

MASTER'S THESIS

ACADEMIC YEAR 2021/22

**Detecting collusion:
An application of the synthetic control method**

MASTER IN ECONOMICS: EMPIRICAL APPLICATIONS AND POLICIES

Daniel Martínez Felip

Supervisors: María Paz Espinosa Alejos and Javier García Enríquez



Department of Economics
UNIVERSITY OF THE BASQUE COUNTRY, UPV/EHU



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Abstract

The Spanish antitrust authorities charged car makers with information sharing and collusion in the Spanish market in the period 2006 - 2013. Using data on car prices for models sold in a set of European countries, in the period 1993 - 2011, we measure how explicit collusion affected car prices in Spain in that period using the synthetic control method. By following a demand-driven approach, that is, based on the fact that the elasticity of demand is heterogeneous across segments, we focus the analysis on the most representative car segments within the Spanish and European market, selecting a representative car model for each of them. Our results indicate that sharing information caused higher prices in A and B segments, highlighting the great power of explicit collusion. In particular, we show how in oligopolies with a large number of initial members and in cartels that increase its size over time, such an agreement can be maintained, even in periods of economic crisis. Focusing on the segment with the largest market share, the C-segment, there is no evidence that sharing information had an effect of increasing final prices, suggesting that higher competition within the segment may succeed in nullifying the harmful effects of explicit collusion on social welfare.

Keywords: cars · synthetic control method · treatment effect · collusion

¹Departamento de Análisis Económico, University of the Basque Country UPV/EHU, Avda. Lehendakari Aguirre 83, 48015 Bilbao, Spain.

²Departamento de Métodos Cuantitativos, University of the Basque Country UPV/EHU, Avda. Lehendakari Aguirre 83, 48015 Bilbao, Spain.

Acknowledgements

I would like to thank the great help of María Paz Espinosa Alejos and Javier García Enríquez, whose knowledge has helped, inspired and motivated me in the elaboration of this thesis and future projects. I would also like to thank Aitor Ciarreta Antuñano for always being at my disposal in the elaboration of the database. Special thanks to all the EAP master teachers for all the knowledge I have acquired during this year.

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1 Introduction

One of the issues that has traditionally attracted most interest in the Industrial Organization is the study of tacit and explicit collusion among the members of an oligopoly. Collusive agreements are prohibited in most countries because of their harmful effect on society. However, this behavior is very much present in our society because of the incentive to increase their collective profits by coordinating their decisions. This behavior leads to a solution similar to as they were a monopoly, being a big problem faced by antitrust authorities in terms of detecting its existence. As a consequence, it produces irrecoverable losses in social welfare, as well as the loss of incentives to improve product, production process and product quality. Despite their prohibition, the expected profits often exceed the expected punishment, causing them to continue to exist today.

This has been the case in the Spanish automotive sector, where the Spanish antitrust authorities (in this case "Comisión Nacional de los Mercados y la Competencia" (henceforth, CNMC)) accused car makers of sharing information in the Spanish market through the creation of the so-called "Club de las Marcas" (Brands' Club). The CNMC imposed in 2015 substantial fines³ on car makers and distributors, and concluded that this agreement lasted from 2006⁴ to 2013, affecting three information exchange forums, such as: (1) car sales, (2) after-sales activities and (3) marketing policies. Specifically, the affected combined market share of the brands participating in this agreement would be around 91% of the distribution of motor vehicles in Spain. The members of the Brands' Club as well as the periods in which they participated in each of the information exchange forums are summarized⁵ in Table A1.

During this period, the cartel operated without interruption despite the fact that, as shown in Chang (1991) and Thomadsen and Rhee (2007), with substitute products and in markets with high product differentiation (such as the automotive market) collusive agreements are more difficult to sustain when coordination between players has a cost, either economic or high risk due to the expected punishment. This suggests the great power of the information sharing system found by the members of the brand group.

The cartel was dismantled thanks to the fact that SEAT, S.A., as well as Volkswagen Audi España, S.A. and Porsche Ibérica, S.A., all belonging to the same group, applied for the Leniency Program and the CNMC waived payment of the corresponding fine.

Presumably, the information shared over the collusion period helped car makers coordinate and rise prices as it facilitates the construction of anti-competitive agreements. In our study,

³Those fines were confirmed by the Spanish Supreme Court, which upheld the existence of a lack of competition in the Spanish car distribution market with end-consumers as the main victims.

⁴Note that the creation of the club was in 2004. However the collusion period set by the Spanish anti-trust authorities was since 2006 to 2013, since the first accredited meeting of the cartel dates back to 16 January 2006.

⁵Table A1 shows the degree of involvement in the collusive agreement, being high if the brand participated in all the information exchange forums, medium if it participated in two of them, and low if it participated only in one of them.

we test whether this is indeed the case and prices were higher in the period car makers were colluding than what they would have been in the absence of collusion.

One of the first models focusing on collusion detection was proposed by Bajari and Ye (2003). The aim of it is to predict how competitive bids are expected to be as a function of bidders' costs. More studies on detecting collusion are based on the marginal costs as a key variable, as it can help us to detect collusion by comparing its evolution with that of profit margins. In any case, this simplistic method is not very reliable. Paha (2011) provides an impression of the cartel's effect on prices, concluding that in periods of price war, firms' prices are close to marginal costs. However, it is not easy to detect the period when the cartel starts, if prices follow a downward trend driven by cost reductions. Another important limitation of this method is that marginal costs are typically unobservable.

Competitive and collusive behavior can be detected by looking at the changes in industry and firm price and quantity. In the analysis carried out by Bresnahan (1987) about the U.S. automobile industry in the mid 1950s, they estimate a loglinear price and quantity empirical hedonic model⁶, concluding that the collusive solution is sustained in 1954 and in 1956. Regression methods are widely used in competition lawsuits to detect overcharges in pricefixing cases. By using this method they are able to determine how much of the observed increase in price is due to the collusive agreement and how much is due to other factors e.g. increase in production costs. However, with the advent of new technologies new ways of detecting collusion are emerging, in particular Rodríguez et al. (2022) test the accuracy of eleven machine learning algorithms in detecting collusion in public procurement auctions, achieving high detection rates with low information.

Once collusion is detected, the next step is to measure the damage. At that stage, simple comparisons of market structure before and after the infringement are not adequate (see Paha, 2011). Following one of the study prepared by EU-commissioned study (see European Commission and Directorate-General for Competition, 2010), when quantifying antitrust damages, there are there main approaches:

- **Comparator-based approaches.** Use data from sources that are external to the infringement to estimate the counterfactual. Within this approach various methods are used, ranging from comparing averages to panel data regressions.
- **Financial-analysis-based approaches:** Based on accounting data. One important advantage of such methods is the greater likelihood of availability of financial data from company accounts, however the problem appears to distinguish the impact of external factors from the impact of the infraction on financial results.
- **Market-structure-based approaches:** Based on industrial organization theory. This

⁶Introduced by Cowling and Cubbin (1971) in their econometric investigation of the United Kingdom car market.

approach calibrate the counterfactual market by making some competitiveness assumptions to estimate the demand and supply, then it is compared with the actual one.

In our study, we use the comparative case study tool with the aim to detect whether the information sharing between car makers in the Spanish market ended up having an impact on the final consumer in the form of price increases. To carry it out, we contribute to this literature of the *comparator-based approaches* with a modern approach to detect explicit collusion and quantify its damage based on the synthetic control method (henceforth SCM). The SCM was initially suggested by Abadie and Gardeazabal (2003) by using the terrorist conflict in the Basque Country as a case study to estimate the economic costs of conflict in terms of GDP loss. Subsequently, was refined by Abadie, Diamond, and Hainmueller (2010) to study the effects of a tobacco control program that California implemented in 1988. The SCM rationalizes the selection of comparison units through a data-driven procedure with the aim to estimate treatment effects in comparative case studies. In this way, it reduces one of the main problems of comparative case studies related with the ambiguity in the choice of comparison control units. Thus it provides a better comparison for the treated unit than each unit by itself.

To determine whether collusion had an effect on Spanish car prices we compare the evolution of car prices in Spain with the counterfactual of Spanish car prices under no collusion. The counterfactual prices are obtained following the SCM approach, ending up with a synthetic unit which best reflects the prices on the Spanish car market before the time of the creation of the "Club de las Marcas" (Brands' Club). Then the observed post-treatment difference between actual prices and the estimated counterfactual prices yields the price change due to collusion (if any).

We adopt a demand-driven approach, where the elasticity of demand varies across segments. In particular, we focus on segments A, B and C, as they account for more than 50% of the market share during the post-treatment period (2006 - 2011). We show that, as a consequence of the information exchange through the creation of the Brand's Club, prices of models belonging to A and B segments (with Fiat Panda and Peugeot 207, respectively, as representative models) increased significantly in Spain relative to a comparable synthetic model. As for C-segment (with the Volkswagen Golf as a representative model), we found no evidence that such explicit collusion resulted in a significant price increase in Spain relative to a comparable synthetic model. This result can be explained as a consequence of the high level of intra-segment competition in (around 30% market share during the period analyzed) making the number of car manufacturers supplying this segment to be very high and, consequently, destabilizing the collusive arrangement. (see Matsumura and Matsushima, 2012 or Orzen, 2008 among others).

The paper is organized as follows. Section 2 describes the SCM. Section 3 is focused on the data, that is, we describe the variables included on it, the procedures carried out to make

it comparable and the selection criteria to detect collusion. Section 4 is devoted to present the results for the selected car models, dividing it in subsections for each of the segments analyzed and its robustness checks. Section 5 presents the main conclusions obtained from the study.

2 Methods

As mentioned before, we follow a novel approach to detect collusion based on the SCM. The SCM can be briefly described as follows. Suppose that we observe data for $J + 1$ units: $j = 1, 2, \dots, J + 1$ and $t = 1, 2, \dots, T_0, \dots, T$ periods. At some point during the observed period, one of the observed units experiences an interrupted treatment (in our case an event). Lets note that this unit experiences the event for all $t > T_0$, therefore the number of pre-treatment periods is given by $t = 1, 2, \dots, T_0$ and the number of post-treatment periods is given by $t = T_0 + 1, T_0 + 2, \dots, T$. We assume that the first unit ($j = 1$) is the treated unit affected by the event and the “donor pool”, that is the set of potential comparisons, $j = 2, \dots, J + 1$ is a set of untreated units not affected by the event.

In order to obtain the treatment effect (τ_{1t}) we must compare the potential outcome under treatment (Y_{1t}^1) with what it would have been if the unit had not been treated (counterfactual), that is the potential outcome under no treatment (Y_{1t}^0). Therefore the treatment effect for unit 1 is given by:

$$\tau_{1t} = \underbrace{Y_{1t}^1}_{\text{Observed}} - \underbrace{Y_{1t}^0}_{\text{Unobserved}} \quad (1)$$

for all $t = T_0 + 1, T_0 + 2, \dots, T$

Note that Eq.(1) allows the treatment effect to change over time. This is of great importance since the effect of being treated may not be immediately reflected in the final output. In particular, it plays a crucial role in the object of this study because of the learning process of the agents involved. As showed by Kimbrough, Lu, and Murphy (2005) in a repeated game with learning regime, agents are able to reach at a tacit form of collusion, setting output levels close to those of a monopolist.

As the counterfactual is not observed, the SCM tries to solve this problem by constructing a synthetic treated unit. This is obtained by means of a convex combination between the untreated units that imitates as closely as possible the evolution of the output of the treated unit during the pre-treatment period. In order to build the synthetic unity let \mathbf{X}_1 be a $(K \times 1)$ vector of pre-treatment values of K covariates for the treated unit and \mathbf{X}_0 be a $(K \times J)$ matrix that collects the values of the predictors for the J untreated units during the pre-treatment period. Therefore, optimal weights that are given for the control units, $\mathbf{w}^* = (w_2, \dots, w_{J+1})'$ are obtained by solving the following minimization problem:

$$\begin{aligned} & \min_{\{w_j\}_{j=2}^{J+1}} (\mathbf{X}_1 - \mathbf{X}_0)'V(\mathbf{X}_1 - \mathbf{X}_0) \\ \text{s. t. } & \begin{cases} \mathbf{X}_0 = \sum_{j=2}^{J+1} \mathbf{X}_j w_j, \\ w_j \geq 0, \text{ for } j = 2, 3, \dots, J + 1, \\ \sum_{j=2}^{J+1} w_j = 1 \end{cases} \end{aligned} \quad (2)$$

The last two restrictions guarantee that there is no extrapolation outside the support of the covariates.

Note that V is $(K \times K)$ diagonal choice matrix with non-negative elements in the main diagonal that reflects the relative importance of the covariates represented in vector \mathbf{X} as a predictor of the outcome variable, i.e. it controls the relative importance of obtaining a good match between each value in \mathbf{X}_1 and the corresponding value in \mathbf{X}_0 . It directly affects optimal weights, $w^*(V) = \{w^*(V)\}_{j=2}^{J+1}$. Therefore, as each potential choice of V produces a synthetic control, its selection plays an important role. There are several ways to determine V , in our case we determine it by solving a nested double minimization problem where matrix V and w^* are jointly obtained so that $w^*(V)$ solves the problem in Eq.(2) and V minimizes the pre-treatment mean squared prediction error⁷ (henceforth, MSPE) between Y_{1t}^0 and the synthetic unit during the pre-treatment period (presented in Abadie and Gardeazabal, 2003)

Denote that the estimated pre-treatment MSPE is defined as:

$$\widehat{Pre - MSPE} = \sum_{t=1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{J+1} Y_{jt} w_j^*(V) \right)^2 / T_0 \quad (3)$$

For this purpose, we use the R/**MSCMT** (**M**ultivariate **S**ynthetic **C**ontrol **M**ethod using **T**ime Series) package, version 1.3.3. Becker and Klößner (2018) proved that it improves other computational procedures implemented in R (such as R/**Synth**), Stata and Matlab in terms of computational time and accuracy. In particular, the root mean squared prediction error (henceforth, RMSPE) obtained with R/**MSCMT** is considerably smaller than the RMSPEs obtained with the other implementations.

Once optimal weights, $w^*(V)$, are obtained, we are able to obtain an estimation of the potential outcome under no treatment (\hat{Y}_{1t}^0).

$$\hat{Y}_{1t}^0 = \sum_{j=2}^{j+1} \mathbf{w}_j^* Y_{jt} \quad (4)$$

⁷It measures the expected squared distance between what the predictor predicts for a specific value and what the true value is. Therefore, lower values of it reflects a better fit to the actual series.

for all $t = T_0 + 1, T_0 + 2, \dots, T$

Therefore the SCM estimates the treatment effect as the difference between the observed potential outcome and the estimated counterfactual:

$$\hat{\tau}_{1t} = Y_{1t} - \hat{Y}_{1t}^0 \quad (5)$$

for all $t = T_0 + 1, T_0 + 2, \dots, T$

Hence, now we are able to get an estimation of the following sequence of treatment effects: $\{\tau_{1T_0+1}, \tau_{1T_0+2}, \dots, \tau_{1T}\}$, that is, the goal of the SCM.

Is important to note that if the "donor pool" has been correctly specified none of the controls experiences the treatment or is affected by the treatment experienced by unit 1.

3 Data description and variables

We use data on car prices available in the vast majority of European countries that comes from reports published by the European Commission. This reports feature-adjusted prices on a bi-annual basis in the period 1993-2007 and annual basis from 2008. It started to be collected because of the major problems consumers faced when comparing car price differentials between member countries and includes pre-tax and post-tax prices for about 75 car models available in most European countries.

The reports adjust the price of a car given the differentiation between the same car models in different countries (e.g the guarantee period, engine characteristics or equipment items), to allow an accurate comparison of the price of new cars in different countries.

The first of these surveys was published in May 1993 and covered 10 European countries, i.e. Belgium, Germany, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal and the UK. In 1995 the data set was extended due to the inclusion of Austrian and Swedish car prices. However, the most relevant enlargement, which allows for a significant increase of the donor pool, took place in 1999, with the inclusion of Greece, Finland and Denmark. In later years more countries are included but not contemplated in the study because of the data requirements of the SCM. Considering those countries included since 2000 onwards would significantly reduce the pre-collusive period with which to construct the synthetic unit.

3.1 Data selection and procedures

Given the nature of the data, in order to make prices comparable, some adjustments have been made to the data. Firstly, we focus on pre-tax prices in order to avoid differences in taxation policies across countries. Subsequently for those periods where prices are expressed

in local currency (1993 - 1997), the exchange rate (national currency/ECU) has been applied for each period within the year, as the ECU served as the unit of account of the European Monetary System. Finally, in order to make prices comparable across countries, adjustment for purchasing power parity (henceforth, PPP) has been made for the whole period, thanks to the official database provided by the The Organization for Economic Cooperation and Development (OECD).

The criteria to choose the brands and car models to be analyzed as a case study has been made on the basis of the representativeness of the model within the segment to which the car model belongs and also the Spanish and European car market as a whole. Therefore, we have taken into account the position it takes within the total car sales in Spain and Europe, also within each segment and finally if it has been the car of the year in Spain or Europe within the period of analysis. The degree of involvement in the collusive agreement (see Table A1) has also been taken into account, as a high level of involvement in the collusive agreement is expected to result in a higher and significant treatment effect. Based on these criteria, we select the Fiat Panda as a representative car model of the A-segment, Peugeot 207 as the representative model of the B-segment and the Volkswagen Golf as a representative car model of the C-segment. Their sales data, awards and brand's degree of involvement in the collusive agreement on which we have based the selection of these models and segments will be explained in more detail in the next section.

The criteria for choosing the period and units included in the donor pool in each of the Spanish models analyzed was based on the following 4 principles:

- (1) **Correct donor pool specification.** As mentioned in Section 2, the SCM assumes that countries included in the donor pool and thus used for synthetic control are not treated, i.e. they have not been affected by anti-competitive behavior rulings during the period under review. Therefore, we checked that during the analysis period, no charges of collusion in price coordination were brought against car manufacturers in the countries used for synthetic control. There was an EU antitrust case against German car manufacturers for colluding to restrict competition in emission cleaning equipment for diesel engines. Specifically, they were accused of limiting technical development in the period from 25 June 2009 to 1 October 2014. However, the collusive agreement did not include price coordination, i.e we can assume that they have not been affected by the treatment. Other antitrust cases related to truck brands (some common to car brands) have also been found during 1997-2011, which should not be considered as treated because of the lack of relation with the car market.

As pointed out by Abadie (2021) the number of pre-treatment periods is crucial in order to avoid over-fitting, increasing the probability that the synthetic unit in the post-treatment period fail to estimate the counterfactual. Hence, the period 1993 - 2011 was selected to apply the SCM, setting 2006 as the treatment period. The last

two years of the collusive agreement (2012 and 2013) are not analyzed because car price reports do not provide data for those years. Car models included in the donor pool are those set by each selected brand in the following non-Spanish car markets: Belgium, Germany, France, Finland, Netherlands, Ireland, Portugal, Italy, Luxembourg and the UK.

It is important to note that although not all the brands analyzed in the study became part of the cartel since 2006 on-wards (see Table A1), the period to create the synthetic control is up to that year for all of them. This is because in a context of price competition, if there is a price increase by rivals in the same segment, the best response of that firm to maximize profits is to do the same (despite not being part of the agreement).

- (2) **Data availability in the sample period.** The SCM needs data availability for all units, therefore, we took into account that each Spanish model we studied did not have any missing values in the selected period. In addition, it is important to mention that given the nature of the data, the research period was selected facing a trade-off between the availability of pre-treatment periods and the size of the donor pool. In particular, more pre-collusion periods implied fewer countries included in the donor pool and vice versa.
- (3) **Predictive power.** In this respect, a good predictor is one that helps to increase the quality of the generated synthetic unit. This is evaluated by looking at the Pre-MSPE (eq.(3)), a measure which shows an improvement when it decreases. From a demand-side point of view, the degree of brands competition is heterogeneous by segment, i.e. the elasticity of demand is different in each segment. Thus, economic shocks may affect each of them differently. In our case, we follow the approach used in many studies (such as Hinrichs (2012), Gardeazabal and Vega-Bayo (2017) and others) using all pre-treatment values of the outcome variable (PPP adjusted prices of the model analyzed in a country other than Spain) in order to increase the synthetic quality. By construction outcome's lagged values are its best predictors. In addition, we also use as predictors pre-treatment PPP adjusted prices of those models belonging to the same segment for each of the countries included in the donor pool. We assume that the best predictor of current prices are past prices.
- (4) **Economic meaning.** Note that as pointed out by Abadie (2021), by including in the donor pool units with similar characteristics as the treated unit reduces interpolation bias and, if it is the case of over-fitting in the pre-treatment period, reduce its serious consequences. Therefore, in our study, the donor pool for each selected brand is composed of car models within the same segment in countries with similar characteristics to Spain, as they all belong to the European Union.

4 Results and inference on the effect on prices due to information sharing

The aim of this section is to assess the impact that sharing information between car makers through the creation of the so-called "Brands' Club" during the period 2006 - 2013 had a significant positive effect on the prices faced by final consumers.

The analysis will be divided by following a principle of market representativeness , i.e. we focus on car models in the best-selling segments in Spain and Europe. During the study period which is precisely before the SUV-segment sales boom, the top of the best-selling car models in Europe was systematically made up of cars belonging to the three main segments. These are the A, B and C segments. In particular small (A+B) and medium (C) cars account over half of the market share during the vast majority of the periods when the cartel was operational⁸. Within the A-segment are all car models that are small, but larger than micro-cars, having a length between 3.30 and 3.70 meters. In segment B are those with a length between 4 and 4.20 meters. These, like those in segment A, are targeted at consumers who need vehicles that are easy to drive in urban traffic. Finally, car models belonging to C-segment have approximately 4.3 meters long and a compact body, being targeted to consumers who need more space and easy mobility in urban traffic.

4.1 A-segment analysis: Fiat Panda

Fiat is an historic Italian automobile brand, which began manufacturing vehicles in 1899, being the origin of the creation of what was the largest industrial group in Europe and the largest in Italy, Fiat S.p.A.

Focused in Spain, Fiat Group Automobiles Spain, S.A. is responsible for the distribution of vehicles of Fiat, Alfa Romeo and Lancia brands, and since July 2010 also Chrysler, Jeep and Dodge. As can be seen in Table A1, it participated in all 3 information exchange forums and is therefore classified as a company with a high degree of involvement in the collusive agreement. As a consequence, brands belonging to this group are likely to have increased prices as a result of the collusive agreement.

In our case, we select the car model called Fiat Panda, that is an A-segment model. Given the demand driven approach we are using in this study, this model has been chosen because of the magnitude of sales to the final consumer. Specifically, it was the third best-selling car in the A-segment in Spain in 2006 and the best-selling car in Europe in 2021. In addition, in 2004 it was awarded the European Car of the Year award.

Table 1 shows the PPP adjusted Fiat Panda prices in Spain, the synthetic Spain generated by solving the Eq.(2), and the average of the prices of all A-segment models (sold in non-

⁸Results obtained from the European Vehicle Market Statistics published by the International Council on Clean Transportation (2006-2011).

Spanish markets during the period 1993 - 2011) included in the donor pool. Given the limitations in terms of the number of car models that are produced in this segment that are included in the database and fulfill the SCM requirements, we have few units in the donor pool⁹. One of the direct consequences is that we did not manage to have a high goodness of fit (or low expected squared distance between the synthetic unit and the true unit) during the pre-treatment period, 1993 - 2005, obtaining a Pre-MSPE (see Eq.(3)) equal to 68489.18. Even so, the fit of the synthetic unit during the pre-treatment period is much better than that obtained by the averages of A-segment models sold in non-Spanish markets.

Table 1 also shows the car models included in the donor pool¹⁰ and the diagonal elements of matrix V that are jointly obtained with \mathbf{w}^* so that $\mathbf{w}^*(V)$ solves the minimization problem in Eq.(2) and V minimizes the MSPE. Note that both are expressed in percentage terms and normalized so that the sum equals 100%. It can be seen that the highest percentages are those corresponding to Fiat Panda sold in other countries where there was no exchange of information.

Table 1: Fiat Panda price prediction before the creation of the "Brands' Club"

Period	Prices in Spain			V(%)	Synthetic Fiat Panda	
	Fiat Panda	Synthetic Fiat Panda	Donor Pool Average		Country - Model	w*(%)
1993	6723.918	6826.830	9459.031	8.1	France - Fiat Panda	31.19
1994	6721.186	6942.624	9665.391	6.1	Portugal - Fiat Panda	21.6
1995	6774.160	6723.036	9671.895	9.2	Luxembourg - Fiat Panda	20
1996	7302.058	6795.903	9447.387	6.1	Germany - Fiat Panda	14.92
1997	7046.644	6929.414	9335.908	6.1	Ireland - Peugeot 107	10.56
1998	7110.845	6817.265	9151.964	6.1	Ireland - Fiat Panda	1.72
1999	6178.217	6551.085	9413.985	7.4	-	-
2000	6024.023	6279.921	9652.492	9.3	-	-
2001	6224.766	6506.178	9503.500	8.5	-	-
2002	6717.525	6987.651	9719.476	8.7	-	-
2003	7980.426	8183.063	10267.956	8.8	-	-
2004	9145.510	8915.050	10591.643	9.2	-	-
2005	9319.592	9174.170	10792.616	6.1	-	-
$\widehat{Pre - MSPE} = 68489.18$						

Figure 1 shows the price time path for both the Fiat Panda in Spain and synthetic Fiat Panda in Spain. It also includes the evolution, on average, of all the units in the donor pool.

Focusing on the evolution of the Fiat Panda prices in Spain (PPP adjusted) it can be seen how it is from 2004 when its prices start to increase¹¹, going from EUR 7980.426 in

⁹Specifically in the donor pool there are prices of 3 car models (Fiat Panda, Nissan Micra and Peugeot 107) of 9 countries (Germany, Belgium, France, Netherlands, Ireland, Italy, Luxembourg, Portugal and UK).

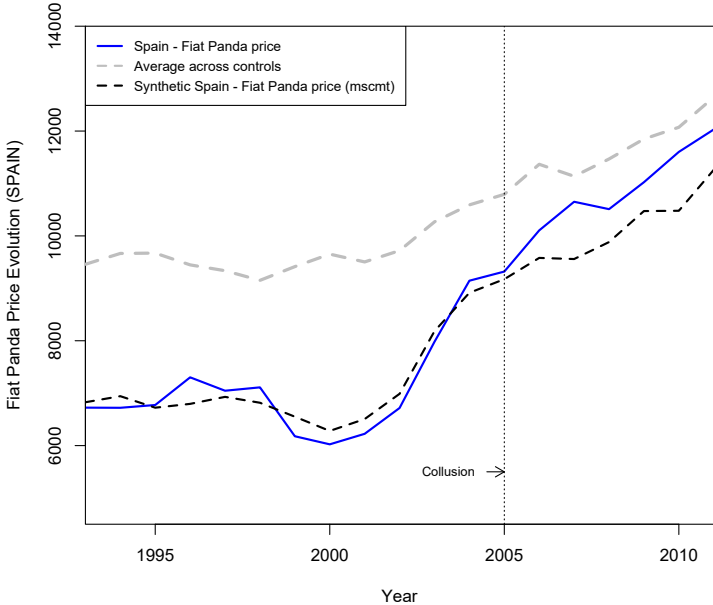
¹⁰Only those that have been used by the SCM to build the synthetic unit are shown.

¹¹Note that the official creation of the Brands' Club was in 2004

2003 to EUR 12030.04 in 2011. However, there are periods such as 1996, 1998 and 2008 where the growth rate is negative, although there is a clear positive trend through the period analyzed. With regard to the evolution of the average across controls, it can be observed that is systematically above the evolution of Fiat Panda prices in Spain. However, this gap diminishes significantly after 2005 onwards.

Finally, we can observe the evolution of the synthetic prices of the Fiat Panda in Spain. Note that the evolution up to and including 2005 is very similar, after that year, their patterns start to diverge. This is expected since the SCM is based on minimize the gap between both the observed and the synthetic one. Figure 1 also shows a clear comparison between the fit of the synthetic unit and the average across controls on the real price evolution (PPP adjusted) of the Fiat Panda in Spain (also showed in Table 1). The most important conclusion is how the weighted averages of the donor pool units (on which the SCM is based) is able to reproduce the pre-treatment period much better than a simple average across control units (whose estimated Pre-MSPE is equal to 7034390).

Figure 1: Trends in A-segment car prices: Spanish Fiat panda, synthetic Spanish Fiat Panda and Donor pool average



The the goal of the SCM is to estimate the following sequence of treatment effects: $\{\tau_{1T_0+1}, \tau_{1T_0+2}, \dots, \tau_{1T}\}$, therefore our estimate of the effect of sharing information on the Spanish Fiat Panda prices is given by the difference between the observed prices and its estimated counterfactual (see Eq.(5)), clearly visualized Figure 2. It suggests that sharing

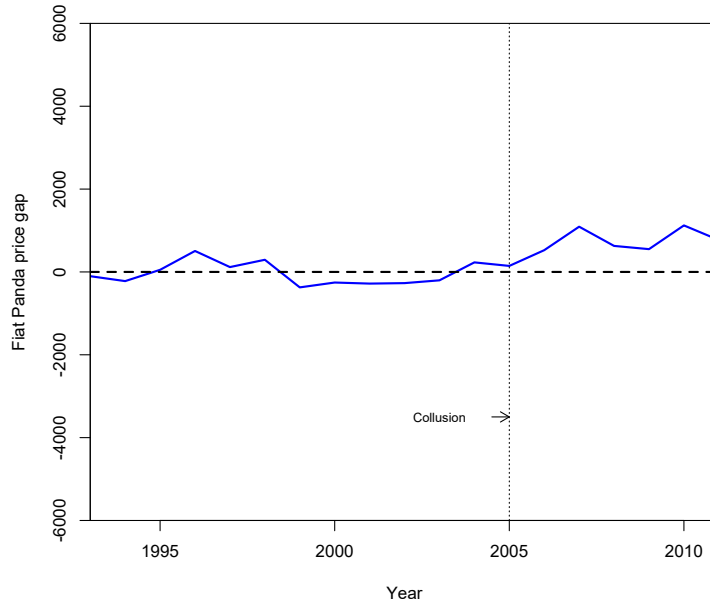
information thanks to the creation of the Brands' Club had a positive effect on the Spanish Fiat Panda prices, and this effect has been maintained through the duration of the collusive agreement.

In order to obtain an estimated average treatment effect or average gap (henceforth, AG) we averaged over all post-treatment periods as follows:

$$\widehat{AG}_j = \frac{\sum_{t=T_0+1}^T \left(Y_{jt} - \sum_{p=1, p \neq j}^{J+1} Y_{pt} w_{jp}^* \right)}{T - T_0} \quad (6)$$

Where, in our case, the treated unit (Spanish Fiat Panda) is denoted with $j = 1$, w_{jp}^* trivially denotes the optimal weight for control unit p and for synthetic unit j . The result is that the AG of the Spanish Fiat Panda is positive and equal to 781.4159.

Figure 2: Fiat Panda price gap between Spain and synthetic Spain



However, it is of great importance to study whether the results shown in this section are actually caused by the treatment considered in this study (sharing information). For this purpose, the next step is developed through the application of the so-called *In-space placebo test*.

4.1.1 A-Segment: Robustness Check

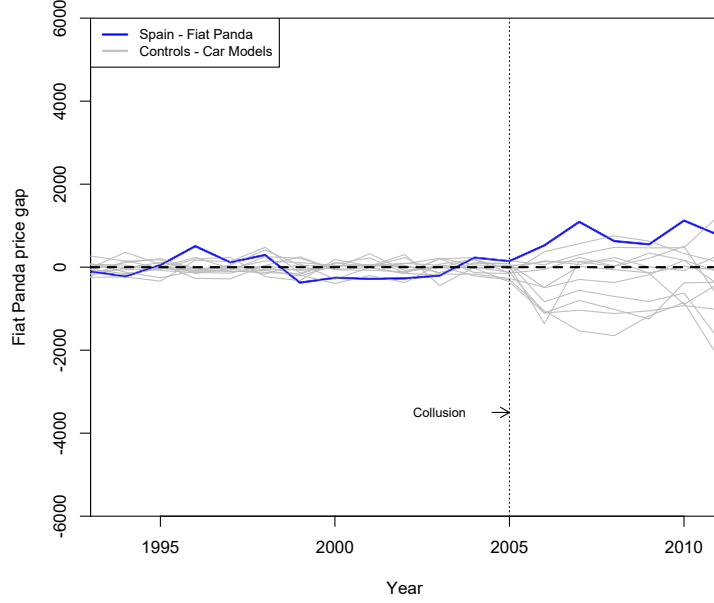
In-space placebo tests, as used in many studies such as Abadie, Diamond, and Hainmueller (2010) and Abadie, Diamond, and Hainmueller (2015) among others, and explained in detail in Abadie (2021), are based on moving the unit of interest together with the all units included in the donor pool in order to apply a systematization of the SCM to all control units, i.e. conducting a series of "placebo studies" that will allow us to infer whether the effect of sharing information via the creation of the "Brands' Club" had a positive and significant effect on final prices. This model of inference is based on the fact that the difference between the Spanish car model and the estimated synthetic control shows the impact of, in our case, sharing information and that this would not be significant in the case of equal or larger estimated effects on the control units, where by definition they are not affected by such collusive activity.

Following the same procedure carried out by Abadie, Diamond, and Hainmueller (2010) we discard those placebo runs whose estimated Pre-MSPE are notably higher than the unit of interest. In our case, we discard those placebos whose estimated Pre-MSPE during the pre-treatment period is not at least as good as that of the Spanish Fiat Panda. The results are shown in Figure 3. Each gray line denotes the estimated gap of each of those 13 A-segment car models sold in the remaining countries, while the blue line denotes the estimated Spanish Fiat Panda price gap.

As can be seen in Figure 3 the Spanish Fiat Panda price gap is positive and located at the top of the distribution for the vast majority of the periods, giving indications that the information exchange effect may have translated into a price increase of the Spanish Fiat Panda. In order to obtain an estimated average treatment effect for all post-treatment periods of both the Spanish Fiat Panda and the A-segment placebos that have remained after eliminating those with an excessive Pre-MSPE, we will use the above mentioned criterion¹², estimating the AG (see in Eq.6), thus obtaining the following vector $\widehat{AG} = (\widehat{AG}_1, \widehat{AG}_2, \widehat{AG}_3, \dots, \widehat{AG}_{14})'$.

¹²There are other methods to test its significance, such as the ratio of post- to pre-treatment mean squared prediction error, R_j , as the relationship between both can be interpreted as a natural assessment of the quantitative treatment effect.

Figure 3: Spanish Fiat Panda price gaps and placebo gaps of 3 A-segment control car models (discarding those with an estimated Pre-MSPE greater than the Spanish Fiat Panda).



In order to objectively test the significance of this effect, we are going to follow the same procedure used in Echevarría and García-Enríquez (2019) to obtain the p value (Eq.(7)), or the probability of finding an AG that is higher than or equal to the one estimated for the Spanish Fiat Panda.

$$p(\widehat{AG}_1) = \frac{\sum_{k=1}^{J+1} \mathbf{1}[\widehat{AG}_k \geq \widehat{AG}_1]}{J+1} \quad (7)$$

where $\mathbf{1}(\ast)$ denotes an indicator of function event \ast , it returns one for nonnegative arguments and zero otherwise.

The result is that the Spanish Fiat Panda's AG is the highest ($\widehat{AG}_1 = 781.4159$), as a consequence the probability of finding an AG higher than or equal than the one estimated for the Spanish Fiat Panda is $1/14 = 0.071$. Based on this results, we can reject the null hypothesis that sharing information by the creation of the Brand's Club had no effect on the final Spanish Fiat Panda prices at 10% of significance level. Therefore, based on this test, we can argue that SCM has correctly identified the effect of sharing information in the A-segment cars in Spain, assuming that the Fiat Panda is representative of all models belonging to this segment. This evidence yields important negative implications in terms of losses in social welfare as it means that sharing information through participation in the Brands' Club had

a positive and significant effect on the Spanish Fiat Panda price. In addition, due to the principle of representativeness of this model, one could extrapolate this effect to the whole of the A-segment.

4.2 B-Segment analysis: Peugeot 207

Peugeot, with more than 200 years of history, is a French car manufacturer, which participated in the three information exchange forums throughout 2006 - 2010 (see Table A1), being classified as having a high level of involvement in the collusive agreement.

During the period under review, it belonged to the Peugeot Société Anonyme (PSA) group, which was the second largest car manufacturer in Europe with a total market share of 15.4%. Among the wide range of models it produces and segments it supplies throughout its history it has won numerous awards such as 6 times European Car of the Year, 9 times Spanish Car of the Year, 5 times Italian Car of the Year, 2 times Irish Car of the Year and in 2021 the Women's World Car of the Year.

In our case, following the car model's representativeness within the B-segment (given the demand driven approach on which the study is based) we selected the Peugeot 207 model. In the European car market as a whole, this model systematically achieved a large number of sales during the analysis period. In particular, it was the second best-selling car in 2006 and the best-selling car in 2002 and 2007. Moreover, its market share has been maintained outside the analysis period, as it was the second best-selling car in the B-segment in 2021.

Table 2 shows the real PPP adjusted Peugeot 207 prices in Spain, the synthetic Peugeot 207 and the diagonal elements of matrix V . It also shows the average of the prices of all B-segment models (sold in non-Spanish markets during the period 1993-2011) included in the donor pool. In this case, we have a wide variety of models sold in non-Spanish markets belonging to segment B and therefore, we ended having a total of 12 models belonging to 9 countries included in the donor pool¹³.

However, is important to note that we do not have all 12 models for each country due to missing values, that is why we ended up having a total of 93 units included in the donor pool.

One of the consequences of having such a variety of units to construct the synthetic unit is that it has been able to achieve a high predictor quality during the pre-treatment period 1993-2005, obtaining an estimated Pre-MSPE of 24561.86 (see Eq.(3)). It can be observed numerically how the fit of the synthetic unit during the pre-treatment period is much better than that obtained by the averages of B-segment models sold in the selected non-Spanish markets. Specifically, its estimated Pre-MSPE equals 1950251.

Table 2 also shows the car models included in the donor pool which have been used by the SCM by means of weighted averages. Note that both are expressed in percentage terms

¹³Composed by the Fiat Punto Evo, Ford Fiesta, Lancia Ypsilon, Nissan Micra, Nissan Note, Opel Corsa, Peugeot 207, Renault Clio, Sat Ibiza, Toyota Yaris and Volkswagen Polo which were sold in Germany, Belgium, France, Netherlands, Ireland, Italy, Luxembourg, Portugal and UK.

and normalized so that the sum equals 100%.

Table 2: Peugeot 207 price prediction before the creation of the "Brands' club"

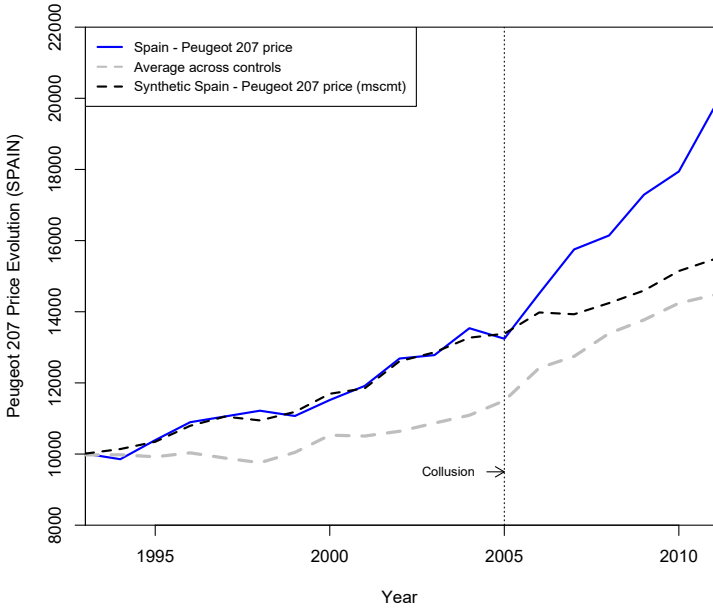
Period	Prices in Spain			V(%)	Synthetic Peugeot 207	
	Peugeot 207	Synthetic Peugeot 207	Donor Pool Average		Country - Model	w*(%)
1993	10009.866	10012.25	9975.013	9	Germany - Nissan Micra	28.5
1994	9854.545	10140.45	9979.885	9	France - VW Polo	21.69
1995	10391.291	10344.65	9921.994	8.5	Germany - Ford Fiesta	17.13
1996	10894.777	10793.75	10033.774	7.8	Portugal - Renault Clio	6.58
1997	11056.487	11052.14	9886.238	9	Ireland - Nissan Note	11.97
1998	11218.2	10945.14	9756.318	5.5	Germany - Fiat Punto Evo	8.95
1999	11069.926	11183.75	10045.815	6.5	UK - Nissan Note	4.18
2000	11518.225	11694.02	10529.275	9	Portugal - Fiat Punto Evo	0.95
2001	11914.586	11846.57	10505.607	9	-	-
2002	12685.367	12609.82	10640.497	6.2	-	-
2003	12781.457	12858.59	10869.765	5.5	-	-
2004	13537.104	13270.99	11090.533	6.5	-	-
2005	13241.578	13381.74	11499.628	8.4	-	-
$\widehat{Pre - MSPE} = 24561.86$						

Figure 4 shows the price (PPA adjusted) time path for both the Peugeot 207 in Spain and synthetic Peugeot 207 in Spain. It also includes the evolution, on average, of all the units included in the donor pool. Focusing on the evolution of the Peugeot 207 prices, it seems to evolve at a constant growth rate throughout the pre-collusive period of 13 years, causing its price to increase in EUR 3231,712. However, it is from 2005 onwards that this trend changes to grow at a higher rate. Specifically, in the post-collusive period prices of the Peugeot 207 increased by EUR 6474,748, approximately twice as much as in the pre-collusive period in just under half the time.

With regard to the evolution of the average across controls, it can be observed that is systematically below the evolution of Fiat Panda prices in Spain. However, the gap increases considerably from 2005 onwards. The respective growth rates seem to be quite similar in the years before the collusion. However, the capacity to improve the pre-treatment performance is still very large, as corroborated by observing the Spanish synthetic Peugeot 207.

Finally, looking at the evolution of the synthetic prices of the Peugeot 207 in Spain, note that the evolution between the Spanish Peugeot 207 and the synthetic up to 2005 is quite accurate, and after that year, their patterns start to diverge, i.e. the gap after sharing information is higher than the gap before sharing information. This make a lot of sense since the SCM is based on minimize the gap between both the observed and the synthetic one.

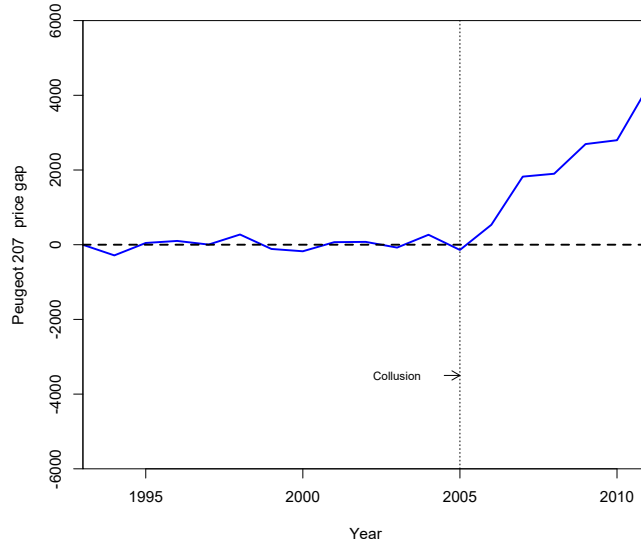
Figure 4: Trends in B-segment car prices: Spanish Peugeot 207, synthetic Spanish Peugeot 207 and Donor pool average



The large difference in the post-treatment price evolution of the Spanish Peugeot 207 and its synthetic observed in Figure 4, can be clearly visualized in Figure 5, observing the effect of information exchange by looking at the difference between the prices under collusive agreement and its counterfactual. Figure 5 suggests that the effect of sharing information in the B-segment throughout the creation of the Brands' Club had a large effect on the Spanish Peugeot 207. In addition this effect has been increasing over time, which may be due to a learning process among the agents involved in the explicit collusive agreement.

The estimated AG of the Spanish Peugeot 207 is positive and equal to 2331.89 suggesting a negative impact on social welfare.

Figure 5: Peugeot 207 price gap: Spain vs synthetic Spain



However, as in the previous section, we must test whether this AG is due to the sharing information via the participation in the Brands' Club or whether it is a mere statistical coincidence. The following subsection is developed through the application of the *In-space placebo test*.

4.2.1 B-Segment: Robustness Check

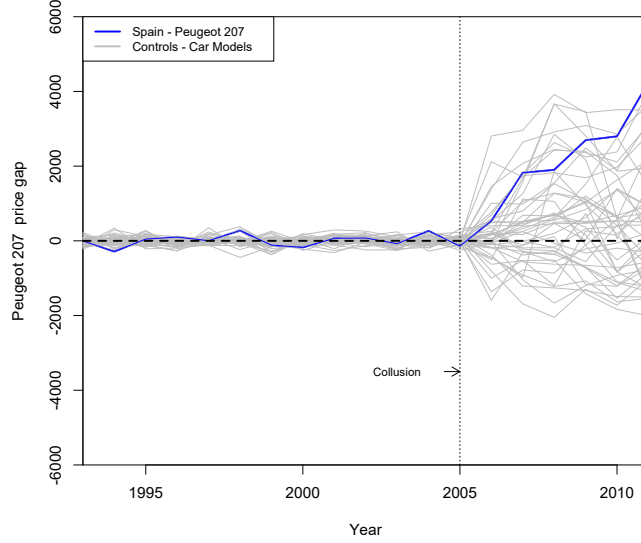
Following the same procedure as in Subsection 4.1.1 the Spanish Peugeot 207 was moved to the donor pool, and subsequently we applied the SCM to each of the other brands that produce B-segment cars models sold in the selected non-Spanish car markets.

Once we discard those placebo whose estimated Pre-MSPE is higher than the one of the Spanish Peugeot 207 we end up with 45 units, the Spanish Peugeot 207 and 44 B-segment car models sold in the remaining non-Spanish car markets. The results are shown in Figure 6. Each gray line denotes the estimated gap of each of the 44 B-segment car models, while the blue line denotes the estimated Spanish Peugeot 207 price gap.

As can be seen in Figure 6 the Spanish Peugeot 207 price gap is positive, however it is only at the top of the gap distribution of all the placebos in 2011, as time allows cooperation to be an equilibrium. Moreover, the gap tends to increase as the time of operation of the Brand's Club increases. This may be due to, as shown in Mouraviev (2013), that agents involved in explicit agreements tend to communicate more often as the cartel increase its size (see Table A1) or the uncertainty of demand increases¹⁴.

¹⁴Note that the Spanish car cartel was in operation during the 2008 crisis in Spain.

Figure 6: Spanish Peugeot 207 price gaps and placebo gaps of 12 B-segment control car models (discarding those with an estimated Pre-MSPE greater than the Spanish Peugeot 207)



As in the previous section, to obtain an estimated average treatment effect for all post-treatment periods of both the Spanish Peugeot 207 and all the B-segment placebos that have remained after eliminating those with an excessive Pre-MSPE, we will use the AG criterion, thus obtaining the following vector: $\widehat{AG} = (\widehat{AG}_1, \widehat{AG}_2, \widehat{AG}_3, \dots, \widehat{AG}_{45})'$.

Following Echevarría and García-Enríquez (2019) and using Eq.(7) we are able to test the significance of the effect on the Spanish Peugeot 207. As mentioned above the \widehat{AG}_1 is equal to 24561.86, which is only surpassed by France - Toyota Yaris ($\widehat{AG} = 3355.08347$) and Germany - Peugeot 207 ($\widehat{AG} = 2755.22394$). The resulting p value, or the probability of finding an estimated AG that is higher than or equal to the one estimated for the Spanish Peugeot 207, is equal to $3/45 = 0.066667$. As a consequence, we can reject the null hypothesis that sharing information by the creation of the Brand's Club had no effect on the final Spanish Peugeot 207 prices at 10% of significance level.

Therefore, the SCM has correctly identified the effect of sharing information in the B-segment cars in Spain, assuming that the Peugeot 207 is representative of all models belonging to this segment. This evidence yields negative conclusions that affected the final consumer in Spain, since, as a result of the sharing information, there was a positive and significant increase in the Peugeot 207 prices. Moreover, due to the principle of representativeness of this model, one can argue that this effect can be extrapolated to the whole of the B-segment. As a consequence, we find evidence of how explicit agreements are able to be maintained in oligopolies with a large number of agents.

4.3 C-segment Analysis: Volkswagen Golf

The Volkswagen Group, with its origins in Germany, is one of the world’s largest automotive companies and the world’s largest car maker in terms of production. Within this group there are some brands such as, Volkswagen, that is the original brand of the group, Seat¹⁵, Audi and others.

In the study, we are going to focus on Volkswagen (henceforth, VW) since is the best-selling brand within the group and hence the most representative. It produces three of the 10 best-selling cars in automotive history, such as the VW Golf, VW Beetle and VW Passat. Of these three, the VW Golf belongs to the C-segment, the segment to which the best-selling cars in Spain and Europe systematically belong. This car model achieved top sales in the European car market in 2008, an achievement that has retained every year until 2021. This means that it is not only representative of the C-segment during our post-treatment period, but continues to be so. It also received the European Car of the Year award in 2013. As well as the vast majority of the brands belonging to the group, VW participated in the three information exchange forums (see Table A1), being classified with a high level of degree of involvement in the collusive agreement.

Table 3 shows during the pre-treatment period the PPP adjusted VW Golf Prices in Spain, its synthetic and the average of all C-segment models sold in non-Spanish car markets and included in the donor pool. It also shows, as in previous tables, the diagonal elements of matrix V and w^* (jointly obtained) expressed in percentage terms.

Regarding the car models included in the donor pool, we count with a wide variety of C-segment models¹⁶ for the same country markets used in the A-segment and B-segment analyses. After eliminating those specific models sold in markets where we didn’t count with the entire series of prices during the period analyzed, we end up with 114 units which can be used as donors in the construction of the synthetic unit.

Table 3 also shows that the prices obtained with the donor pool average are quite similar to those of the VW Golf in Spain. However, the large number of units together with their economic meaning and predictive power have allowed us to predict the pre-treatment period quite accurately by using the SCM (the estimated Pre-MSPE equals 79845.48).

¹⁵Brand which acted as a whistle-blower in the anti-competitive agreement.

¹⁶Such as Alfa Romeo Giulietta, Ford Focus, Citroën C3, Citroën C4, Mazda 3, Honda Civic, Nissan Qashqai, Opel Astra, Peugeot 308, Renault Megane, Volvo S40, Toyota Auris and VW Golf.

Table 3: VW Golf price prediction before the creation of the "Brands' club"

Period	Prices in Spain			V(%)	VW Golf	
	VW Golf	Synthetic VW Golf	Donor Pool Average		Country - Model	w*(%)
1993	12721.12	12363.67	12535.18	6	Italy - VW Golf	40.98
1994	12221.04	12656.54	12812.00	5.9	Ireland - Alfa Romeo Giulietta	18.53
1995	12315.66	12307.43	13009.09	8.6	Portugal - Opel Astra	11.88
1996	12698.21	12856.17	12916.38	7.1	Italy - Renault Megane	6.09
1997	13462.46	13651.21	13264.63	8.6	Belgium - Nissan Qashqai	6.04
1998	14395.77	14031.02	13295.33	6.9	UK - Honda Civic	3.83
1999	14517.53	14407.10	13602.46	6	France - Toyota Auris	3.68
2000	15070.19	14968.69	14102.29	8	France - Nissan Qashqai	2.24
2001	15332.89	15280.38	14526.13	8.6	-	-
2002	15958.25	15502.13	14972.63	8.6	-	-
2003	15586.15	15609.16	15448.96	8.6	-	-
2004	15474.71	15891.13	16465.04	7.9	-	-
2005	15583.98	15929.87	16845.84	8.6	-	-
$Pre - MSPE = 79845.48$						

Figure 7 shows graphically evolution of the VW Golf real prices in Spain, the synthetic Spanish VW Golf and the average of the donor pool in the period analyzed. Focusing on the evolution of the Spanish VW Golf prices we can observe how there has been a clear positive trend, from EUR 12721.12 to EUR 15583.98 during the period analyzed. The resulting prices of the donor pool average are quite similar to the one of the Spanish VW Golf, which can be a consequence of a low level of vertical differentiation within the segment. Although there may be a certain level of subjective vertical differentiation due to advertising (see Tremblay and Polasky, 2002) that makes the VW Golf systematically the best-selling car model in the C-segment. Also, given that the average donor pool price trend of those C-segment car models sold in the selected non-Spanish car markets are very similar to the one in Spain, it means that the characteristics of those units are similar to the traded one, reducing the risk of interpolation bias when applying the SCM (see Abadie, 2021). As shown in Table 3, the prediction obtained by applying the SCM improves considerably (the estimated Pre-MSPE of the donor pool average is equal to 626969.3), leading us to focus on the analysis of both the observed Spanish VW golf price and its synthetic.

Figure 7: Trends in C-segment car prices: Spanish VW Golf, synthetic Spanish VW Golf and Donor pool average

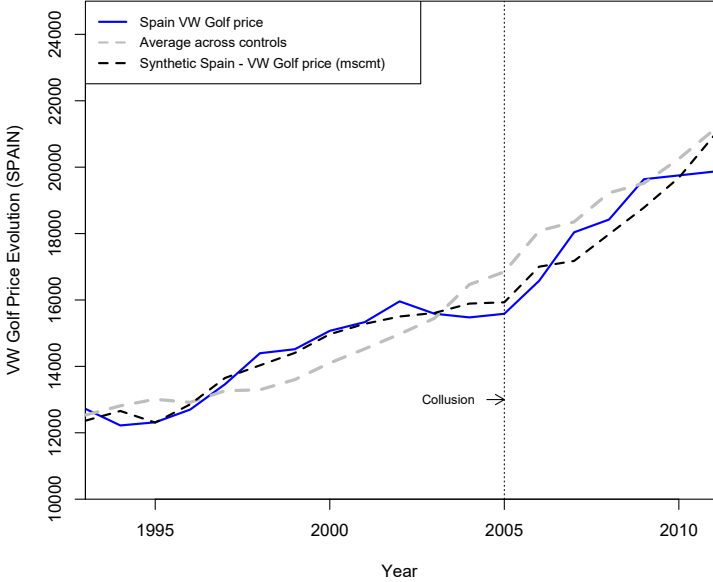
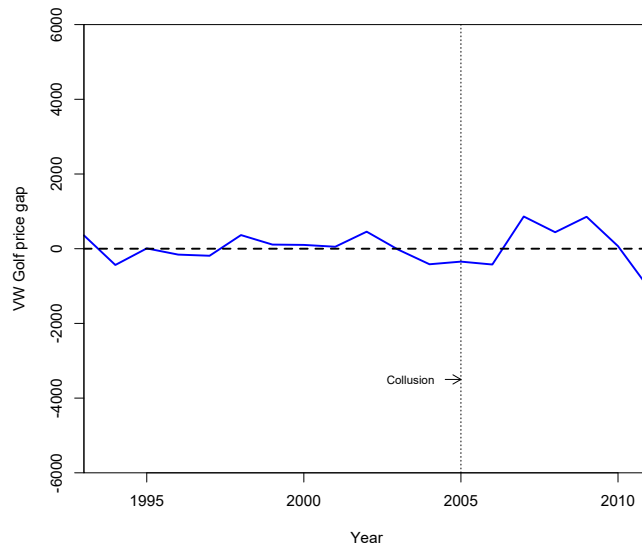


Figure 8 provides a clear comparison of both, the evolution of the synthetic Spanish VW Golf prices and the observed ones. We can see how the evolution of both is very similar even in the post-treatment period, showing small positive (during the period 2007 - 2009) and negative gaps (2006 and 2011). Therefore, the effect of sharing information seems not constant over the period analyzed.

The estimated AG is obtained by averaging across post-treatment gaps (see Eq.(6)) and in this case there are negative periods, as a consequence the estimated AG is equal to 121.4311. Based on this result one can argue that the explicit collusion through the creation of the Brands' Club does not seem to have had such a negative effect on social welfare as the analysis of the other segments.

Figure 8: VW Golf price gap: Spain vs synthetic Spain



The next step is to test its significance, and for this purpose the next section will focus on the application of the *in-space placebo test* for the C-segment.

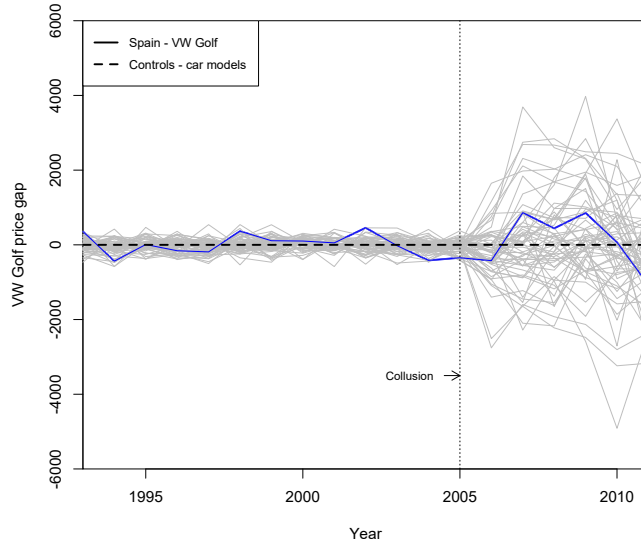
4.3.1 C-Segment: Robustness Check

Following the same procedure as in Subsections 4.1.1 and 4.2.1 the Spanish VW Golf was moved to the donor pool. This is made with the aim to obtain an estimated effect of the placebo creation of the Brands' Club in those countries, that is to apply the SCM to every potential control in our C-segment database.

We focus on those placebos whose pre-treatment predictions are as good as that of the VW Golf in Spain. We select them by discarding those with an estimated Pre-MSPE that are higher than the one of the Spanish VW Golf, ending up with 60 units.

The results are shown in Figure 9. Each gray line denotes the estimated placebo effect of sharing information in the untreated countries of each of the 59 B-segment car models, while the blue line denotes the estimated Spanish VW Golf price gap.

Figure 9: Spanish VW Golf price gaps and placebo gaps of 12 C-segment control car models (discarding those with an estimated Pre-MSPE greater than the Spanish VW Golf)



12 control countries after dropping countries with Pre-MSPE 2 times higher or more than Egypt

Once all placebos had been computed for those with Pre-MSPE lower or equal to the VW Golf in Spain, we compute each of their estimated AG, obtaining the following vector of those remaining C-segment car models: $\widehat{AG} = (\widehat{AG}_1, \widehat{AG}_2, \widehat{AG}_3, \dots, \widehat{AG}_{60})'$. As in previous sections, we are able to test the AG significance of the Spanish VW Golf by using the Eq.(7). The estimated AG of the VW Golf in Spain is equal to 121.431. However, 20 of the placebo studies create effects of a magnitude greater than or equal to the one estimated for the VW Golf in Spain, obtaining p-value equal to $21/60 = 0.35$. Regarding the C-segment, we cannot reject the null hypothesis that the effect of sharing information through the creation of the Brands' Club had no effect on the final prices at a 10% of significance level, using the VW Golf as a representative model.

One explanation for the fact that the effect of sharing information through the creation of the Brands' Club does not have had a significant detrimental effect on social welfare may be due to the high level of competition in this segment. Based on the results provided by European vehicle market statistics made by International Council on Clean Transportation (2006-2011), for the post-treatment periods, the C-segment has just under 30% market share. As a consequence of this high level of competition within the segment, firms have greater incentives to deviate from the agreement in order to increase market share. There is a large experimental evidence to support this result, such as the one obtained by Matsumura and Matsushima (2012) in their study on competitiveness and stability in the collusive behav-

ior (concluding that higher level of competition can destabilize collusive agreements) or the evidence found by Orzen (2008), where under a price competitive market he finds that the results are less collusive in markets with more competition.

5 Discussion

Explicit collusion is prohibited in most countries because of their harmful effect on society. However, this behavior is very much present in our society because of the incentive to increase their collective profits by coordinating their decisions, leading to a monopolistic solution and producing irrecoverable losses in social welfare, as well as the loss of incentives to improve product, production process and product quality. This has been the case in the Spanish automotive sector, where the antitrust authorities of this country charged car makers with information sharing and collusion in the Spanish car market in the period 2006 - 2013 through the creation of the so-called "Club de las Marcas" (Brands' Club). Specifically, the affected combined market share of the brands participating in this agreement would be around 91% of the distribution of motor vehicles in Spain.

We use data on car prices for models sold in a set of European countries in the period 1993 - 2011 to apply the comparative case study tool. The main objective is to test whether sharing information led to higher car prices than would have been the case in the absence of collusion using a modern methodology based on the SCM.

By following a demand-driven approach, that is, based on the fact that the demand elasticity across segments is heterogeneous (economic shocks affects each segment differently) we focus the analysis on the most representative segments of the Spanish and European car market in the collusive period (Segment A, B and C account for more than 50% of market share). Following the principle of representativeness, we selected one model from each segment. For A-segment, the Fiat Panda is analyzed, finding that the effect of information sharing on the final prices of the model sold in Spain was positive and significant. For B-segment the Peugeot 207 is selected, again finding evidence that the effect on final prices in Spain of such an explicit agreement was significant and positive. Moreover, the longer the cartel was in operation, the more the negative effect on social welfare increased. Finally, the analysis of C-segment, with the VW Golf as a representative model, shows how in segments with a large market share (slightly more than 30% in the period analyzed) high intra-segment competition leads to higher incentives to betray as the expected benefits of maintaining the agreement through the Brands' Club are not enough. Betraying considerably increases brands market share within the segment. As a consequence, no evidence of a positive effect in Spain on final prices in the C-segment is found.

In this study we show how the SCM approach is able to be applied to industrial organization and in particular to detect the effects of explicit collusion, thanks to the comparison

with the counterfactual. Regarding the effect of sharing information in the Spanish automotive car market, we show how explicit collusion is able to significantly increase prices in oligopolies with a large number of members and even in a cartel that increase its size over time and face a situation of economic crisis. In addition, it is important to note that higher demand, and therefore more aggressive competition, may not facilitate coordination among agents because of the strong incentives to betray and gain market share. Therefore, as a policy recommendation, we extend the evidence on the benefits of creating situations that favors market competition.

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7 Appendix

The periods in which each group and car brand belonged to each of the 3 information exchange forums are presented below. These dates can be found in the official resolution "Expte. S/0482/13 Car makers". where the CNMC sanctioned in 2015 a group of car makers and distributors in Spain for anti-competitive practices.

Table A1: Periods of brands participation on the information exchange forums

Brands	Information exchange forums			Degree of Involvement
	Brands' Club	After Sales Forum	Builders' Days	
Volkswagen Audi Spain (Audi)	Sep 2010 May 2013	March 2010 June 2013	April 2010	High
BMW Iberica	June 2008 Nov 2009	March 2010 August 2013	April 2010 March 2011	High
Automoviles Citroën España	Feb 2006 July 2013			Low
Chevrolet Spain	Feb 2006 July 2013	March 2010 August 2013		Medium
Chrysler Spain	April 2008 July 2010			Low
Fiat Group Automobiles Spain	Feb 2006 July 2013	March 2010 August 2013	April 2010 March 2011	High
Ford Spain	Feb 2006 July 2013	April 2010 Feb 2011	April 2010 March 2011	High
Honda Motor Europe Limited	April 2009 April 2012	March 2010 August 2013		Medium
Hyundai Motor Spain	July 2011 July 2013		March 2011	Medium
Kia Motors Iberia	March 2007 Nov 2012	June 2010 Feb 2012		Medium
Toyota Spain (Lexus)	Feb 2006 Sep 2012	March 2010 Aug 2013	April 2010 March 2011	High
Mazda Automobiles Spain	March 2010 Feb 2012		March 2011	Medium
B&M Automobiles Spain		March 2010 Aug 2013		Low
Mercedes Benz Spain		March 2010 Feb 2011		Low
Nissan Iberia	June 2008 July 2013	March 2010 Aug 2013	March 2010	High
General Motors Spain (Opel)	Feb 2006 July 2013	March 2010 Jen 2012	April 2010 March 2011	High
Peugeot Spain	Feb 2006 July 2010	March 2010 Dec 2010	April 2010	High
Porsche Iberia		June 2010 Aug 2013		Low
Renault Spain Commercial	Feb 2006 July 2013		April 2010 March 2011	Medium
General Motors Spain (Saab)	Feb 2006 July 2013	March 2010 Jen 2012	April 2010 March 2011	High
Volkswagen Audi Spain (Škoda)	April 2009 Nov 2012	March 2010 June 2013	April 2010	High
Seat	Feb 2006 Jen 2013	Sep 2010	April 2010 March 2011	High
Toyota Spain (Toyota)	Feb 2006 Sep 2012	March 2010 Aug 2013	April 2010 March 2011	High
Volkswagen Audi Spain (VW)	Oct 2008 May 2013	March 2010 June 2013	April 2010	High
Volvo Car Spain		March 2010 Aug 2013	April 2010	Medium