Does Rigidity of Prices Hide Collusion?[1]

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Abstract

Cartel detection is a major, but one of the more complicated tasks of the competition agencies. In recent years variance filters have been developed as a simple tool to primarily reject the existence of collusion and also they take the advantage that require a low volume of data. However, they have not been applied intensively by those Agencies, for two primary reasons: there is no unanimity on the behavior of prices under collusion and the interpretation of the results of the variance filter is often inconclusive. This paper shows evidence of these two constraints by applying a variance filter to a fuel retail market with special features. The results confirm the positive relationship between monopolies and price rigidity, as well as the detection of non-competitive behavior in the market when compared to appropriate benchmarks. These empirical results can help with the dissemination and implementation of this methodology by the Competition Authorities, but taking into account that latter it is necessary to use a deeper and complementary analysis.

Keywords: Competition Policy, Gasoline, Variance filter, Gibbs sampling.
J.E.L.: L13, L59, L71

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1. Introduction

Competition authorities pursue price-fixing conspiracies in three stages: detection, prosecution, and penalization (Abrantes-Metz and Bajari, 2009). However, detecting collusion is not an easy task. In fact, detection of cartels based on empirical data has always been a difficult task for antitrust agencies due to the fact that a great amount of data is needed to check if actual prices in a market area are above the competitive level and, if so, why (Esposito and Ferrero, 2006).

Therefore, to define statistical and econometric tools to detect possible collusive behavior that require a low level of data and easy, fast, and intuitive implementation is one of the objectives of any competition authority. Furthermore, these tools must be understandable to be judged as an indactor of the existence of collusion.[4]

While leniency programs enhance the effectiveness of competition policy in countries that apply, as Borrell and Jiménez (2008) show, and they increase the number of cases handled by the authorities, not everything that can be done is being done. A simple way to analyze the sectors is "screening". As defined by Abrantes-Metz and Bajari (2009), a screen is a statistical test designed to identify markets where competition problems exist and determine, if a problem does exist, which firms in that market are involved in a conspiracy. But the first and most important task is that this mechanism may be used as a preliminary analysis to the study of behavior in markets, to locate anomalous behavior. Then a more thorough analysis has to be applied. In addition, the research process will increase the incentives to break the cartel (complementary to leniency programs).

As these authors suggest, the implementation of this methodology can be done through two strategies: the first is to search for events that are improbable unless firms in the industry have coordinated their actions; and the second one uses the idea of a control group: prices that are anomalous compared to other markets suggest a competition problem.[5]

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[4] Werden (2004) summarizes the economics behind collusion, its relationship with legal aspects, and its use in real cases, mainly in the United States. In fact, legal scholars and economists attach two different meanings to the word "collusion" (Buccirossi, 2006). As this author expose, the former employ it to denote a specific antitrust infringement, whereas the latter use it to mean a market outcome in which prices are above the competitive level, independent of how this outcome is reached.

[5] Price parallelism has been considered as a collusive marker (Harrington, 2006a); even the Department of Justice of the United States has suggested as such (Department of Justice, 2004).

These two approaches have to satisfy three criteria identified by Harrington (2006a): they must be discernible by just looking at prices; the test to be conducted should be routinizable; and the screen should be costly for the cartel to outmaneuver. The use of such methodologies can be extremely useful for competition agencies and is likely to be extended in the near future due to its simplicity and the low level of data required to enable competition agencies to select potential cases on which to perform further analysis.

Despite these advantages, the approaches' application may still be limited by the competition authorities, mainly for two reasons. Regarding the first reason, there is some theoretical and empirical consensus on the behavior of prices in a cartel (as we will see in Section 2), but this consensus is not unanimous. The vast majority of theoretical models and empirical evidence in the literature show that prices under collusion presented higher average prices and a lower standard deviation, that is, more rigid prices. However, Bolotova et al (2008) show how the citric acid cartel actually presents a higher price, but also a higher standard deviation.[6] Brannon (2003) had already shown that the relationship between collusion and variance could not be conclusive. Therefore, this may create doubts in competition authorities when interpreting the results of analyzes using this idea.

The second major problem is the lack of conclusive results when we are not sure that a cartel exists. While the results – higher average prices and lower standard deviation – are observed relatively clearly in known cartels (leniency programs, etc.), on the few occasions on which it has been used to detect cartels, the result has not been satisfactory. The main problem is the result of a parallel behavior, similar prices and deviations, which does not allow us to distinguish between perfect competition and collusive behavior.

This article aims to shed light on these two aspects in the implementation of the methodology of filter variance, using the empirical evidence for the market for fuel in the Canary Islands (Spain). The coexistence of markets (islands) in monopoly and oligopoly in the Canary Islands' petrol retail market will allow us two facts: first, to test whether the prices are more or less rigid in an environment without competition; and, second, to note the importance of finding a benchmark for comparison to help us interpret the results. For this last point, a set of alternatives are presented and discussed (Section 5).

The discussion of these two concepts is intended to clarify and strengthen the use of such methodologies for the detection of cartels, and precede an analysis in greater depth. The

[6] Nevertheless authors suggest that foreign competition can explain this outcome. This result introduce uncertainty in the cartel behavior and consequently in the use of these methodologies for detection stage.

main results show that the relationship between collusion and price rigidity is confirmed, and also demonstrate the importance of having a benchmark of comparison in order to effectively interpret the results.

The rest of the article is structured as follows: Section 2 presents the main theoretical and empirical literature about relations between collusive agreements and rigidity of prices. Section 3 describes the data and the characteristics of the market analyzed, in order to show the methodology and results in Section 4. Section 5 discusses the interpretations of empirical results against different benchmarks, leading to a final presentation of the conclusions in Section 6.

2. Rigidity of Prices: Theoretical and Empirical Literature

The industrial organization literature has not provided a satisfactory theory that links price rigidity with collusion (Athey et al, 2004). Despite criticism of this assertion, most classical studies positively relate collusion with low price variability, as outlined in the work of Mills (1927), Means (1935), Stigler (1961, 1964), Salop (1977), Fershtman (1982), Carlson and McAfee (1983) and Carlton (1986, 1989), among others.[7]

From a theoretical point of view, the most relevant work on collusion and price rigidity is Athey et al (2004). They consider a model of collusion using an infinitely repeated Bertrand game, in which firms are privately informed as to their current cost positions. Assuming an inelastic demand, they conclude that (among others), if firms are sufficiently patient and the distribution of costs is log-concave, optimal symmetric collusion is characterized by price rigidity and the absence of price wars on the equilibrium path.

Harrington and Chen (2006) is another theoretical study relating the existence of collusive agreements to price rigidity. These authors developed a dynamic computational model of cartel pricing with cost variability and endogenous buyer detection. Although the prices are sensitive to cost in the latter phase, they are less volatile in collusive conduct than in competition path because it takes longer for a cost shock to impact on the price.

With regard to articles that present empirical evidence on the relationship between price level and its variance, Genesove and Mullin (2001) is a key example. The authors review the

7 One approach is the dispersion of prices in markets with homogenous products (Borenstein and Rose, 1994; Tsuruta, 2008). Borenstein and Rose conclude that dispersion increases on routes with more competition or lower flight density. Tsuruta (2008) examined gasoline price dispersion in Japan and he concludes that the degree of competition affects price dispersion; as traditionally accepted, a greater competition indicates lower dispersion. Nevertheless we do not use this approach, the positive relationship between competition level and price dispersion is common with our methodology.

rules and the impact of the Sugar Institute, a cartel of 14 firms including nearly all of the sugar cane refining capacity in the United States (from December 1927 until it was ruled illegal in 1936). The cartel did not fix output or set prices directly, but instead homogenized business practices, thereby facilitating the detection of secret price cuts. Genesove and Mullin (2001) calculate the yearly margin on sugar refining in the United States in three stages: before, during and after the cartel period. The most important outcome was that the variance in the margin dropped by nearly 100% during the cartel period.

Another example is the work done by Brannon (2003) for the retail market of gasoline in the United States. The author believes that the introduction of the "Wisconsin's Unfair Sales Act" legislation, which established a minimum price in the market to eliminate potential sales below cost, facilitated collusive agreements. The article calculates the average margin and the variance for two markets affected by this legislation, as well as a similar unaffected market, allowing for comparison. The results show that the average is actually higher in collusive markets; however, the results in terms of variance are ambiguous.

Abrantes-Metz et al (2006) is other pioneering paper, in which the authors examine a case of bid-rigging and, based on its results, then a study of possible collusion in a market. The authors find empirical evidence on higher prices and a lower variability analysis of the cartel in the provision of frozen fish to the American Army during the years 1984 to 1988. This cartel was detected and condemned by the Antitrust Division of the Department of Justice of the United States. The authors note how the collapse of the cartel led to a decline in the prices of 16% and an increase in the standard deviation of 263%. With this empirical evidence the authors implement a filter of variance in the retail market for gasoline in Louisville to try to detect if there are service stations with higher prices and lower standard deviations. This is the first implementation of a filter of variance in the economic literature and the results are not conclusive. Uniformity of behavior among all the service stations does not allow the authors to discern between collusive or competitive behavior.

Bolotova et al (2008) employ extensions of the traditional autoregressive conditional heteroskedasticity (ARCH) and generalized (GARCH) models, and they found some impacts over average prices and variance, simultaneously, in citric acid (1991-1995) and the lysine (1992-1995) cartels. They found mixed outcomes: the variance of prices during the lysine conspiracy was lower while the variance of prices during the citric acid conspiracy was higher than during more competitive periods.

Abrantes-Metz et al (2008) used the filter of variance to analyze whether the LIBOR (an indicator used by banks to determine the profitability of venture capital) was being manipulated by collusive agreements, as reported the Wall Street Journal. Although the variance of fees was very low and the vast majority of banks were identical, the authors believe that, compared to the benchmark, it can not be correct to say that the LIBOR is manipulated.[8]

Regarding the use of this methodology by competition authorities, only the Italian Antitrust Authority has used it. Esposito and Ferrero (2006) applied a variance filter to two cases previously considered by the Authority: the retail gasoline market and personal hygiene products and baby food sales in pharmacies. The authors note how the retail prices of petrol in Italy are higher and the average standard deviation is the lowest of all countries of the EU-15. In the second case the authors perform a comparison of the prices set by the supermarkets, which the authors consider as the more competitive benchmark. The results, as in the previous case, are higher prices and lower standard deviations. As the authors point out, the results of applying the variance filter are the same as the conclusions of the Competition Authority found through other methodologies.

As we have observed and summarized in Table 1, the results regarding the relationship between behavior and collusive price rigidity, despite a relatively clear point to the same scenario (higher prices and lower standard deviations), are not unequivocal. Thus, the work of Brannon (2003) and Bolotova et al (2008) found no such relationship. We have also observed that the works do not use a benchmark to compare the results obtained by the filter of variance, and therefore hardly find a clear interpretation of them.

[8] Other reference is Muthusamy et al (2008), who analyze the behavior of the price of potatoes in the market in Idaho. In this market measures were implemented to coordinate supply through the United Fresh Potato Growers of Idaho. Using the same methodology as in Bolotova et al (2008), they find statistically significant evidence suggesting that fresh potato price volatility is lower during the period when the cooperative is in the market as compared to the pre-cooperative period.

Table 1: Summary of Empirical Evidence on Variance Filters and on the Relationship Between Collusion and Price Rigidity

Authors (Year)	Sector	Results
Genesove and Mullin (2003)	Sugar (USA)	The margin variance falls nearly 100% during the cartel period.
Brannon (2003)	Retail gasoline market (USA)	By introducing a Resale Price Maintenance Law in two cities, variance falls in one of them, while the other remains unchanged. They use a different city as a benchmark.
Abrantes-Metz et al (2006)	Bid-rigging in frozen perch market (USA)	Standard deviation increases by 263% after cartel collapse.
Abrantes-Metz et al (2006)	Retail gasoline market (USA)	No collusive behavior shown.
Esposito and Ferrero (2006)	Retail gasoline market (Italy)	The standard deviations of the prices of gasoline in Italy are among the lowest in the EU-15.
Esposito and Ferrero (2006)	Hygienic products and baby foods in pharmacies (Italy)	The standard deviations of the prices of baby food are lower in pharmacies than in supermarkets.
Bolotova et al (2008)	Citric acid (USA)	The use of ARCH and GARCH models shows that the variance is higher during the collusive period.
Bolotova et al (2008)	Lysine (USA)	The use of ARCH and GARCH models shows that the variance is lower during the collusive period.
Muthusamy et al (2008)	Potatoes (USA)	The volatility of the price of potatoes is less during the cooperative period.
Abrantes-Metz et al (2008)	Financial indicator (USA)	Although the variance is very low, the use of financial ratios and other benchmarks found no evidence of manipulation of results.
Jiménez and Perdiguero (2009)	Retail gasoline market (Spain)	Only the comparison with the Canary Islands market seems to indicate a non-competitive behavior.

Source: Own elaboration.

In summary, this methodology is easy to use and interpret and its use is widespread in the academic literature and in practical applications, but it suffers from some limitations, as already indicated. The empirical implementation that follows seeks to shed light on these limitations in order to assist the interpretation and dissemination of this methodology.

3. An example: retail gasoline market in the Canary Islands (Spain)

The Canary Islands' petrol market has certain characteristics that differentiate it from other markets, including the national one (Spain). Such differences can be summarized into four points. First, greater experience in liberalizing the market, compared to the rest of the country. Second, most of the consumption comes from production (transformation) locally, which reduces the level of imports. Third, the market is characterized by a high concentration in all industry processes. In the retail market, concentration for petrol 95 (similar to diesel) has a CR_1=0.44 and CR_3=0.70, and the leading company is DISA.

Notably, in the gasoline market in the Canary Islands there is only one independent company (PCAN), and there are no gas stations owned by supermarkets, as is usual in the rest of Europe. Fourth and finally, there is the aforementioned feature that the market structure includes seven individual markets (islands). Five of these islands operate under oligopoly and in the other two there exists a monopoly, all simultaneously and with equal taxation (for further description of the market, see Perdiguero and Jiménez, 2009). In these islands, DISA is the only operating firm and its behavior with respect to prices is mimetic to the retailers of the two islands. In summary, primitive conditions in all islands are similar: transport costs in each island, wholesale behavior, taxes, etc. Nevertheless, some control variables have to be taken into account if we want to analyze the market, as in Perdiguero and Jiménez (2009).

In this market we have taken the prices of all the service stations on the islands, both for petrol 95 and for diesel, which are the two products with the highest consumer demand. The data come from the website of the Ministry of Industry, Tourism and Commerce, Government of Spain, where weekly (every Wednesday) we got the price, expressed in euros per liter.

The database includes 24 weeks in the period September 2008 to April 2009, with a total of 420 and 391 service stations that sell petrol 95 and diesel, respectively. several petrol stations did not provide data covering the whole sample period, and if we exclude those with a remarkable number of missing values, we could incur a problem of sample bias. In this case, petrol 95 provided 10,080 values and diesel 8,993, which is 19 and 22% of the values, respectively, were unavailable. However, as explained in Section 4, this potential bias is minimized through the use of simulation techniques using Monte Carlo Markov chains for the imputation of these missing values.

Prior to using the imputation method, we analyzed whether the stations with less information could lead us to a problem of self-sampling: the companies that may provide less information (or worse quality, in general) are those who behave in a "less competitive" manner. In this case, this potential problem is apparently less important, given that the stations with missing values remain almost identical to the sample of each company in the total population, for both types of products.

4. Empirical Strategy and Results

The first step is to "fill in" the missing data with predicted or simulated values. For this, we follow the paper by Abrantes-Metz et al (2006), which discuss the possible options, i.e. mean substitution, simple hot deck, regression methods, and imputation methods. Abrantes-Metz et al also presented arguments for choosing the imputation methods, specifically Gibbs Sampling combined with the data augmentation method, which is a type of Markov chain Monte Carlo.

In general, multiple imputations are drawn from a Bayesian predictive distribution:

$$p\left(z^m,\theta \mid z^o\right)=\int p\left(z^m \mid z^o,\theta\right)p\left(\theta \mid z^o\right)d\theta$$

where z^o is the data vector, z^m is the missing observations and θ is the model parameters. The Gibbs Sampling tries to estimate the numerical approximation of $E\left[g(\theta) \mid z^o\right]$, where $g(\theta)$ is a function of interest, as the mean or standard deviation of prices for some subset of petrol stations.

In our case, we denote z^{ot} as the observed values and z^{mt} as missing values. The distribution of the unknown parameters θ and z^{mt} are conditional on the known z^o being the next predictive distribution:

$$p\left(z^m,\theta \mid z^o\right)=p\left(z^m,z^0,\theta\right)\Big/ p\left(z^0\right)\alpha\, p\left(z^m,z^0,\theta\right)=p\left(z,\theta\right)=p\left(\theta\right)p\left(z \mid \theta\right)$$

Specifically, the interpolation for the missing values uses the following first-order autoregressive model:

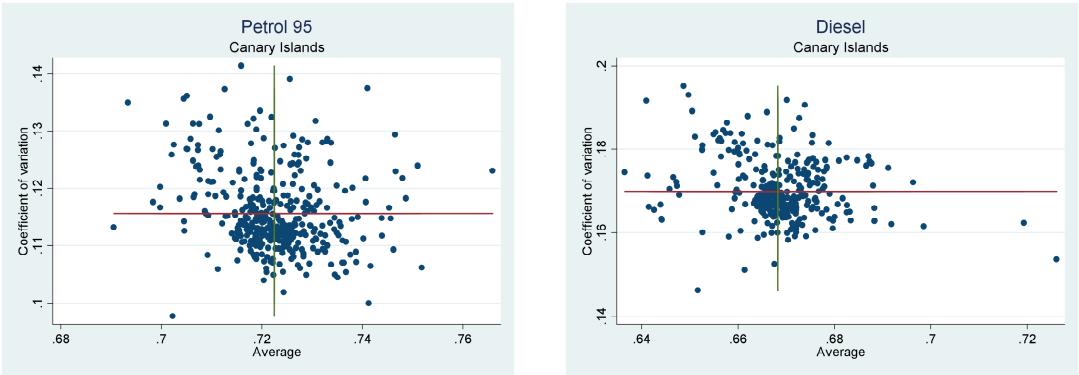
$$z_{it}-\mu_{it}=\rho_i\left(z_{it-1}-\mu_i\right)+\varepsilon_{it}$$

where z_{it} is the difference between price station i on day t minus average daily price. Assuming $\varepsilon_{it}^{iid} : N\left(0,\sigma_i^2\right)$, the model permits a station to have prices that tend to be higher or lower than average by using μ_i.

The next step is to obtain, for each station, the average price and its standard deviation, and to avoid problems of scale, the coefficient of variation[9], for the period studied. Articles that have previously applied this methodology are Abrantes-Metz et al (2006) and Bolotova et al (2008), using the standard deviation and comparing prices within a market. However, our analysis compares the performance of different markets, which may have different costs and different demands, which means that the standard deviation can be affected. For this reason we use the coefficient of variation, in order to minimize it.

It should also be noted that we are not looking at an anti-competitive practice that has already been reported, so we do not know either the beginning point of the period of a hypothetical cartel, nor the end. The aim is to detect possible deviant behavior by gas stations or groups of them in all period. Figure 1 shows the results for petrol 95 and diesel respectively. The horizontal and vertical lines show the average price and their coefficients of variation for the entire sample, respectively.

Figure 1: Price and Coefficient of Variation for Petrol 95 and Diesel (All Petrol Stations)



Source: Own elaboration from data provided by the Ministry of Industry, Tourism and Commerce.
Note: The average prices are expressed in euros per liter of fuel.

[9] The coefficient of variation is a dimensionless measure of dispersion that is the ratio of standard deviation and arithmetic mean.

From these graphs we can note that the results for petrol 95 and diesel are very similar, while the cloud of points is apparently denser in the center for diesel. It also gives a very similar result for all stations. In fact, the results of both perfect collusion and perfect competition are identical, which, as suggested in the previous section, means that the findings are difficult to interpret.

Although the parallel behavior of prices has been indicated as a collusive marker, as pointed out in Harrington (2006a and 2006b), both in the United States and in the European Union is not enough to discern the existence of collusion behavior. In fact, there is a vast body of literature that indicates the possibility of observing parallel prices without there being a collusive equilibrium, as indicated by Turner (1962), MacLeod (1985), Baker (1993) and Buccirossi (2006), among others.

Without a clear benchmark, or analyzing a specific period in which companies are known to have behaved collusively, the analysis result is not conclusive. This problem is typical when we do not have a benchmark that allows us to interpret the results, as seen in Abrantes-Metz et al (2006) or Jiménez and Perdiguero (2009). Without this benchmark of comparison, the best we can do is to identify those retailers that are located in quadrant II, i.e. that have higher prices and a below average coefficient of variation.

This is precisely what is shown in Table 2, but with a nuance. We take the worst situation in competition analysis: petrol stations with both higher prices and lower coefficient of variation by island (Quadrant II). So we obtained the station furthest from the average values. Table 2 shows the percentage change of maximum and minimum deviation with respect to the average island, not only for prices, but also for gross retail margin. For example, the service station in Gran Canaria farthest from the average price set a price 1.86% above that average. This margin (a proxy) has been obtained as the difference between retail prices and spot Rotterdam quote[10].

[10] Spot Rotterdam quote is the Conventional Gasoline Regular Spot Price, provided by the U.S. Energy Information Administration (http://www.eia.doe.gov/).

Table 2: Maximum Range of Variation in Quadrant II, by Island

	% Maximum Highest Price Deviation with Respect to Average Prices by Island		% Maximum Lowest Deviation with respect to the Average coefficient of variation by Island	
	Petrol 95	Diesel	Petrol 95	Diesel
Gran Canaria	1.86 (5.35)	8.40 (3.37)	-7.70 (-15.07)	-8.83 (-13.00)
Tenerife	2.21 (3.29)	2.25 (2.02)	-13.08 (-26.09)	-10.47 (-15.08)
Fuerteventura	4.18 (4.61)	1.28 (2.25)	-12.03 (-18.02)	-7.26 (-14.88)
Lanzarote	1.52 (2.50)	5.86 (10.16)	-6.89 (-17.87)	-5.90 (-15.98)
La Palma	2.38 (1.97)	1.79 (2.00)	-11.47 (-16.91)	-4.32 (-13.02)
La Gomera (m)	0	0	0	0
El Hierro (m)	0	0	0	0

Source: Own elaboration from data provided by the Ministry of Industry, Tourism and Commerce. Deviation using Gross retail margin in brackets. (m) monopolistic island.

As can be seen, the percentage differences in these extreme cases regarding the average values in quadrant II of each island do not attain even a 9% increase in prices, nor more than a 13% increase for the low coefficient of variation. In fact, the variations are greater in the coefficients of variation than for the prices. In terms of margins, variations are higher, more than 10% of the average margin, and more than 26% of the average coefficient of variation.

Although there is no threshold set for determining collusion, Abrantes-Metz et al (2006) explain that it must at least be average price plus/minus two standard deviation. Neither of the two conditions is met but, as set out by Perdiguero and Jiménez (2009), we have to remind that this market is characterized by low margins for large quantities. In summary, following this methodology and if we do not establish a clear benchmark, we can not conclude the existence of any collusive agreement, a result similar to that described for the city of Louisville (USA) by Abrantes-Metz et al (2006).

5. Interpretation of results: a comparative analysis with different benchmarks

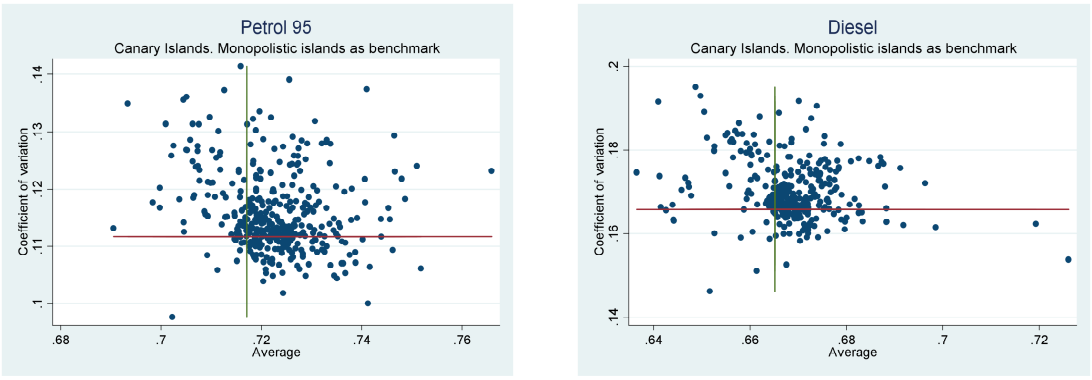
In practice, there are at least two screening approaches. The first is to monitor the price variance and assess whether it is low relative to a benchmark. The second is to identify the transition from non-collusion to collusion or vice versa.

The latter approach includes some bias, because the cartel's behavior before and after the collusive period should be not competitive, as will be elaborated on below. The approach taken in this article is the first one, monitor the price variance and assess whether it is low relative to a benchmark. Brannon (2003) took a city that had not been affected by legislative change. In our case, we can use at least two different types of benchmarks and also highlight the problems that could arise with a third hypothetical benchmark.

i) If a monopoly exists

The use of this benchmark allows us to change the perspective of the analysis shown in Figure 1. In Figure 2, the horizontal and vertical lines show the average price and average coefficient of variation of the monopolistic islands, thus reflecting the less competitive market structure. In this case we are looking for service stations that have coefficients of variation similar to the perfect collusion (monopoly). As we can see, the cloud of points for both products is close to the average coefficient of variation of the monopolistic islands, and some stations are even below it.

Figure 2. Price and Coefficient of Variation for Petrol 95 and Diesel (All Petrol Stations) Using the Monopolistic Islands as the Benchmark.



Source: Own elaboration from data provided by the Ministry of Industry, Tourism and Commerce.
Note: The average prices are expressed in euros per liter of fuel.

Taking as a reference the behavior of the monopolistic islands, we can reach an important conclusion: gas stations in an oligopoly have a higher coefficient of variation. This means that we obtain evidence for a positive relationship between monopoly behavior and price rigidity.

As Harrington and Chen (2006) explain, firms under collusive behavior show a more price rigidity.[11] The main advantage of this case is the existence of a real monopoly in two of the seven geographic markets analyzed, which in the literature (as far as we know), has never before been the case. In fact, comparison of monopolistic islands with oligopolistic markets is an ideal situation. The petrol stations on the monopolistic islands show the same prices for all service stations and on both islands, but are not the lowest of all markets. This is due to the vast difference in demand between these markets, since the population and economic activity on the monopolistic islands is up to 100 times lower than the rest. In fact, Perdiguero and Jiménez (2009) examine the same market through an analysis of conjectural variation and they emphasize that the population is a statistically significant factor affecting the quantity sold and, indirectly, the price.

We can, however, draw a significant conclusion: the standard deviation and coefficient of variation of the oligopolistic islands are always below those of the monopolistic islands. Table 3 shows the percentage change of the coefficient of variation for each island respect to monopolistic island, which varies between 1.06 and 8% higher in oligopolistic islands. If we use gross retail margin, deviation increases with ranges from 6.44% to 28.3%. In summary, monopolistic firms yield to a more rigid price behavior than oligopolistic one.

Table 3: Percentage Variation of Coefficient of Variation of the Monopolistic Islands (El Hierro and La Gomera) in comparison with the Oligopolistic Islands

	Petrol 95	Diesel
Gran Canaria	1.22 (6.79)	1.66 (6.44)
Tenerife	4.82 (18.4)	2.81 (10.3)
Lanzarote	5.06 (11.3)	3.89 (10.62)
Fuerteventura	8.00 (28.3)	5.28 (16.35)
La Palma	1.06 (16.1)	1.25 (8.06)

Source: Own elaboration. Deviation using Gross retail margin in brackets.

ii) If a Very Competitive Firm Exists.

The question remains of how best to analyze the situation if there is no monopoly as a benchmark. One option is to locate companies that are known to be more competitive

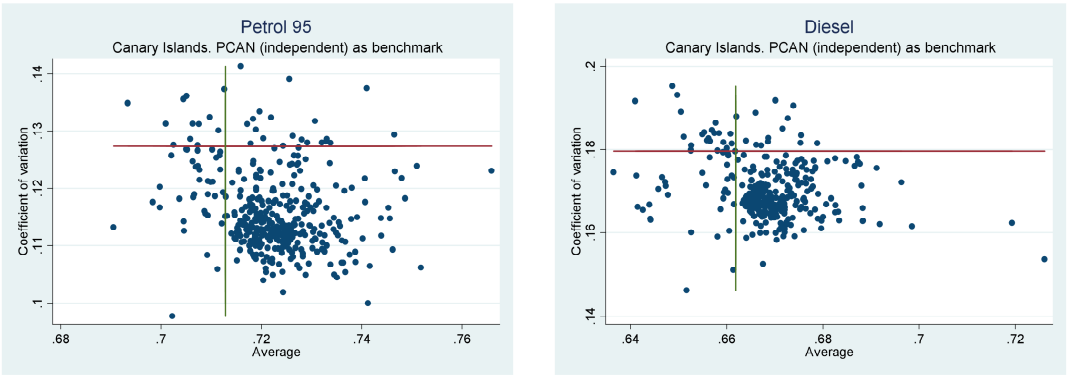
[11] In Annex I we also demonstrate in a theoretical way in which cases prices are more rigid in monopoly or collusive behavior than in perfect competition, using linear and non-linear demand equations.

than the rest. This was done by Brannon (2003) and Esposito and Ferrero (2006) for their respective cases. In the retail market of petrol, Hastings (2004) and Clemenz and Gugler (2004) suggest that only independent firms increased competition in this market.

As we have aforementioned, in the Canary Islands there are no service stations run by supermarkets (which traditionally compete more aggressively on prices), but there is a company which operates in a similar way and which is cheaper: PCAN.

Figure 3 uses average price and coefficient of variation for PCAN stations in the Canary Islands as a benchmark. The objective is to find whether there are retailers in quadrant II with higher prices and lower deviations. As can be seen, the vast majority of the stations are located in this quadrant.

Figure 3. Price and Coefficient of Variation for Petrol 95 and Diesel (All Petrol Stations) Using PCAN (Independent) as the Benchmark.



Source: Own elaboration from data provided by the Ministry of Industry, Tourism and Commerce.

Note: The average prices are expressed in euros per liter of fuel.

As can be seen most service stations have a higher price and a lower coefficient of variation when compared with the average of PCAN's pumps. In the Table 4 we can show the average percentage of price (and gross margin variation) and coefficient of variation for each brand with respect to this company.

Table 4: Percentage Variation of Average Prices and Coefficients of Variation of Each Brand with Respect to PCAN (Independent Brand)

	Petrol 95		Diesel	
Brand	**Price (euros)**	**Coefficient of variation**	**Price (euros)**	**Coefficient of variation**
Cepsa	1.1 (1.92)	-9.80 (-25.98)	0.9 (1.55)	-5.89 (-15.61)
Disa	1.1 (1.98)	-13.06 (-24.39)	1.5 (2.78)	-5.63 (-14.19)
Shell	1.3 (2.11)	-11.01 (-28.79)	1.1 (2.00)	-7.70 (-17.99)
British Petroleum (BP)	1.7 (2.85)	-11.38 (-24.13)	1.1 (1.92)	-6.04 (-11.50)
Repsol	1.1 (2.01)	-7.63 (-20.50)	0.3 (0.61)	-5.33 (-13.97)
Texaco	1.8 (3.21)	-10.42 (-23.21)	1.4 (2.58)	-4.66 (-11.04)
Others	1.5 (2.59)	-8.01 (-21.66)	1.2 (2.27)	-4.52 (-11.51)
Total	1.3	-9.93	0.9	-5.89

Source: Own elaboration. Deviation using Gross retail margin in brackets.

The average prices of other brands are superior to those of PCAN by between 0.3 and 1.8%, while the average coefficient of variation of PCAN is always greater than that of the other competitors, by between 4.5 and 13.1%. In terms of margins, differences are higher, between 0.61 and 3.21%. But the most important change is on coefficient of variation: its range is between -11.04 to 28.79%, more important in petrol 95 than in diesel. One possible explanation for this pattern of prices could be the different locations of the stations of different brands. However, as shown in Table 4, the distribution of pumps is very similar among different brands.[12]

In fact, this company not only shows a similar pattern to other brands to establish in cities, (see Table 5) but also PCAN is more located at smaller cities than the rest. For example, 5 petrol stations of PCAN (19% of total PCAN petrol stations) operate as a monopoly in their cities. Despite this advantage to set higher prices, they remain the lowest of all brands.

[12] As seen in Perdiguero and Jiménez (2009) do not exist significant differences in the number of complementary services (Shops, restaurant, etc…) that offer the different Brands.

Table 5: Brands by population (percentage)					
Type of city	Repsol	Disa (*)	Texaco	BP	PCAN
Population < 2,000	3,7	1,8	0,0	0,0	7,7
2,000<Pop<5,000	3,7	4,5	2,9	0,0	0,0
5,000<Pop<10,000	11,1	10,7	14,7	10,7	15,4
10,000<Pop<20,000	33,3	14,3	17,6	10,7	11,5
20,000<Pop<30,000	0,0	13,4	11,8	10,7	19,2
Pop > 30,000	48,1	55,4	52,9	67,9	46,2

Source: Own elaboration. (*) Disa is also CEPSA and Shell.

Moreover, in order to test whether PCAN stimulates competition, we take two empirical approaches. The first one is to obtain two values (prices and coefficient of variation) both in municipalities with PCAN service stations and without them. The results suggest that prices are always higher and the coefficient of variation is smaller if PCAN is not in the municipality. In particular, prices in towns with PCAN stations are 0.5% lower for petrol 95 and 0.3% for diesel, and the coefficient of variation is 5.1 and 2% higher respectively. Cities with PCAN show gross margin retail lower than other cities in 2.5% for petrol 95 and 1.8% for diesel, and a coefficient of variation higher in 34% for petrol 95 and 17% for diesel.

In the second approach we measure the influence of PCAN in the behaviour of the other brands through the estimation of a logit models. In this estimation the dependent variable takes value 1 if the petrol station is in the second quadrant (higher prices and lower coefficient of variation) compared to the number of rivals of PCAN in a half mile, the number of rivals of other brands and the number of own brand pumps.[13] Econometric results can be seen in the following table.

[13] To perform this analysis we have been georeferenced all service stations operating in the different islands and then calculated the minimum Euclidean distance to each. To Matlab codes with which the calculations have been made requiring the authors..

Table 6: Econometric results. Logit estimations.				
Constant	-0.261**	-0.297***		
	(0.120)	(0.115)		
No. Rivals No PCAN	0.142	0.143	0.003	-0.026
	(0.134)	(0.133)	(0.119)	(0.118)
No. Rivals PCAN	-0.506*	-0.607**	-0.578**	-0.760***
	(0.305)	(0.298)	(0.301)	(0.295)
No. Own Brand	-0.238		-0.359*	
	(0.212)		(0.208)	
No. Obs.	445	445	445	445
Wald Chi2	6.05	4.69*	10.08**	7.54**
	(0.1094)	(0.0959)	(0.0179)	(0.0230)

Source: Own elaboration

As can be seen the only variable is consistently significant is the number of rivals of PCAN present in a half a mile. This econometric result indicates that the presence of an independent service station has a negative impact on the likelihood of higher pricing and more rigid, pricing structure consistent with collusion. Therefore, it seems that PCAN lead to a more competitive behaviour of gas stations that are around.

The result of the comparison with the independent company, PCAN, points in the same direction as when we used the monopolistic islands as the reference. Service stations outside PCAN have higher average prices and lower coefficients of variation. Therefore, we obtained empirical evidence of a positive relationship between less competitive behavior and rigidity of prices. Once we show this empirical evidence, we have to analyze if PCAN behavior is due to differences on quality, to a more sensible demand in these municipalities or other strategical factors. Using the screen variance like a prospective analysis these factors have to be into account before take any relevant conclusion. In the specific case of PCAN the level of quality (gasoline product and additional services) and the territorial distribution are similar the rest of brands. Two approaches reach the same conclusion: PCAN is a more competitive firm and no structural factors affect it.

iii) If a Cartel Breaks

The discovery and the breakdown of a cartel may also be useful for analyzing the behavior of firms before and after the event, and to obtain a counter-factual analysis: how should the price have been in the absence of the cartel? However, although the breakdown of a cartel can be used, Harrington (2006) challenges this approach, arguing that post-prosecution

prices are not good measures of the "but-for" price – that is, the price that would have been obtained in the industry if not for the cartel – because firms have an incentive to maintain higher prices in order to limit their civil liability.

Moreover, cartel histories seem to demonstrate a greater proclivity for large price collapses after termination than for price wars before termination (Connor and Bolotova, 2006), as in the most of the vitamin cartels (Connor, 2005). That is, cartels do not seem to end in price wars that lead them to a level of price competition, but instead tend to finish at higher levels. For this reason, although we can confirm the breakdown of a cartel in a given time, we must be cautious with the counterfactual analysis that we make.

Summary of Results

Analyzing the results of the filter of variance without comparing it with a benchmark did not allow discernment of any conclusive results. Applying the above two types of benchmarks yields to this conclusion: the service stations are close to monopoly behavior and are clearly less competitive than the independent firm, PCAN.

Although the coefficient of variation of service stations operating in oligopolies is higher than in a monopolistic situation and lower than that for the company PCAN, petrol stations are closer to the former than the latter. We can therefore conclude that the average performance of different service stations (excluding PCAN) is very close to a monopoly. This evidence would justify further investigation of the behavior of these service stations by the Authorities of Competition Policy.

This result is not surprising if we take into account the characteristics of the gasoline market in the Canary Islands and the empirical evidence obtained on it earlier. Moreover, this retail market conforms to most of the factors that facilitate tacit collusion described by Ivaldi et al (2003): symmetrical costs, transparency of information, and so on. Furthermore, this market meets some that produce rigidity on prices, as is described in the literature. For example, Athey et al (2004) confirm that rigidity on prices results if companies know the costs of their rivals. In this case, all companies share the same wholesaler.

Genesove and Mullin (2001) suggest market transparency as a way to control the variability in prices, and this market is one of the most transparent we know of. Connor (2005) argues that preventing or limiting entry increases the likelihood that price variation will be reduced. Without formally accusing firms of being part of a cartel, entry can be reduced in this sector, either for environmental reasons or due to difficulty in obtaining licenses for

opening in new areas, especially with the current stagnation of demand, even at high fixed costs (and sunk).

Empirical evidence obtained through other approaches also supports the conclusion of non-competitive behavior. The results obtained by Jiménez and Perdiguero (2008) and Perdiguero and Jiménez (2009) using both conjectural variation analyses show an average behavior of the service stations that operate in oligopolistic markets which is closer to perfect collusion. In fact, the authors can not rule out the possibility that retailers are behaving as a monopoly.

Thus, while the aggregate analysis did not allow us to conclude the existence of a collusive behavior, using two different benchmarks (a monopoly market and a company with a more aggressive attitude to price competition), together with the results of other structural approaches to this sector, allow us to conclude that the market could be more competitive than currently and, while there are no business exercising an effective competition (such as PCAN), the implicit behavior of the firms is more pro-collusive than pro-competitive.

6. Conclusions

The detection, analysis and prosecution of cartels is one of the competition agencies' main tasks. However, detection of cartels is an extremely complicated task. Therefore, developing simple methods and requiring a relatively low level of data, which allow identification of possible collusive behavior, can be very useful. Thus, the methodology of the variance filter has been developed and popularized in recent years, which satisfies the features described above.

The dissemination and implementation of this methodology by the competition authorities is still limited, however, for two main reasons. On the one hand, there is no unanimity on the behavior of prices under a cartel. While evidence shows that prices are higher and tighter under collusion, the evidence is not unanimous, which may hamper the interpretation of results. Furthermore, the results of implementing a variance filter are less explanatory when there is no benchmark for comparison to assist in its interpretation. Obtaining similar behavior to the average of all market participants makes it very difficult to draw conclusions from the analysis.

This article aims to shed light on these limitations by applying a variance filter in the retail market for gasoline in the Canary Islands (Spain). This market presents the peculiarity of being made up of five islands in oligopoly and two in the monopoly of a firm (DISA). This

market structure allows us to see if monopoly prices were more or less rigid in comparison with a potentially more competitive market, and thus draw conclusions about the level of competition.

The empirical results show firstly how the monopolistic market shows lower coefficients of variation than the rest of the market, which would confirm that lower competition markets, lower price variability. Secondly, the comparison of results both with respect to the monopoly in gas stations, and to the independent firm (PCAN), suggests that the situation is closer to a perfect collusion than a competitive outcome. This evidence has already been shown by other authors through different methodologies, for example Jiménez and Perdiguero (2008) and Perdiguero and Jiménez (2009).

As economic policy recommendations, we stress the appropriateness of such tools as collusive markers. The empirical evidence shown in this article can help to consolidate methodologies such as confirming the existence of more rigid prices in the presence of a cartel, and helps the interpretation of results with the proposal of different benchmarks.

We should note, however, the importance of correctly defining the benchmark of comparison for this method, to give a real practical method of operation for the competition authorities. In this case we used monopoly situations, but if this is not possible and there is no known period of collusion, we have seen that the behavior of independent service stations can be a reference.

References

Abrantes-Metz, R.M., Bajari, P., 2009. Screening for conspiracies: applications for litigation, pre-litigation, regulation and internal monitoring. SSRN-Working paper. [Online]. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1357862

Abrantes-Metz, R.M., Froeb, L.M., Geweke, J.F., Taylor, C.T., 2006. A variance screen for collusion. International Journal of Industrial Organization, 24, 467-486.

Abrantes-Metz, R.M., Kraten, M., Metz, A., Seow, G., 2008. LIBOR manipulation? SSRN-Working Paper. [Online]. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1201389

Athey, S., Bagwell, K., Sanchirico, C., 2004. Collusion and price rigidity. Review of Economic Studies, 71, 317-349.

Baker, J.B. 1993. Two Sherman Act Section 1 Dilemmas: Parallel Pricing, the Oligopoly Problem and Contemporary Economic Theory, The Antitrust Bulletin, 38(1), 143-219.

Bolotova, Y., Connor, J.M., Miller, D., 2008. The impact of collusion on price behavior: Empirical results from two recent cases. International Journal of Industrial Organization, Vol. 26(6), 1290-1307.

Borrell, J.R., Jiménez, J.L., 2008. The drivers of antitrust effectiveness. Hacienda Pública Española/Revista de Economía Pública, 185, (2), 69-88.

Borenstein, S., Rose, N., 1994. Competition and price dispersion in the U.S. Airline Industry. The Journal of Political Economy, 102, (4), 643-683.

Brannon, I., 2003. The effects of resale price maintenance laws on petrol prices and station attrition: Empirical evidence from Wisconsin. Applied Economics, 35(3), 343-349.

Buccirossi, P., 2006. Does parallel behavior provide some evidence of collusion? Review of Law and Economics, Vol. 2(1), 85-102.

Carlton, D.W., 1986. The rigidity of prices. American Economic Review, 76(4), 637-658.

Carlton, D.W., 1989. The theory and the facts of how markets clear: Is industrial organization valuable for understanding macroeconomics? In: Schmalensee, R. & Willig, R.D. (eds.) Handbook of Industrial Organization, Vol. 1, Handbooks in Economics, 10, 909-946.

Carlson, J.A., McAfee, R.P., 1983. Discrete equilibrium price dispersion. Journal of Political Economy, 91, 480-493.

Clemenz, G., Gugler, K., 2004. Locational choice and price competition: Some empirical results for the Austrian retail gasoline market. Mimeo, University of Vienna.

Connor, J.M., 2005. Collusion and price dispersion. Applied Economics Letters, Vol. 12(6), 335-338.

Connor, J.M., Bolotova, Y., 2006. Cartel overcharges: Survey and meta-analysis. International Journal of Industrial Organization, 24, 1109-1137.

Department of Justice. (2004) Price fixing, bid rigging and market allocation schemes: What they are and what to look for. [Online]. Available at: http://www.usdoj.gov/atr/public/guidelines/211578.htm

Esposito, F., Ferrero, M., 2006. Variance screens for detecting collusion: an application to two cartel cases in Italy. Italian Competition Authority, Working Paper.

Fershtman, C., 1982. Price dispersion in oligopoly. Journal of Economics, Behavior and Organization, 3, 389-401.

Genesove, D., Mullin, W., 2001. Rules, communication and collusion: Narrative evidence from the sugar institute case. American Economic Review, 91(3), 379-398.

Harrington, J.E., 2006a. Behavioral screening and the detection of cartels. EUI-RSCAS/EU Competition 2006-Proceedings.

Harrington, J.E., 2006b. Detecting cartels. In Buccirossi, P. (ed.), Handbook in Antitrust Economics. MIT Press. Massachussets, MIT Press.

Harrington, J.E., Chen, J., 2006. Cartel pricing dynamics with cost variability and endogenous buyer detection. International Journal of Industrial Organization, 24, 1185-1212.

Hastings, J., 2004. Vertical relationships and competition in the retail gasoline markets: Empirical evidence from contract changes in Southern California. American Economic Review, Vol. 94(1), 317-328.

Ivaldi, M., Jullien, B., Rey, P., Seabright, P., Tirole, J., 2003. The economics of tacit collusion. Final report for DG Competition, European Commission.

Jiménez, J.L., Perdiguero, J., 2008. Análisis de fusiones, variaciones conjeturales y la falacia del estimador en diferencias. Documento de Trabajo de FUNCAS, nº 404. [Online]. Available at: http://www.funcas.ceca.es/Publicaciones/InformacionArticulos/Publicaciones.asp?ID=1414

Jiménez, J.L., Perdiguero, J., 2009. (No) competition in the Spanish retailing gasoline market: variance filter approach. IREA Working paper. Available at: http://www.pcb.ub.es/xreap/aplicacio/fitxers/XREAP2009-5.pdf

MacLeod, B., 1985. A Theory of conscious parallelism. European Economic Review, 27, 25-44. Means, G., 1935. Industrial prices and their relative flexibility. Senate Document 13, 74th Congress, 1st Session. Washington D.C.

Mills, F.C., 1927. The behavior of prices. New York, NBER. New York.

Muthusamy, K., McIntosh, C., Bolotova, Y., Patterson, P., 2008. Price volatility of Idaho fresh potatoes: 1987-2007. American Journal of Potato Research 85, 438-444.

Perdiguero, J., Jiménez, J.L., 2009. ¿Competencia o colusión en el mercado de gasolina? Una aproximación a través del parámetro de conducta. Revista de Economía Aplicada, 50 (XVII), 27-45.

Salop, S., 1977. The noisy monopolist: Imperfect information, price dispersion and price discrimination. Review of Economic Studies, 44, 393-406.

Stigler, G., 1961. The economics of information. The Journal of Political Economy, 69. 213-225.

Stigler, G., 1964. A theory of oligopoly. Journal of Political Economy, 72(1), 44-61.

Tsuruta, Y., 2008. What affects intranational price dispersion? The case of Japanese gasoline prices. Japan and the World Economy, 20, 563-584.

Turner, D., 1962. The definition of agreement under the Sherman Act: conscious parallelism and refusals to deal. Harvard Law Review, 75, 655-702.

Werden, G.J., 2004. Economic evidence on the existence of collusion: Reconciling antitrust law with oligopoly theory. *Antitrust Law Journal*, 71, 719-800.

Annex I: Theoretical view of rigidity of prices

The question what we have to demonstrate is whether changes in prices due to changes in costs are more rigid in monopoly or collusion than in perfect competition. For this reason, we try four cases: linear and non-linear demands, in both cases (perfect competition and monopoly).

First case: linear demand

1.1. Perfect competition. In this case, outcome is obvious: prices are equal to marginal cost and all changes are included in price. I.e., $p_{pc} = c$ and $\frac{\partial p_{pc}}{\partial c} = 1$

1.2. Monopoly. We have next sequence to maximize benefits. From demand equation, $p = a - bQ$, and using this total cost function, $TC = cQ + F$, the equilibrium is when marginal revenue is equal to marginal cost ($MgR = MgC$), which yields to quantity of equilibrium $Q_{pc}^{e} = \frac{a-c}{2b}$. If we replace into demand equation, price equilibrium is $p_{m}^{e} = \frac{a+c}{2}$, where $\frac{\partial p_{m}^{e}}{\partial c} = \frac{1}{2} < 1 \Rightarrow \frac{\partial p_{m}^{e}}{\partial c} < \frac{\partial p_{pc}^{e}}{\partial c}$.

Second case: non-linear demand

1.1. Perfect competition. In this case, outcome is the same that previous case: prices are equal to marginal cost and all changes are included in price. I.e., $p_{pc}^{e} = c$ and $\frac{\partial p_{pc}^{e}}{\partial c} = 1$

1.2. Monopoly. The difference is that we have the next demand equation: $p = a - b\log Q$ and then the quantity of equilibrium is $\ln Q_{m}^{e} = \frac{a-c}{b^2}$ and price is $p_{m}^{e} = \frac{ab-a+c}{b}$. The partial derivative of price equilibrium in monopoly with respect to cost is $\frac{\partial p_{m}^{e}}{\partial c} = \frac{1}{b}$.

Three cases are possible, depending on *b* value:

$$\text{if } b > 1 \Rightarrow \frac{\partial p_m^e}{\partial c} < \frac{\partial p^e}{\partial c}$$

$$\text{if } b = 1 \Rightarrow \frac{\partial p_m^e}{\partial c} = \frac{\partial p^e}{\partial c}$$

$$\text{if } b < 1 \Rightarrow \frac{\partial p_m^e}{\partial c} > \frac{\partial p^e}{\partial c}$$

Price elasticity of demand is $\varepsilon = \frac{dQ}{dp}\frac{p_m^e}{Q_m^e} = -\frac{1}{b}e^{\frac{a-p}{b}}\frac{p_m^e}{Q_m^e}$

In summary, we have these outcomes for each type of demand and market structure:

	Perfect competition	Monopoly
Linear demand	$\frac{\partial p_{pc}}{\partial c} = 1$	$\frac{\partial p_m^e}{\partial c} = \frac{1}{2}$
Log-linear demand	$\frac{\partial p_{pc}}{\partial c} = 1$	$\frac{\partial p_m^e}{\partial c} = \frac{1}{b}$

From these results we can conclude that using log-linear demand equations, prices are more rigid in monopoly than in perfect competition in markets with inelastic demands.