spillovers from Saab, a treated firm, to the control group. It may also be the case Saab's financial distress spilled over onto the control group or the whole market in a negative way, inducing buyers to postpone the purchase of a car or not purchasing a car altogether. Assuming that the potential number of total buyers is stable across time, then, controlling for other factors, any decline in the total number of control group cars sold during the post-treatment period would indicate that buyers of control group cars may also have been affected.

To test whether there was any negative spillover from Saab's financial distress, we proceed as in Huse and Lucinda (2014) who estimate whether the market share of the outside good in Sweden increased due to the GCR. We estimate the spillover effect by regressing the total number of control group cars sold during our sample period on our baseline control variables and a post-treatment period dummy. A significant post-treatment period dummy would suggest that after controlling for general time trends, seasonality, and economic confidence, there was an additional change in sales due to there being a treatment effect spilling over from Saab onto the control group.

As reported in column 1 of Table VIII, we find a point estimate that indicates that, during the treatment period, there was an additional decline of roughly 27 units for the Saab brand control group. For the Saab 9-3 control group, the point estimate in column 2 suggests that during the treatment period, there were roughly 15 fewer units sold and for the 9-5 control group, roughly seven fewer units sold as seen in column 3. However, none of these point estimates are statistically significant. Further, we conduct the same analysis for the entire market in column 4 of Table VIII and find that although there was an indication of there being roughly 700 fewer units sold during Saab's treatment period, this estimate is also statistically insignificant. These results suggest that if there were negative spillovers due to Saab's financial distress, such effects were quite small.

6.3. Placebo Tests

We conduct two sets of placebo tests to assess whether there were significant differences between treatment and control groups, pre-treatment. The first placebo test considers a treatment period between January 2008 and October 2008, that is, a treatment period of exactly the same length, exactly prior to the beginning of the treatment period used in the paper. The second placebo test considers a treatment period between February and November 2007, thus ending one year prior to the start of the main treatment window used.

For each case, we consider the specification with the full set of controls, that is, the GCR indicator, the consumer confidence measure and the interaction of

Table VIII.
Results of Spillover Specifications

	(1)	(2)	(3)	(4)
Dependent Variable	Brand Control Group Sales	9-3 Control Group Sales	9-5 Control Group Sales	Total Market Sales
Sample Period	2005-01/2009-12	2005-01/2009-12	2005-01/2009-12	2005-01/2009-12
Postreatment Period	**−27.59**	**−14.69**	**−7.08**	**−696.98**
	[−70.60, 15.43]	[−42.30, 12.92]	[−39.54, 25.39]	[−2,024.61, 630.65]
Month FE:s				X
Month × Introductions FE:s	X	X	X	
Time Trend	X	X	X	X
Consumer Confidence	X	X	X	X
GCR FE	X	X	X	X
Observations	60	60	60	60
R-squared	0.88	0.85	0.75	0.87

Notes: Results of specification trying to measure any spillover of Saab's financial distress on total car sales in the Swedish market, that is, whether there was a negative spillover from Saab onto the Saab brand control group or total cars sales. The coefficient of interest is γ and measure whether, controlling for month fixed effects, consumer confidence measures, and a GCR fixed effect, total car sales in Sweden fell during the posttreatment period. The 95% robust confidence intervals are given in parenthesis. Introduction variable excluded in column (4) as it was constructed for each control group but not for the market as a whole.

Table IX. Results of Placebo Tests

	(1)	(2)	(3)
Dependent Variable	Saab Brand Sales	Saab 9-3 Sales	Saab 9-5 Sales
Sample Period	2006-01/2009-12	2006-01/2009-12	2006-01/2009-12
Placebo Test 1:			
Bounded Treatment Effect: $[\underline{\delta}, \bar{\delta}]$	**[−168.23, −152.94]**	**[−548.90, −499.00]**	**[−349.20, −317.46]**
	[−828.88, 375.19]	[−230.71, 863.01]	[−984.82, 7625.58]
Placebo Test 2:			
Bounded Treatment Effect: $[\underline{\delta}, \bar{\delta}]$	**[23.21, −]**	**[−13.49, −12.26]**	**[2.35, −]**
	[−110.22, 237.60]	[−69.31, 46.51]	[−158.64, 652.79]
GCR FE	X	X	X
Consumer Confidence	X	X	X
Month × Introductions FE:s	X	X	X
Observations	76	76	76

Notes: Results of placebo tests to check whether there were significant differences between treatment and control groups pre-treatment. The estimation window excludes the true treatment window. Placebo test 1 is for the period 2008-01/2008-10, thus exactly prior to the true treatment window, whereas Placebo test 2 is set to 2007-02/2007-11 or ending a year prior to the start of the true treatment window. DD specifications described in Section 4 and given by $y_{it} = \theta_i + \mu_t + T_t G_i \delta + x_{it}^{'} \beta + u_{it}$ compare the sales of the Saab brand (1) and its two products (2) and (3), to the sales of the relevant, annually rebalanced control group in order to measure the effect of financial distress on Saab sales. Each specification contains a vector of additional control variables including fixed effects for the Green Car Rebate, month interacted with the number of new car models introduced a given year within the control group as well as a consumer confidence index. The estimated lower and upper bounds for the true treatment effect δ are given by $[\underline{\delta}, \bar{\delta}]$ above in bold. The 95% block bootstrapped confidence intervals are reported within square brackets below the estimated treatment effect bounds. If the treatment effect is estimated to be positive (Placebo test 2, columns 1 and 3), we provide no upper bound, indicated by "-", because the bounds derived in Section 4 assume that the treatment effect is negative and the bounds are therefore no longer applicable.

product introduction and month fixed effects. Table IX reports results for the Saab brand in column 1, for the Saab 9-3 in column 2, and for the Saab 9-5 in column 3. The results consistently show the lack of significant differences between treatment and control groups, pretreatment. Although insignificant, the results of the first placebo test suggest that there may have been a decline in Saab sales in the months prior to treatment.

6.4. Additional Robustness Tests

We have conducted a number of additional robustness checks; we have explored whether the decline in Saab sales was the result of increased promotional activity on behalf of other brands trying to use Saab's situation to increase their own sales. To account for the potential that some brands may have increased their promotional activity in order to gain market share at the time Saab was experiencing financial distress, we assume that the two models within each control group that had the highest percentual increase in sales between 2008 and 2009 would have been the models that saw a large increase in promotional activity. We drop these two models and reestimate the models with the remaining eight models in each control group and we find that the treatment effects are smaller but still statistically significant.

Further, we look at the extent to which news coverage and technological laggardness can explain the drop in sales observed for Saab and its products. We have also constructed control groups using fewer or more elements, leaving the control groups fixed rather than rebalancing them on a yearly basis. We find that the results are quantitatively and qualitatively similar to the main specifications.

We have also looked at different time frames for the treatment window and run Granger causality tests to test exogeneity of treatment whereby lagged sales are able to predict the probability of being treated. We find that increasing the treatment window length increases our results but that lagged sales are not able to predict being treated in the future.

A full description and discussion of the robustness checks can be found in online Appendix D.

7. Conclusion

In this paper, we examine how consumers respond to the financial problems of Swedish carmaker Saab. Our empirical strategy consists of matching Saab products to a set of close competitors and performing a DD analysis. We match the Saab products to other vehicles based on product characteristics and aggregate up to construct the control group for the Saab brand.

On the methodological front, we show that substitution from Saab products to those of the control group will lead to an overestimation of the true treatment effect. Assuming that all consumers substituting away from Saab either purchase a vehicle in the control group or opt for the outside good, we show that the true treatment effect can be bounded. What is more, since the substitutability between products is at the root of the overestimation of the DD effect, we provide conditions under which the bounds depend on own- and cross-price elasticities of the products considered and not on the number of control group elements.

Our bounds provide a way to look at DD methods in settings where treatment affects both treatment and control groups, an issue recently discussed by Angrist and Pischke (2010) and Nevo and Whinston (2010) in the context of Industrial Organization and Antitrust, but which should also be applicable to other fields.

Our findings are robust to changes in the treatment window, control groups, and control variables. This lends further support to the conclusions of previous studies according to which consumers do worry about void warranties, difficulties in securing spare parts, and qualified service.

Although the qualitative results of this paper are similar to that of the studies by Hammond (2013a) and Hortaçsu et al (2013), we focus on the primary market. Given both institutional and empirical evidence that prices in the Swedish new vehicle market are well behaved, our analysis allows to infer how a firm will be affected by financial distress. In fact, we find a significant drop in Saab's monthly sales amounting to 50–56% of average pretreatment sales, which will likely be larger for firms not benefiting from home-bias, as seems to be the case of Saab.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Table B1: Demand estimates for alternative nested logit specifications for the pretreatment period. Nests are defined according to five market segments (subcompact, compact, intermediate, standard, and luxury).
Table D1: Evolution of Sales and Research and Development Costs of Saab Automobile AB during the Period of 2005–2009. Numbers in Million SEK.
Table D2: Granger Causality Tests to Check Exogeneity of Treatment.

Table D3: Results of Difference-in-Differences Specifications Described in Section 4 and Given by $y_{it} = \theta_i + \mu_t + T_t G_i \delta + x'_{it}\beta + \mu_{it}$ Comparing the Sales of the Saab 9-3 to the Sales of the Relevant, Annually Rebalanced Control Group in Order to Measure the Effect of Financial Distress on Saab Sales.
Table D4: Results of Difference-in-Differences Specifications Described in Section 4 and Given by $y_{it} = \theta_i + \mu_t + T_t G_i \delta + x'_{it}\beta + \mu_{it}$ Comparing the Sales of the Saab 9-5 to the Sales of the Relevant, Annually Rebalanced Control Group in Order to Measure the Effect of Financial Distress on Saab Sales.
Table D5: Results of Difference-in-Differences Specifications Described in Section 4 and Given by $y_{it} = \theta_i + \mu_t + T_t G_i \delta + x'_{it}\beta + \mu_{it}$ Comparing the Sales of the Saab Brand (1), and Its Two Products (2) and (3), to the Sales of the Relevant, Fixed 2006 Control Group in Order to Measure the Effect of Financial Distress on Saab Sales.

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