

Preventing Anti – Competitive Behavior: Employing Game Theory to detect Cartels and Collusion

Cartel da Banca case

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Abstract

The objective of this Paper is to understand whether it would be possible to predict and prevent the formation of cartels and collusive behavior. The literature review shows that even when the best market conditions are met, it is not always certain that cartel formation will occur. This gave rise to the possibility of focusing the study on a specific type of cartels: mixed cartels. The literature on this, as it is not very common, is still scarce, so it is to contribute to the increase of available information on this topic that this Paper is carried out. To this end, a model of a game à la Cournot was developed and later applied to the case of the Cartel da Banca in Portugal, in order to explain its formation and then to be used in the future for prevention. This model is an extension of Mota et al. (2020), where the players are considered symmetric in terms of costs and where there is an increase in the scope of application of the model. It was concluded that without a cartel, given its concern for consumer surplus, the public firm always produces more. With the cartel, the excess production is transferred to the private firms, mainly for the ones the cartel. However, the major result and implications of this model are that, in addition to being able to be used for predicting cartel formation, the creation of mixed cartels can contribute to the increase in total and consumer surplus.

Keywords: Game theory, mixed cartels, collusion, oligopoly, Cartel da Banca

1. INTRODUCTION

Game Theory presents itself as being a field of study of applied math with applications in several other fields of study. It is used to create an optimum strategy in order to succeed in competitive situations where there is incomplete information, which is the case of almost all real-life scenarios. The first person to make Game Theory a true unique field of study was John von Neumann with the

publication of the paper “*On the Theory of Games of Strategy*” in 1928. A few years later, John von Neumann and Oskar Morgenstern, with the publication of another groundbreaking book, “*Theory of Games and Economic Behavior*”, in 1944, established game theory as an interdisciplinary research field. Around 1950, John Nash introduced the concept of Nash Equilibrium which is

essentially a criterion for mutual consistency of players' strategies. With this, Nash proved that Nash proved that every finite n-player, non-zero-sum (not just two-player zero-sum) non-cooperative game has what is now known as a Nash equilibrium in mixed strategies. Nash was very important for the development of the concept of the Prisoner's Dilemma, which in competitive environments, is highly observable, becoming a major focus of study. Delving a little deeper into Game Theory itself, we can essentially divide it into 3 major groups: Games of Skill, Games against Nature and Strategic Games. This paper will contribute to the existing literature on mixed cartels that, so far, is still rather scarce, given the rarity of this type of cartel.

As far as the game theory applications, over time it has been used in a huge range of studies belonging to many different fields. The main fields of study and application of game theory are economics and business, in which it can be addressed auctions, acquisitions and mergers, price structures, and oligopolies. Industrial organization is a field that deals with the strategic behavior of firms, regulatory policies, competition in markets, and antitrust policies, so it makes perfect sense that game theory is strongly applied in this field.

This paper focuses essentially on the competition and antitrust part, more precisely on anti-competitive behaviors. These anti-competitive behavior practices are mainly observed through the formation of cartels and collusion. Over the last 20 years there were many cases of conviction for anti-competitive practices in Portugal, more precisely 93 cases, coming from the most diverse sectors of activity, like commerce and services, distribution and the food and media.

2. LITERATURE REVIEW

The most relevant theory to the subject of this paper is mainly found in the Strategic Games and will make it possible to explain the characterization of the game in which Cartel da Banca is inserted. Within this category of

games are incorporated two-person games ($n = 2$) and n-person games ($n \geq 2$). For two-person games, they can be of zero-sum and non-zero-sum, the gains of one player do not necessarily correspond to the losses of the other; this type of game combines competitive aspects with some opportunities for collaboration so, some assumptions about the degree of communication need to be made. With no communication, the concept of Nash Equilibrium arises and when communication between players is available, the concept of Nash Bargaining Solution arises. Increasing the number of players leads to n-person games, which is the type of game that represents the topic in study, that is,

Cartels and collusive behaviors being the main manifestations of anti-competitive practices directly affect the functioning of the markets in which they are present. This literature review aims to analyze and then understand how the various authors have dealt with these events and see their opinions and conclusions. The topic will focus on something closely related to the Cartel da Banca: mixed cartels and banking activity itself will be addressed.

2.1. Cartel Formation

When it comes to cartel formation, or better the decision to join a cartel or not, there are differences if this decision is made by just one individual or by a group, Kerr et al. (1999) and Kerr and Tindale (2004) explained these differences from a psychological point of view, however, in the context of Industrial Organization, Insko et al. (1998) found that groups are more competitive than individuals (which they called the Discontinuity Effect) explaining that groups are less trustworthy than individuals and are more selfish in situations where they expect cooperation from others, which would lead to fewer cartels and lower prices. Gillet et al. (2011) compared decisions made by groups and by individual people in a Bertrand-type game, and they found no evidence to support the evidence of fewer cartels and lower prices when decisions

were made by groups. They even found that there was no difference in the tendency for cartels to form whether decisions were made by individuals or groups, however, prices would always be higher if there was a cartel. They also defined that when a group makes the decision, that decision is either made by the CEO, Majority, or Consensus, and without a cartel, the prices set are higher if they are chosen by the CEO or Majority compared to Consensus and Individual choice with a cartel the prices set by the CEO tend to be higher than when it is by Majority with Consensus and Individual choice prices being somewhere in between. Therefore, CEO pricing decisions tend to be the highest whether or not there is a cartel.

The main challenge in measuring the impact of competition policies or antitrust laws on cartels and collusive behaviors is that the total population of cartels is unobservable and only the cartels that have already been discovered are observed. Harrington Jr and Chang (2009) built a model in which in some industries there would be cartels and in others not, in some cases the cartels would collapse and in others not, and in some cases, they would be discovered and in others not, using a Prisoner's Dilemma formulation. They found that competition policies are effective in reducing the rate of cartel formation and that there is an increase in the number of cartels discovered. Feinberg (2016) grouped the main determinants of the stability and consequent duration of cartels into three categories: factors that affect the profitability of collusive activities, factors affecting the monitoring and ease of organization of cartel members and actions of the government in terms of detection and prosecution. From the first category, the author drew that it is expected that there will be differences across industries in the incentives for cartel formation. From the second, the number of actual and potential cartel members is quite high, which makes it very difficult to monitor them all so, it is necessary to identify characteristics of certain

members that can help to force an agreement to denounce cartels and from the last, the author says, it is expected that its actions will have an influence on the stability of cartels.

2.2. Types and Factors that facilitate collusion

Under the law of competition there is a clear and important distinction between explicit and tacit collusion. Explicit collusion is when a group of firms communicate directly with each other, with the intention of coordinating. Tacit collusion occurs when firms coordinate and monitor their actions but without direct communication (this behavior is usually not considered illegal so firms guilty of tacit collusion face no penalties despite the fact that their conduct leads to similar economic effects as explicit collusion.). Garrod and Olczak (2017) developed a simple framework that captures the incentives for explicit collusion when firms can alternatively collude tacitly saying it is common sense that cartels are more likely to happen in markets with fewer firms, coming to the conclusion that the medium number of firms in a cartel was five.

Byford and Gans (2014) argue that there is still another mechanism by which a collusive arrangement can arise, and it is called collusion by the extensive margin, where firms collude by avoiding entering each other's markets or business territories. Turning now to the strategic variables used to collude, the factors that facilitate collusion cannot always predict the occurrence of cartels. Examples of such factors are the concentration of the industry under study, the homogeneity of the product, the symmetry of the firms present in that market, and regular orders. The impact of these factors is quite clear and can easily be explained and derived from analyses of simple repeated games. However, the power of the factors that facilitate collusive behaviors effectively help in predicting cartel formation is quite limited. Several authors such as Posner (1970), Hay and Kelley (1974), Grout and Sonderegger (2005) and Levenstein and

Suslow (2006) when studying the correlation between these factors and the frequency of cartel detection led to empirical results that do not report clear results.

2.3. Success of Cartels and Determinants of Success

Harrington Jr (2021) taking convicted cartel cases has developed research that answers the questions whether in fact it is harmful to consumers when firms share information and if it is harmful, what should these information exchanges be subject to. He concluded that private exchanges of price information by competitors are harmful to consumers when the cost of adjusting the price is neither too low nor too high, adding that the agreement on information exchanges that causes the harm since it is the anticipation of sharing prices that causes firms to set high prices. According to Levenstein and Suslow (2006), cartels to be successful have to solve 3 problems: coordination, cheating, and potential market entry. The most successful cartels create organizations to be able to deal with these three problems simultaneously.

2.4. Antitrust, Fines and Sanctions

Cosnita-Langlais and Tropeano (2022) identified two ways that competition agencies have at their disposal to address an antitrust violation through anticompetitive practices: negotiate a settlement with the infringing firm or to decide to pursue formal litigation. Going the formal litigation route can be favorable because it leads to the creation of legal precedents that serve as a useful stock of knowledge for evaluating future cases (over 70% of abuse of power cases were resolved with commitments).

2.5. Mixed Cartels

"Cartel da Banca", which was a well-known and recently highly talked about Portuguese case involved private banks but also a public one, thus speaking of a mixed cartel. Mixed cartels are not very often discussed since, when thinking about collusion it is only

thought that it is practiced by private entities. Correia-da-Silva and Pinho (2017) tried to understand what are the effects of a potential privatization of the public entities participating in the collusion so that the cartel becomes more private and found that it makes collusion easier to sustain, becoming socially detrimental when firms are only able to collude after privatization. This notion goes against the traditional belief that privatization is socially desirable if there are too many firms in the same industry. By studying the presence of a public firm in a collusion, Mota et al. (2020) tried to understand what was the impact of that firm's preference for the consumer surplus. Using a simple model of only one private firm and one public firm, they characterized the collusion outcome that resulted from the Nash bargaining power (equally distributed) between the two firms and compared it with the competitive outcome and evaluated the sustainability of that same collusion concluding that without collusion, the public firm, by having a preference for consumer surplus produces more than the private firm, leading to productive inefficiencies. Collusion reduces or even eliminates these inefficiencies since it makes possible the transfer of outputs from the public firm to the private firms.

3. THE CASE OF CARTEL DA BANCA

Cartel da Banca, according to the accusations of the Autoridade da Concorrência (AdC) involved 14 banking entities operating in Portugal and together hold about 95% of market share of the Portuguese banking market, that between 2002 and 2013 communicated with each other sharing confidential information about housing loans. The banks in question accused were Caixa Geral de Depósitos (CGD), Banco Português Comercial (BCP), Santander Totta, Banco Português de Investimentos (BPI), Banco Montepio, Banco BBVA, Banco Espírito Santo (BES), Banco BIC, Crédito Agrícola, Banco UCI, Barclays, Banif and Deutsche Bank and The AdC sentenced them to pay fines for

exchanging sensitive and private commercial information. In this scheme the banks provided information about their commercial offers. The case against the Cartel da Banca essentially rests on 7 charges and in face of these charges the argument used by the major banks has been based on saying that the shared data "was public" and accessible and that the decisions made by the banks "helped customers".

4. BANKING MARKET IN PORTUGAL

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
National Institutions								22	22	22
Foreign Institutions								14	14	14
Total	53	53	50	40	48	48	45	36	36	36

YEAR	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
National Institutions	21	22	18	18	19	17	18	17	19	19
Foreign Institutions	13	10	10	11	12	13	14	12	11	11
Total	34	32	28	29	31	30	32	29	30	30

The table show the number of financial institutions in Portugal over the years and passing now to the definition of the type of market that is the Portuguese banking market, it is necessary to make an assessment of the competition in this market and an increase has been observed in the concentration of the Portuguese banking system since 1990. This development was particularly evident in the 1990s and was reinforced in two periods during which major mergers and acquisitions took place – 1995 and 2000 so, it can be concluded that, the Portuguese financial market has an oligopolistic market structure, although close to competition.

5. RESEARCH METHODOLOGY

Regarding mixed cartels, it has been shown that the existing literature is still very limited given the rarity of public companies participating in cartels. The purpose of this paper is to contribute precisely to this, that is, with the creation of a model applicable to potential mixed cartels, that first demonstrates under which conditions the creation of the cartel is preferred and then whether it has conditions to be sustainable. Considering cost symmetry among all players,

that is, that all players present an identical cost, the model is applied to markets where firms are competing à la Cournot, that is, in quantity. This decision variable is set for the long term so, setting Q is typical in cartels and by deciding on Q , P gets determined by the demand curve.

Taking as a starting point Mota et al. (2020). The extension of this model to the one developed here involves two important points, one being a simplification and the other an increase in the scope of application of the model. After defining the theoretical model and applying it to the banking cartel with the relevant specific data from the Portuguese banking market, we will first compare the quantities produced by both types of banks in the two situations (competition and cartel) and then, for private banks, we will compare the profit they would obtain under the competition scenario with the profit they would obtain under the cartel or the staying out of the cartel scenario and, for public banks also in the competition versus the cartel situation. Once this is done, the results and conclusions obtained are then discussed in order to determine the incentives of each type of bank to form a cartel and then the explanation of what the consequences of the creation of the cartel were. At the end, this Paper ends with the overall conclusion and main findings made in conducting this study.

6. THEORETICAL MODEL

Consider an industry with 1 public firm, p , and n private firms, $i = 1, 2, \dots, n$, producing homogeneous products over an infinite period of periods. In each period, the firms simultaneously choose quantities, q_p and q_i . Demand is linear and is given by the function $P = 1 - Q$, where Q is the sum of the quantities of all firms, that is, total output, $q_p + q_i$.

The total cost of producing q units is the same for the public firm as for the private firms, following the model of De Fraja and Delbono

(1989) and Correia-da-Silva and Pinho (2018), resulting in the total cost being given by $TC(q) = cq$ (giving $MC(q) = c$).

The profit function for each private firm i , is given by the expression:

$$\max_{q_i} \Pi_i = \left(1 - q_i - \sum_{\substack{j=1 \\ j \neq i}}^n q_j - q_p - c \right) \cdot q_i$$

The profit function for the public firm, p , is given by the expression:

$$\max_{q_p} \Omega = \mu CS + (1 - \mu)\pi_p = \mu \frac{(\sum_{i=1}^n q_i + q_p)^2}{2} + (1 - \mu) \left(1 - q_p - \sum_{i=1}^n q_i - c \right) q_p$$

The coefficient μ is the weight that the public firm gives to consumer surplus. For example, if the firm is purely profit maximizing, then $\mu = 0$, on the other hand, if the firm gives as much weight to own profit as to consumer welfare, then $\mu = \frac{1}{2}$. Both parameters μ and c must have values between 0 e 1 ($0 < \mu < 1$; $0 < c < 1$).

6.1. Nash Equilibrium (pre-cartel situation)

In the situation of normal competition, the market equilibrium is obtained naturally, and a Nash equilibrium is reached. Private firms choose the quantity, q_i^N , while the public firm chooses the quantity, q_p^N . These quantities are obtained through First Order Conditions (FOC) and are as follows:

- For the private firms:

$$\frac{\partial \pi_i}{\partial q_i} = 0$$

- For the public firm:

$$\frac{\partial \Omega}{\partial q_p} = 0$$

Knowing the individual quantities of the firms, it is possible to obtain the profit equation of each firm, to know the payoffs of each (π_i^N for private and Ω^N for public) for the non-cooperative situation.

6.2. Collusive agreement (Explicit collusion/ Cartel situation)

In this cartel, not all firms, particularly the private ones, that are active in the market participate. So, this cartel consists of 1 public firm and m private firms ($m < n$). By assuming that the private firms all produce the same quantity, it is adjacent to assume that these firms are symmetric, however, when comparing the private firms to the public firm this assumption can no longer be made, as the public firm is asymmetric to the private firms.

For this model, the modeling of the cartel scenario was done by creating the following objective functions.

For the firms inside the cartel:

$$\begin{aligned} \max_{q_i, q_p} m \Pi_i + \Omega \\ m \left(1 - q_i - \sum_{\substack{ii=1 \\ ii \neq i}}^m q_{ii} - q_p - \sum_{l=m+1}^n q_l - c \right) q_i \\ + \mu \frac{(\sum_{i=1}^m q_i + \sum_{l=m+1}^n q_l + q_p)^2}{2} \\ + (1 - \mu) \left(1 - \sum_{i=1}^m q_i - \sum_{l=m+1}^n q_l - q_p - c \right) q_p \end{aligned}$$

For the firms outside the cartel (all private, denominated as l)

$$\max_{q_l} \Pi_l = \left(1 - q_l - \sum_{\substack{ll \neq l \\ ll=1}}^n q_{ll} - \sum_{i=1}^m q_i - q_p - c \right) q_l$$

The way to determine the quantities of each type of firm is done in a manner analogous to the pre-cartel situation, using First Order Conditions.

- For the private firms inside the cartel:

$$\frac{\partial (m \Pi_i + \Omega)}{\partial q_i} = 0$$

- For the public firm inside the cartel:

$$\frac{\partial (m \Pi_i + \Omega)}{\partial q_p} = 0$$

- For the private firm outside the cartel:

$$\frac{\partial \Pi_l}{\partial q_l} = 0$$

Then, in the practical application of this cartel model, by defining n and m , it is possible to obtain the quantities q_i^* , q_p^* and q_l^* . Adding all these quantities together will give the total cartel quantity, Q^* . Then, again using the inverse demand equation, we obtain the final price, P^* .

7. MODEL APPLICATION TO CARTEL DA BANCA

7.1. Nash Equilibrium (pre-cartel situation)

Solving the FOC mentioned above regarding the competition scenario:

- For the private bank:

$$\frac{\partial \pi_i}{\partial q_i} = 0 \Rightarrow q_i = \frac{1 - q_p - c}{n + 1}$$

- For the public bank:

$$\frac{\partial \Omega}{\partial q_p} = 0 \Rightarrow q_p = \frac{nq_i(1 - 2\mu) - (1 - c)(1 - \mu)}{(3\mu - 2)}$$

By combining the two expressions, the Nash quantities of the pre-cartel equilibrium are as follows.

$$q_i^N = \frac{(1 - c)(1 - 2\mu)}{n(1 - \mu) + 2 - 3\mu}; q_p^N = \frac{(1 - c)(1 + \mu(n - 1))}{n(1 - \mu) + 2 - 3\mu}$$

Bearing in mind that $c < 1$ and $\mu < 1$. The next step to take into account is to make sure that the individual quantities of both the private banks and the public bank have to be positive. Solving the 2 inequations and joining the intervals resulting from solving each one, it follows that for the pre-cartel situation, $\mu \in [0, \frac{1}{2}]$, that is, μ has to be smaller than 0.5. Then the total quantity, price, and are also obtained.

$$Q^N = \frac{(1 - c)(n + 1)(1 - \mu)}{n(1 - \mu) + 2 - 3\mu}; P^N = \frac{c(n + 1)(1 - \mu) + 1 - 2\mu}{n(1 - \mu) + 2 - 3\mu}$$

To finish the chapter on competition, all that remains is to know the expression of the profits of the two types of banks.

$$\Pi_i^N = \frac{((1 - c)(1 - 2\mu))^2}{(n(1 - \mu) + 2 - 3\mu)^2};$$

$$\Omega^N = \frac{(1 - c)^2(1 - \mu)(-\mu^2(n^2 + 6n - 3) + \mu(n + 5)(n - 1) + 2)}{2(n(1 - \mu) + 2 - 3\mu)^2}$$

7.1.1. Impact of the parameters n, c, μ

Regarding the total quantity (Q^N) equation, higher the n , the higher the total quantity available in the market, the higher the c , the lower the total quantity and the higher the μ , the higher the total quantity will be. Regarding the price (P^N) equation, the impacts of the parameters on price are symmetric to their impact on total quantity. Regarding the private banks profit (Π_i^N) equation, the higher n , the lower the profit of the private banks will be, the higher the c , the lower the profit of the private banks and the higher the μ , the lower the profit of the private banks. Finally, regarding the public bank profit (Ω^N) equation, the higher the n , the lower the public bank's objective function will be, the higher the c , the lower the objective function will be and the higher the μ , the higher the public bank's objective function.

7.2. Collusive agreement (Explicit collusion/ Cartel situation)

Solving the FOC mentioned above regarding the cartel scenario:

- For the private banks inside the cartel:

$$q_i = \frac{-2mq_p(1 - \mu) - m(n - m)(1 - \mu)q_l + m(1 - c)}{m^2\left((1 - \mu) + \frac{1}{m}\right)}$$

- For the public bank inside the cartel:

$$q_p = \frac{-2mq_i(1 - \mu) - (n - m)(1 - 2\mu)q_l + (1 - c)(1 - \mu)}{2 - 3\mu}$$

- For the private bank outside the cartel:

$$q_l = \frac{1 - q_p - mq_i}{n - m + 1}$$

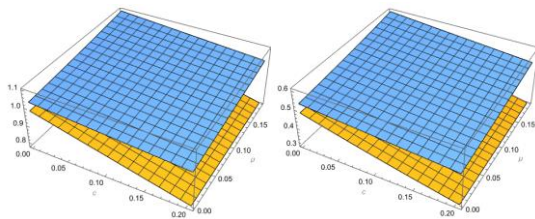
Considering $n = 52$ and $m = 13$ (data of 2002, year of the cartel creation), combining the 3 expressions gives the final quantities of each bank type. After, once again making sure that the individual quantities of the banks are positive, new ranges for the parameters are discovered: $0 < c < 0.2043$ and $< \mu < 0.1882$. Knowing the individual quantities of each type of bank in the cartel situation, the total quantity available in the market, Q^* and the price, P^* can be deduced. To finalize the

application of the model in the cartel situation, it is necessary to obtain and analyze the expressions of the banks' objective functions.

Disclosure: Impossible to show the expressions due to their complexity.

8. KEY COMPARISONS AND DISCUSSION

This step is one of the most important steps of this paper because it provides relevant information on: benefits or harms of the creation of this cartel (compare the total quantity and consumer surplus), and on the incentives that each type of bank had to join the cartel on the incentives that they had to use the leniency program. The first action is to apply in the expression of the total quantity under competition the known values relative to banking activity in Portugal in 2002. From which it is already known that 53 banks operated in Portugal.

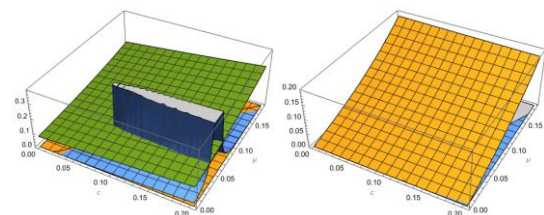


On the left the graph of total quantity and on the right the graph of CS. The total quantity and CS under competition are shown in orange and the total quantity and CS under the existence of the cartel are shown in blue. There is one scenario that always comes out on top, the one under the existence of the cartel. This result is highly contradictory to the existing theory regarding the impacts on the market with the existence of a cartel, namely the fact that theoretically the total quantity and consumer surplus would decrease as well. but can be explained because, although there is a cartel, the profit maximization of private banks is done in combination with the optimization of the public bank's objective function, which values the consumer surplus and causes the quantity to increase.

8.1. Incentive to form the cartel

For the private banks, the individual quantity produced banks under competition is always positive for all combinations of the parameters within the set values. However, the same is not true when looking at the quantity produced by these banks under the existence of the cartel. For the region where all three quantities are positive, two situations happen: one, the lowest quantity produced is by those outside of the cartel, followed by the quantity produced by private banks under competition, and the highest quantity produced is by the banks participating in the cartel and second, the order reverses, meaning that the lowest quantity is produced by the banks participating in the cartel, followed by the quantity produced by the private banks under competition and finally the highest quantity is produced by the banks that stay out of the cartel. However, it is much more likely to choose a parameter combination that falls on the first situation, resulting in the private banks inside the cartel being the largest producers. For the public bank, the scenario of under competition, always produces more quantity.

Moving on to the incentives of the different banks to form the cartel, on the left the payoffs of the private banks, on the right, the payoffs of the public one. There is only incentive if the payoff is higher.



Regarding the private banks' payoffs, under competition is the lowest of the three situations. As for the profit under the existence of the cartel where banks may or may not participate in it, it depends for which region of values is being studied. For the most part, the profit is higher when staying out of the cartel, but for the low values of μ , the best option is

to participate in the cartel. The fact that the payoffs of the ones outside the cartel grow more than the payoff of the ones inside the cartel is a free-riding incentive, where the banks became "softer" and internalized the adverse effects of the competition that existed between them.

Regarding the public banks' payoffs, in the vast majority of the parameter combinations, the objective function presents higher values in the scenario under competition, however, for values of μ very close to 0, the best option is to join the cartel. There, the public firm has practically no regard for consumer surplus, so it is like a normal cartel, in which there is a gain in participating, however a small variation of μ is enough for the public company to prefer to stay out of the mixed cartel. Putting all this information together, it is possible to see that for both types of banks to participate in the cartel, the public bank assigned a very low value to the parameter μ , which can lead to the conclusion that the public bank adopted an extreme position, which is not what is expected from a state-owned company.

8.2. Consequences of the existence of the cartel

Since the cartel did exist, and both the public bank and some private banks were part of it, it is possible to assess the consequences arising from it, namely in terms of the total quantities available, consumer surplus, and in the end the resulting price. According to the results of the model, the total quantity available and consumer surplus after the formation of the cartel were higher than when all banks were under competition, which is a positive aspect and, consistent with the quantity being higher, the resulting price after the cartel formation was lower, turning it to be the best option for the consumer.

The increase in quantity lies mainly in the increase in the individual quantity produced by the private banks, since with the existence of a cartel the quantity produced by the public bank is lower. This makes the public bank the

biggest beneficiary because it decreased the quantity produced and increased its payoffs.

8.3. Incentive to use the leniency program

Barclays, knowing that with the cartel all parties involved were better off than when they were competing, the only explanation why it reported the cartel is that after 11 years of cartel activity, it was no longer being able to bear the extra quantity compared to the competition scenario that was required by the cartel participation scenario. Or the bank officials would have known well in advance that in 2014 the bank would exit the Portuguese banking market, perhaps they saw this as an opportunity to leave the cartel without any kind of charges or fine to be paid. Upon exiting the market, there is incentive to report the cartel as there is nothing more to be gained from it. That said, the game comes to an end. For Barclays this game went from an infinitely repeated game (this is the case for all the banks in the cartel) that can lead to collusion to a finite repeated game, where there is no more incentive for cooperation, leading to expose the cartel

9. CONCLUSION

The cartel did exist, and both the public bank and some private banks were part of it. The only way that the cartel could have been created, with both types of banks, was if the public bank assigned very low values to μ , this way, the role of the public bank to optimize the social function becomes distorted, not having much concern for consumer surplus, from which can be concluded that the public bank adopted a very extreme position. So, this suggests that the cartel was created in a highly unconventional manner since the only way the private banks knew about the value of μ , was if it had been the public bank that told them this information and had taken the initiative to create the cartel or if it had been an arrangement between all of them and there had been consent from the public bank to set the value low. However, the biggest result with the biggest policy implications is that the

creation of mixed cartels can lead to benefits in terms of increasing total quantity and consumer surplus.

There were some limitations, so some assumptions had to be made: all players have the same cost function and produce the same quantity. Two suggestions for future work are, since the banks' financing costs may be very low, redo the model without the parameter c , as it would allow to see better the dependency on μ ; admit different costs in a possibly still tractable way, by considering that companies differ by a common constant to "adjacent" firms when ranked in terms of efficiency.

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