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# Pro-competitive Price Beating Guarantees: Experimental Evidence

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**Abstract.** We report experimental results on duopoly pricing with and without price beating guarantees (PBG). In two control treatments, price beating is either imposed as an industry-wide rule or offered as a business strategy. Our major finding is that when price beating guarantees are imposed as a rule or offered as an option, effective prices are equal to or lower than those in a baseline treatment in which price beating is forbidden. Also, when price beating is treated as a business strategy, less than 50% of subjects adopted the guarantee, suggesting that, subjects realize the pro-competitive effects of the guarantee.

**Key words:** experimental oligopolies, price beating guarantees.

**JEL Classifications:** C91, L11.

## I. Introduction

At a first glance, a low-price guarantee can be seen as a advertisement of a firm's willingness to offer the best price in the market. In that case, price guarantees could represent a strategy intensifying competition among oligopolists. As observed in Edlin (1997), "a price matching policy seems the epitome of cutthroat competition: what could be more competitive than sellers' guaranteeing their low prices by promising to match the prices of any competitor?". Furthermore, a firm's commitment to *beat* rather than simply *match* its rivals' prices or the lowest price in the market should be considered as a sign of even stronger competition among oligopolists. However, since Stigler's (1964) early work on oligopoly, it has been recognized

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that low-price guarantees may be used by colluding firms as a way of effectively detecting deviations by disloyal partners. In that sense, the apparently pro-competitive practice of matching or beating any rival's price may have anti-competitive effects. Early papers by Porter (1983a, 1983b), Green and Porter (1984) and Dobson and Sinclair (1990) had already argued that the lack of price transparency may contribute to cartel failures. Thus, transparency-enhancing strategies (like low price guarantees) could facilitate collusion.

Starting with the seminal work of Salop (1986), theoretical and empirical research has contributed to an ongoing debate on whether low price guarantees facilitate tacit collusion leading to higher prices and profits. Although price matching guarantees are beyond the scope of this paper, the majority of authors seem to agree that matching a rival's price may lead to higher price levels for a number of different reasons.

In the case of price beating guarantees, the debate gained momentum only more recently. Furthermore, there seems to be a systematic division of opinions on the effects of such guarantees, which are not treated as illegal *per se* by either European or US antitrust authorities.

For example, Dixit and Nalebuff (1991), Sargent (1993) and Baye and Kovenock (1994) conclude that price-beating guarantees are effective supporting high prices. On the basis of these analyses, they claim antitrust actions should be taken against this class of guarantees. There is, however, some tension in this argument as recent papers have argued in the opposite direction. Corts (1995) and Hviid and Shaffer (1994) suggest that if firms can promise to beat as well as match posted prices, the Bertrand intuition may re-emerge as firms offer in practice unmatchable final prices. In related work, Hviid and Shaffer (1999) extend the analysis of low price guarantees by removing the traditional assumption that it is costless for consumers to activate the guarantee. The introduction of *hassle costs* borne by the consumers claiming the promised re-imbursement is sufficient to limit the ability of price guarantees to support supra-competitive prices. On the other hand, Doyle (1988) and Edlin (1997) show that monopoly pricing is restored if both final and posted prices can be matched or beaten, an assumption which better fits with the spirit of guaranteed lowest prices. Also, Kaplan (2000) finds that even with price-beating guarantees, if the strategy set is expanded to include policies on effective as well as announced prices, the collusive result is re-established.

The relevant empirical work for price guarantees starts from quite different points and no work provides conclusive evidence. In an analysis of conventional supermarket price setting Hess and Gerstner (1991) documents the anticompetitive effects of low price guarantees, as these allow firms to tacitly collude on increasing prices to supra-competitive levels. Smith et al. (2000) look at evidence of pricing patterns in digital markets to find that, as in Corts (1996), price matching provides a price discrimination technique for Internet retailers.

Using a different approach (the scrutiny of guarantee adoption patterns on Sunday newspapers in the US), Arbastkaya et al. (1999 and 2001) conclude that price guarantees (both matching or beating) do not have any effect on the firms' own prices, although they point out that this result may be due to firm, market or guarantee heterogeneity.

There are some good reasons for this lack of irrefutable conclusions concerning the effects of price beating on prices. First, as long as collusion is an illegal activity, it is always difficult to study anti-competitive practices in real markets. This is because it is usually impossible to say what prices would have been in place without collusion, at least in the absence of precise cost and demand conditions. This makes the experimental laboratory an ideal environment for determining which market conditions facilitate the emergence of supra-competitive prices. A further advantage of laboratory experiments like the ones reported here is that usual unrealistic assumptions like full information on demand and cost conditions, agent homogeneity and capacity to explicitly calculate optimal strategies can be relaxed. Often[1] but not always[2] implicit optimization with try-and-error algorithms based on feedback received from previous own strategies has been found to converge towards limit strategies predicted by static game-theoretic equilibrium concepts. Therefore, our experiment aims at studying price beating guarantees as a mechanism favoring convergence towards higher price levels, rather than as a transparency-enhancing device used to sustain collusive agreements.

Along this line, the paper by Deck and Wilson (2003) is the only experimental study so far on an issue related to price beating guarantees, corresponding to what they call an automated "undercutting" algorithm. Their results show that, contrary to price matching, price beating or trigger strategies lead prices near (or below, in the case of the latter) the static Nash equilibrium prediction.[3]

Contrary to the design of Deck and Wilson (2003) whose subjects are offered a wider and complex variety of pricing policies (none of which coincides with the price beating guarantee used here), our design is different in that it permits a specific comparison of different market environments, by studying price beating guarantees as a market institution and as a business strategy. The two control designs are compared to each other

[1] García-Gallego (1998).

[2] García-Gallego and Georgantzís (2001).

[3] The puzzling result that most subjects kept on offering the non profitable undercutting guarantee and abandoning the profitable price matching one seems to be context dependent: subjects simultaneously chose the extent of the different guarantees, so complexity might play a role.

and each one of them to a baseline setup in which no price beating commitment is available. In this way, we guarantee that, sufficient evidence is obtained on markets in which price beating is totally absent (treatment I), globally present (treatment II) and voluntarily adopted by the subjects (treatment III). Therefore, data availability on different combinations of prices and pricing policies do not depend on the observed adoption rates. Also, alternative matching protocols are studied: "strangers" vs. "partners". In this way, we implement two different levels of difficulty for the collusive outcome to be tacitly reached.

Our findings are twofold. First, although in most cases the availability of price beating policies leads to higher posted prices, effective prices remain close or even below non cooperative (Bertrand) levels. Second, subjects realizing the pro-competitive effects of price beating guarantees, adopt it in less than half of the cases. A clear cut policy implication is that a *per se* treatment of price guarantees by antitrust authorities is unnecessary.

The remaining part of the paper is structured as follows: Section II describes the experimental design; the results are analyzed and discussed in Section III and Section IV concludes.

## II. Experimental Design

Consider a price-setting duopoly in which two firms choose a posted price ($p_i^{\mathrm{p}}$) and a price policy:

$$\delta_i = \begin{cases} \mathrm{NPB} = \text{No Price Beating} \\ \mathrm{PB} = \text{Price Beating} \end{cases} \tag{1}$$

Let the effective price of firm $i$ under each one of these strategies be:

$$p_i^{\mathrm{e}} = \begin{cases} p_i^{\mathrm{p}} & \text{if } \delta_i = \mathrm{NPB} \\ p_i^{\mathrm{p}} - \alpha(p_i^{\mathrm{p}} - \min\{p_i^{\mathrm{p}}, p_{-i}^{\mathrm{p}}\}) & \text{if } \delta_i = \mathrm{PB} \end{cases} \tag{2}$$

In the second part of (2), the parameter. $\alpha$ denotes the reduction in own posted price promised by a firm adopting a guarantee as a reaction to a lower rival price. Generally speaking, the parameter corresponds to price matching ($\alpha = 1$) or price beating ($\alpha > 1$). We focus on the latter of the two cases. Then, the higher the value of $\alpha$ is, the fiercer is the undercutting announced by the firm adopting the guarantee. For example, a "double-the-difference" guarantee corresponds to $\alpha = 2$. Each one of two firms, $j$ and $k$, sells one of the two varieties of a differentiated product, knowing that the demand for each variety is given by:

$$q_i = V - \beta p_i^{\mathrm{e}} + \gamma p_{-i}^{\mathrm{e}} \tag{3}$$

where $\{i, -i\} = \{j, k\}$. $V$ is the demand intercept, while $-\beta$ and $\gamma$ represent, respectively, the derivatives of the demand with respect to own and rival prices. The unit (marginal, average) cost of production, $c$, is constant and equal for both firms. Therefore, the profits of firm $i$ are given by:

$$\Pi_i = (p_i^{\mathrm{e}} - c)q_i. \tag{4}$$

We consider the following salient solutions:

1. The Bertrand Nash Equilibrium (BNE) of the one-shot game, satisfying the first order conditions: $\frac{\partial \Pi_i}{\partial p_i} = 0$.
2. The Collusive solution (CS), satisfying the first order conditions: $\frac{\partial \Pi}{\partial p_i} = 0$, where $\Pi = \Pi_j + \Pi_k$.

In order to study the effect of PB guarantees on prices, we consider three different treatments. In all treatments, two firms (each represented by an experimental subject) offer two varieties of a differentiated good during 50 rounds. In the baseline treatment (BSL) subjects decide on posted (thus, effective) prices only. In all other treatments PBGs were introduced using two different Implementation Rules (IR): First, PBGs were exogenously imposed as an industry-wide institution (labeled as "Market rule" or "M"). Second, PBGs were offered to the subjects as an option (labeled as "Business strategy" or "B"). In treatments using the second implementation rule, each firm's effective selling price depends both on own and rival posted prices as well as on the price-policy decisions.

To check for the robustness of the effects on market prices, we use two different matching mechanisms: strangers and partners. In the former (labeled as "S"), random pairs of subjects are formed in each period, whereas in the latter (labeled as "P") subject pairs forming duopolies are kept constant throughout the session. Obviously, the strangers protocol does not prevent subjects from being matched with the same opponent more than once along a session, but the probability is relatively low. Note that protocol "S" implies an unfavorable environment for the emergence of collusion and provides a strong test for the hypothesis of anti-competitiveness of PBGs. Analogously, the "P" protocol provides a strong test for the hypothesis of competitive behavior. Table I summarizes all treatments, classified by design variables. For each treatment using a strangers matching protocol, we ran two experimental sessions, whereas for treatments with a partners protocol a single session was run.[4] As PBGs were introduced both as a market rule and a business strategy, we ran a total of 6 PBGs sessions

[4] For each experimental sessions with a strangers protocol, we strictly obtained a single independent observation from the 900 decisions (50 pricing decisions times 18 subjects), so we run twice as many sessions as under a partners protocol.

*Table I.* Summary table

| Treatment | PBG | RMM | IR | Sessions label | Markets | Subjects |
|---|---|---|---|---|---|---|
| BSL-S | No | Strangers | – | S11, S12, | 18 | 36 |
| BSL-P | No | Partners | – | S13 | 9 | 18 |
| PBG-SM | Yes | Strangers | Market rule | S21, S22 | 18 | 36 |
| PBG-SB | Yes | Strangers | Business strategy | S31, S32 | 18 | 36 |
| PBG-PM | Yes | Partners | Market rule | S23 | 9 | 18 |
| PBG-PB | Yes | Partners | Business strategy | S33 | 9 | 18 |
| | | | | Total | 81 | 162 |

with 18 subjects each. A total of 162 subjects participated in the experiment.

The time structure of the game is as follows. At each round of BSL and M treatments, subjects decide independently and simultaneously the posted price of the variety they sell. At the end of each round, subjects receive feedback regarding own and (this round's) rival prices, demands and profits. A complete history of these results and the corresponding actions is also available to them. In BS, each firm decides both on its posted price and price policy, receiving additional information concerning the price-policy decision by the rival firm. In fact, firms decide their posted prices in every round, but they choose whether they adopt or not a PB policy every five rounds. This design represents the fact that in the real world prices may be changed more often than the pricing policies. Furthermore, this sequence of 5-period pricing games during which price policies are kept fixed allows subjects to "learn" the optimal price that corresponds to each combination of own and rival policies. Once the players' information is updated, a new round starts. Subjects are not aware of the underlying demand model and have equal and common information about the rules of the game.

In Table II, we present competitive and collusive equilibrium values for prices, demands and profits for the parameter values used in the analysis: $V=730, \beta=1.5, \gamma=0.5$ and $c=30$. These parameter values were chosen so that theoretical predictions were not focal points in any way. Subjects could post any price between 30 (below-unit-cost pricing was not allowed) and 1000 (including non-integer prices in steps of 0.1 monetary units) expressed in experimental currency units (ExCUs). Also, a relatively high price beating parameter ($\alpha=2$) was chosen, making our results rather specific to the case of aggressive price beating.[5]

[5] Although not unrealistic, given numerous examples of price beating announcements of the type: *"if you find it cheaper, we double the difference"*.

*Table II.* Theoretical values of prices, demand and profits

| | Bertrand–Nash equilibrium (BNE) | Collusive solution (CS) |
|---|---|---|
| $p_i$ | 310 | 380 |
| $q_i$ | 420 | 350 |
| Π | 117600 | 122500 |

Inexperienced subjects were recruited among undergraduate students from different economics or business-related courses, using standard recruitment procedures at the University of Valencia.[6] Before the beginning of each session, subjects were given written instructions, while the organizers read aloud the instructions and answered any remaining questions.[7] At the end of each session, subjects were privately paid in cash. A typical session lasted 60–80 minutes (depending on the experimental treatment) and subjects obtained average earnings of about € 18. All sessions were computerized and carried out at the LINEEX,[8] using a specific software based on the Z-Tree toolbox.[9]

## III. Experimental Results

### 1. Descriptive Statistics and Figures

It is a general feature of our results that, in all sessions, price dispersion decreases over time. In Table III we see that the standard deviation of prices is lower in the second half of a session than in the first half of it.[10]

On the same table, we can see that profits get closer to the Bertrand equilibrium prediction as we move from the initial 25 rounds to the last 25 ones. As we would have expected, baseline duopolies formed by partners (session S-13) reach the highest profits among all sessions towards the

[6] By means of specific public advertisements and by phone using our subjects' database.

[7] The translated instructions are included in the appendix.

[8] Experimental Economics Laboratory at the University of Valencia.

[9] Z-Tree is designed to program and conduct economic experiments and was originally developed by Urs Fischbacher at the Institute for Empirical Research of Economics (University of Zürich).

[10] Similar results are obtained (detailed results are available upon request) by regressing for each experimental session per-period standard deviation on a dummy variable that takes the value of 1 for the last twenty five rounds and 0 otherwise. All coefficients estimated are negative and significant (depending on the treatment, they range between −21.9 and −94.2) indicating a lower dispersion of prices over time. As García-Gallego and Georgantzís (2001) point out, this is partly a consequence of subjects' lack of information about the true demand model, forcing them to randomly choose their initial price strategies which, following some try-and-error learning, get closer to the theoretical values as the session proceeds.

*Table III.* Observed price averages (Av), standard deviations (SD) and percentage of Bertrand profits ($\%\Pi_B$) for rounds 1–25 and rounds 26–50

| Treatment | Posted/ effective | $Av_{1-25}$ | $SD_{1-25}$ | $Av_{26-50}$ | $SD_{26-50}$ | $\%\Pi_B^{1-25}$ | $\%\Pi_B^{26-50}$ |
|---|---|---|---|---|---|---|---|
| *BSL-S* | | | | | | | |
| S-11 | $p_i$ | 280.70 | 67.29 | 284.74 | 44.97 | 90.56 | 94.47 |
| S-12 | $p_i$ | 303.18 | 70.25 | 293.52 | 32.56 | 93.22 | 96.13 |
| *BSL-P* | | | | | | | |
| S-13 | $p_i$ | 328.19 | 117.24 | 331.32 | 59.25 | 89.52 | 99.01 |
| *PBG-SM* | | | | | | | |
| S-21 | $p_i^p$ | 386.72 | 143.31 | 324.50 | 61.23 | | |
| | $p_i^e$ | 265.38 | 125.72 | 260.54 | 72.74 | 75.03 | 86.16 |
| S-22 | $p_i^p$ | 433.60 | 165.64 | 380.69 | 96.07 | | |
| | $p_i^e$ | 273.94 | 159.74 | 285.02 | 111.15 | 67.03 | 83.05 |
| *PBG-PM* | | | | | | | |
| S-23 | $p_i^p$ | 341.81 | 193.10 | 426.29 | 164.37 | | |
| | $p_i^e$ | 252.36 | 179.82 | 340.18 | 171.62 | 60.30 | 75.47 |
| *PBG-SB* | | | | | | | |
| S-31 | $p_i^p$ | 328.56 | 102.88 | 295.51 | 45.78 | | |
| | $p_i^e$ | 278.81 | 104.22 | 283.03 | 52.53 | 83.77 | 93.24 |
| S-32 | $p_i^p$ | 399.82 | 185.37 | 308.57 | 67.51 | | |
| | $p_i^e$ | 291.22 | 170.53 | 269.75 | 68.70 | 67.29 | 88.42 |
| *PBG-PB* | | | | | | | |
| S-33 | $p_i^p$ | 388.49 | 181.04 | 371.65 | 145.03 | | |
| | $p_i^e$ | 319.93 | 163.72 | 323.04 | 128.82 | 74.64 | 85.28 |

second half of the session. Interestingly, the same matching protocol under price beating as a market rule yields the lowest profits as compared to any other session for both the first and the second half of the session.

Figures 1–3 show average per round prices (effective, in the case of R and B treatments) for each treatment under the two matching protocols (M and S). The Bertrand Nash Equilibrium (BNE, dotted line) and Collusive Solution (CS, continuous line) price levels are also provided.

Although formal econometric tests are performed below based on observations generated as subject-specific averages, some preliminary observations are in order. Generally speaking, the BNE prediction seems to be a better predictor of average effective prices. However, partner sessions yield higher prices than sessions with a stranger protocol. In fact, in some cases, the CS is reached or even exceeded in partner sessions.

In Figures 4 and 5 we observe that the profits corresponding to treatments with price beating as a rule (M) or as an option (B) yield lower profits than BSL, under both matching protocols.

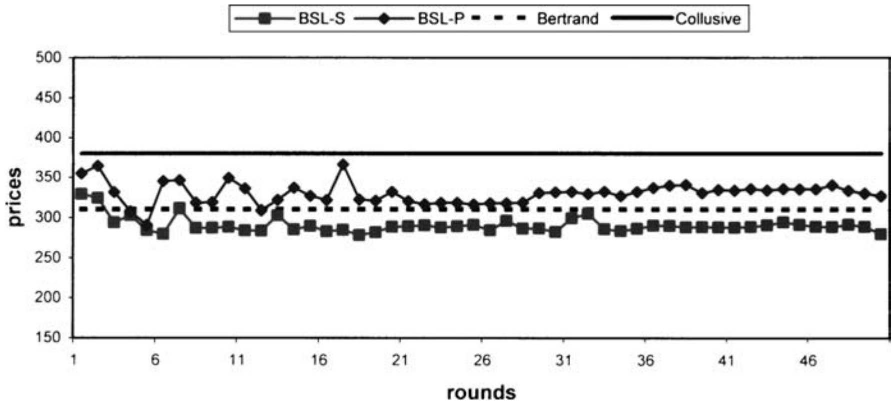


*Figure 1.* Evolution of average per round prices, BSL-S and BSL-P.

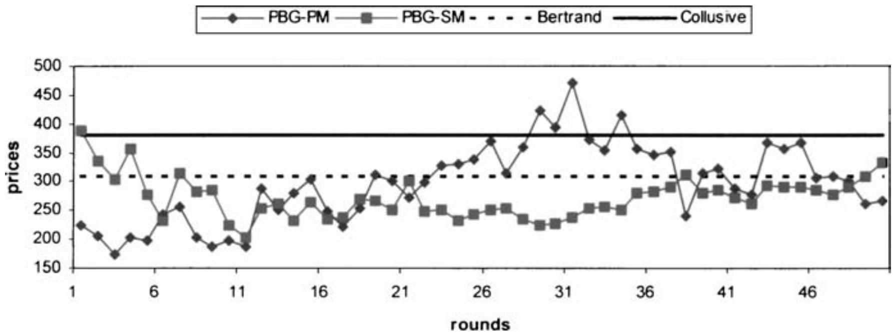


*Figure 2.* Evolution of average per round effective prices, PBG-SM and PBG-PM.

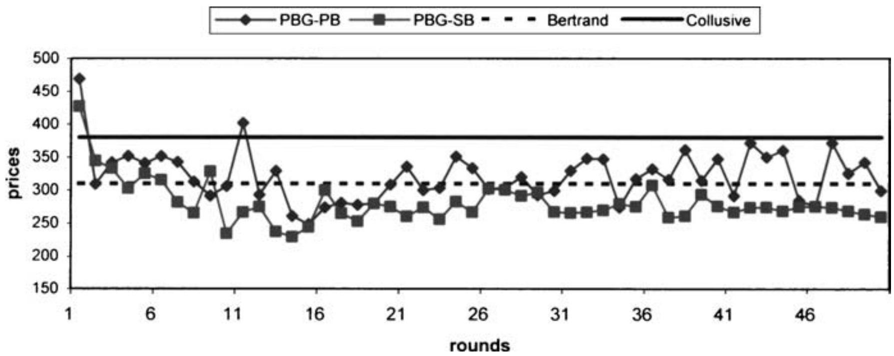


*Figure 3.* Evolution of average per round effective prices, PBG-SB and PBG-PB.

Aggregating the individual observations obtained in the last 25 rounds, we can estimate[11] the density functions presented in Figures 6–8; they confirm previous findings by García-Gallego (1998) on the ability of

[11] Details on the estimation method are provided in the appendix.

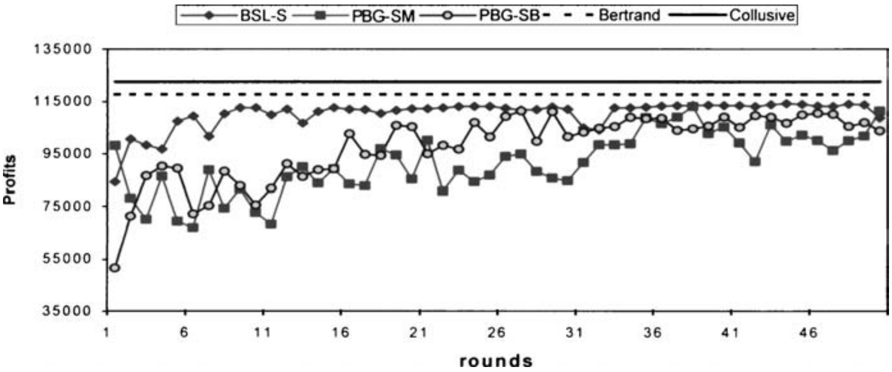


*Figure 4.* Evolution of average per round profits, BSL-S, PBG-SM and PBG-SB.

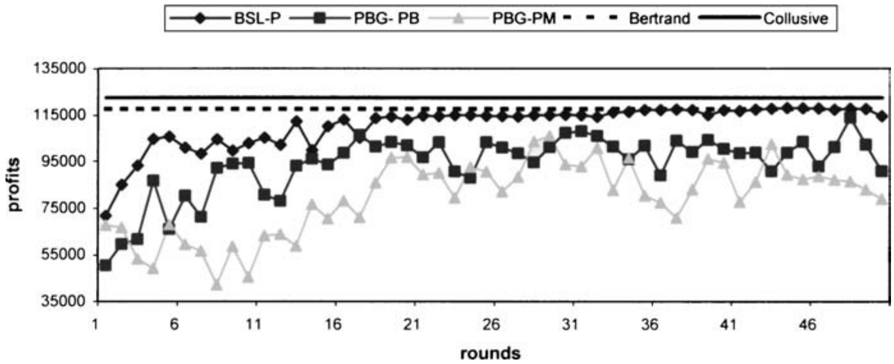


*Figure 5.* Evolution of average per round profits, BSL-P, PB-PM and PB-PB.

the static Bertrand Nash Equilibrium to explain observed behavior in symmetric differentiated oligopolies better than the corresponding joint-profit maximizing solution. Although Figures 7 and 8 show an almost identical pattern for both matching protocols when price beating guarantees are available, price distributions under a strangers protocol in the BSL sessions are more skewed around the BNE prediction than are prices collected under a partners protocol.

## 2. Comparison of Prices and Profits across Treatments

To compare prices and profits across treatments, we estimate a model taking into account all the experimental treatments at the same time. We use panel data techniques to estimate a random effects model using the following reduced form equation:

$$s_{it} = \beta_0 + \beta_1 D_{\mathrm{M}} + \beta_2 D_{\mathrm{B}} + \beta_3 D_{\mathrm{P}} + \beta_4 D_{\mathrm{M}} D_{\mathrm{P}} + \beta_5 D_{\mathrm{B}} D_{\mathrm{P}} + \mu_{it} \tag{5}$$

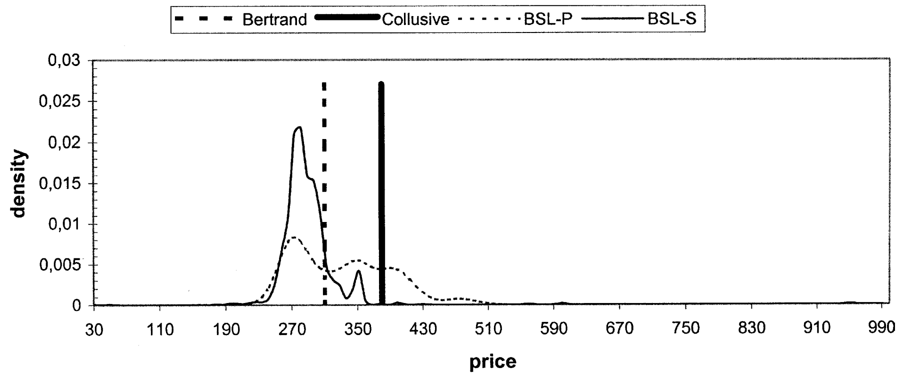


*Figure 6.* Density function corresponding to observed prices in BSL-S (continuous curve) and BSL-P (dotted curve) against the BNE (dotted vertical line) and the CS (continuous vertical line) predictions.

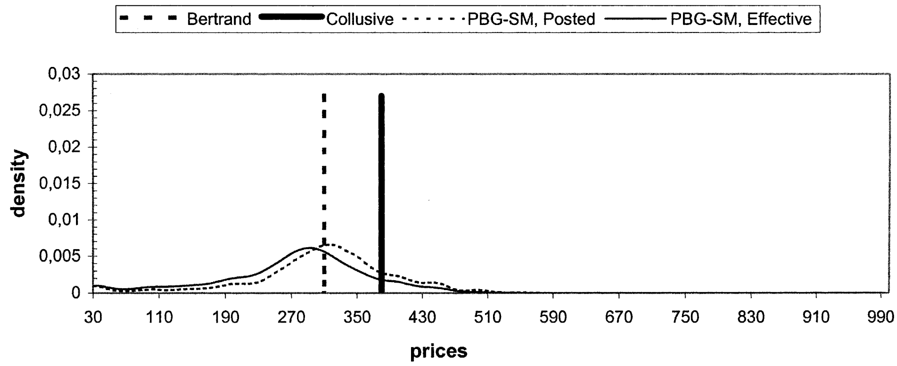


*Figure 7.* Density functions corresponding to effective prices in PBG-SM (continuous curve) and PBG-PM (dotted curve) against the BNE (dotted vertical line) and CS (continuous vertical line) predictions.

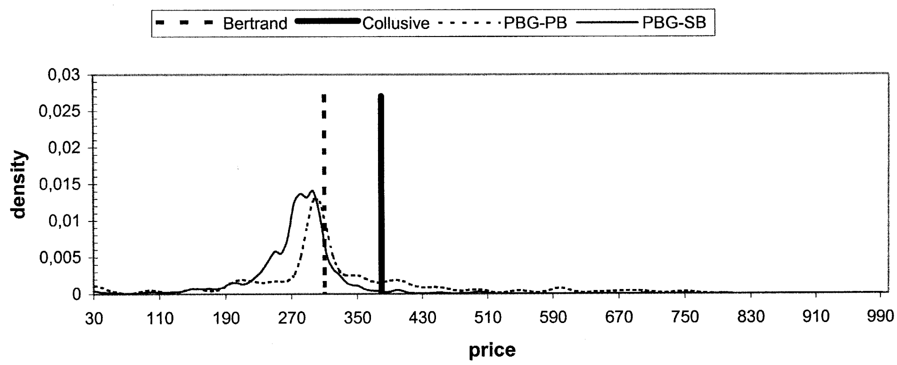


*Figure 8.* Density functions corresponding to effective prices in PBG-SB (continuous curve) and PBG-PB (dotted curve) against the BNE (dotted vertical line) and CS (continuous vertical line) predictions.

where the endogenous variable, $s_{it}$, is price or profit of firm $i$ in period $t$ (for $t = 26, \ldots, 50$). $D_M$ is a dummy variable set equal to one for prices (profits) of the experimental sessions in which PBG is a market rule. $D_B$ is a dummy variable set equal to one for prices (profits) of the sessions in which PBG is a business strategy, $D_P$ is a dummy variable set equal to one for prices (profits) of the sessions in which subjects are matched using a partners protocol, and $\mu_{it} = \alpha_i + \delta_t + \varepsilon_{it}$ where $\alpha_i$ are the individual effects that are considered as random effects, $\delta_t$ are the time effects that are considered as fixed effects and $\varepsilon_{it}$ is the error term.

By construction, $\beta_0$ is the mean price (profit) for the BSL sessions in which subjects are matched using a strangers protocol and $\beta_3$ is the average variation to this price (profit) due to the change from a random to a partner protocol. Further, $\beta_1$ and $\beta_2$ are the average price (profit) differentials between PBG-M and BSL ($\Delta_S^{PBG-M/BSL}$) and PBG-B and BSL ($\Delta_S^{PBG-B/BSL}$) when subjects are matched using a strangers protocol. Analogously, $(\beta_1 + \beta_4)$ and $(\beta_2 + \beta_5)$ are the average price differentials PBG-M/BSL ($\Delta_P^{PBG-M/BSL}$) and PBG-B/BSL ($\Delta_P^{PBG-B/BSL}$) for partners sessions. The average price variations of PBG-M and PBG-B prices due to the change from a strangers to a partners protocol ($\Delta_{P/S}^{PBG-M}$ and $\Delta_{P/S}^{PBG-B}$) are $(\beta_3 + \beta_4)$ and $(\beta_3 + \beta_5)$, respectively.

The average differences in differentials, ($\bar{\Delta}^{PBG-M/BSL} = \Delta_P^{PBG-M/BSL} - \Delta_S^{PBG-M/BSL}$ and $\bar{\Delta}^{PBG-B/BSL} = \Delta_P^{PBG-B/BSL} - \Delta_S^{PBG-B/BSL}$) compare the impact of the PBG guarantee in the partners sessions and in the strangers sessions ($\bar{\Delta}^{PBG-M/BSL}$ is given by $\beta_4$ and $\bar{\Delta}^{PBG-B/BSL}$ by $\beta_5$).

The estimates of (5) for posted prices, effective prices and profits appear in Table IV. To facilitate interpretation, beside each variable appears in parentheses the average price differential or average difference in differentials that the coefficient of the variable estimates. Thus, for example, the coefficient of the $D_B D_P$ interaction term is an estimate of $\bar{\Delta}^{PBG-B/BSL}$. In Table V we show the $\chi^2(1)$ tests comparing each one of the estimated average prices (profits) to the BNE price (profit).

### 2.1. *Comparison of Average Effective Prices*

The estimates indicate that the average effective price in the baseline sessions in which subjects are matched using a strangers protocol (288.04) is significantly below the Bertrand-Nash prediction (see Tables IV and V). However, average effective price in the partners session in which a PBG is not available (330.27) is not significantly different from the one corresponding to the Bertrand-Nash prediction.

Regardless of the matching protocol, the introduction of PB either as a market institution or as business strategy does not result in average effective prices significantly different from those obtained when PBG is not

*Table IV.* Price differentials for effective prices, posted prices and profits

| | Effective prices | Posted prices | Profits |
|---|---|---|---|
| Constant | 288.05 (0.000) | 288.44 (0.000) | 110747.5 (0.000) |
| $D_M \left(\Delta_S^{PBG-M/BSL}\right)$ | −16.32 (0.179) | 63.50 (0.000) | −12811 (0.000) |
| $D_B \left(\Delta_S^{PBG-B/BSL}\right)$ | −12.71 (0.295) | 12.94 (0.354) | −5492 (0.055) |
| $D_P \left(\Delta^{BSL-P/BSL-S}\right)$ | 42.22 (0.004) | 42.22 (0.014) | 4131 (0.239) |
| $D_M D_P \left(\bar{\Delta}^{PBG-M/BSL}\right)$ | 25.17 (0.231) | 31.48 (0.193) | −14875 (0.003) |
| $D_B D_P \left(\bar{\Delta}^{PBG-B/BSL}\right)$ | 4.42 (0.833) | 27.38 (0.258) | −10664 (0.032) |
| Number of obs | 4050 | 4050 | 4050 |
| $R^2$ | 7.41 | 18.33 | 10.55 |

Note: *p*-values between brackets.

*Table V.* Comparison of average effective prices, average posted prices and average profits to the BNE (BNE price = 310; BNE profit = 117600)

| | Effective prices | | | Posted prices | | | Profits | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average | $\chi^2(1)$ | *p*-value | Average | $\chi^2(1)$ | *p*-value | Average | $\chi^2(1)$ | *p*-value |
| BSL-S | 288.04 | 4.35 | 0.037 | 288.44 | 3.62 | 0.057 | 110747 | 6.87 | 0.00 |
| PBG-SM | 271.72 | 13.21 | 0.000 | 351.94 | 13.71 | 0.000 | 97936 | 56.57 | 0.00 |
| PBG-SB | 275.34 | 10.83 | 0.001 | 301.39 | 0.58 | 0.447 | 105255 | 22.30 | 0.00 |
| BSL-P | 330.27 | 2.23 | 0.136 | 330.67 | 1.89 | 0.169 | 114878 | 0.68 | 0.41 |
| PBG-PM | 339.12 | 4.60 | 0.032 | 425.64 | 59.19 | 0.000 | 87193 | 84.52 | 0.00 |
| PBG-PB | 321.99 | 0.78 | 0.378 | 371.00 | 16.47 | 0.000 | 98722 | 32.57 | 0.00 |

If the price (profit) is higher than the BNE price (profit) we test the null hypothesis that price (profit) is higher than the BNE price (profit). If the opposite happens we test the null hypothesis that the price (profit) is lower than the BNE price (profit)

available, given that ($\Delta_S^{PBG-M/BSL}$, $\Delta_S^{PBG-B/BSL}$, $\Delta_P^{PBG-M/BSL}$ and $\Delta_P^{PBG-B/BSL}$ are not significant. The only relevant effect is that although not significantly different from the BSL-P average price, the PBG-PM average price is higher than the BNE one.

Furthermore, the positive and significant $\Delta_{P/S}^{PBG-M} = \Delta^{BSL-P/BSL-S} + \bar{\Delta}^{PBG-M/BSL}$ and $\Delta_{P/S}^{PBG-B} = \Delta^{BSL-P/BSL-S} + \bar{\Delta}^{PBG-B/BSL}$ (67.40 and 46.65, respectively) suggest that average effective prices for the partners protocol PBG-M and PBG-B sessions are higher than the corresponding strangers protocol average effective prices. However, the average price variation induced by the introduction of PB either as a market institution or as a business strategy is independent of the matching procedure, given that neither $\bar{\Delta}^{PBG-M/BSL}$ nor $\bar{\Delta}^{PBG-B/BSL}$ are significant.

The results on effective prices can be summarised as follows:

*Result 1:* If PB is not included among the alternatives, the average effective price is below the BNE price in the strangers sessions and not significantly different from it in the partners session.

*Result 2:* Independently of the matching mechanism, the introduction of PB either as a market rule or as business strategy has no significant effect on average effective prices.

*Result 3:* As in the BSL sessions, average effective prices under PB as market rule and as a business strategy are higher when the matching mechanism is partners than when it is strangers.

### 2.2. *Comparison of Average Posted Prices*

Neither the average posted price in the baseline sessions with a random matching protocol (288.44) nor the average posted price in the corresponding partners session (330.67) are significantly different from the BNE price (at a conventional 5% level of siginificance). However, the BSL-P average posted price is significantly higher than the BSL-S average posted price (the BNE price is in an intermediate situation between the higher BSL-P average price and the lower BSL-S one).

Regardless of the matching protocol, the introduction of PB as a market rule increases posted prices as both $\Delta_{S}^{PBG-M/BSL}$ and $\Delta_{P}^{PBG-M/BSL}$ are positive and significant (their estimates are 63.50 and 94.97, respectively). As a result, average posted prices both for the PBG-SM sessions and for the PBG-PM session are above the BNE price. However, the introduction of PBG as a business strategy raises average posted price in the partners session but not in the strangers sessions ($\Delta_{P}^{PBG-B/BSL}$, 40.32, is significant, nevertheless $\Delta_{S}^{PBG-B/BSL}$ is not significant). As a consequence, whereas average posted price for the PBG-PB session is above the BNE, average price for the PBG-SB sessions is not significantly different from the BNE one (as it is when PBG is not allowed). Furthermore, both in strangers and partners sessions posted prices are higher under PB as a market institution than under PB as a business strategy $\Delta_{S}^{PBG-M/PBG-B}$ and $\Delta_{P}^{PBG-B/PBG-B}$ are 50.56 and 54.65, respectively).

Finally, the positive and significant $\Delta_{P/S}^{PBG-M} = \Delta^{BSL-P/BSL-S} + \bar{\Delta}^{PBG-M/BSL}$ and $\Delta_{P/S}^{PBG-B} = \Delta^{BSL-P/BSL-S} + \bar{\Delta}^{PBG-B/BSL}$ (73.70 and 69.61, respectively) indicate that average posted prices for the partners protocol PBG-M and PBG-B sessions are higher than the corresponding strangers protocol average posted prices.

We can summarize the results on posted prices in the following way:

*Result 4:* Average posted prices when PB is available to the subjects are higher than when it is not, except when PB is a business strategy and a strangers protocol is used.

*Result 5:* Like in the BSL sessions, average posted prices under PB as a market rule and as a business strategy are higher when the matching mechanism is partners than when it is strangers.

## 2.3. *Comparison of Average Profits*

Whereas average profit for the BSL session in which subjects are coupled using a partners protocol is not significantly different from the BNE profit, average profit in the corresponding strangers session is below this profit (average profit for the strangers protocol sessions is 110747 and for the partners protocol session 114878). Moreover, the fact that $\Delta^{BSL-P/BSL-S}$ is not significant indicates that different matching protocol does not imply significantly different profits in the BSL sessions.[12]

Both for strangers and partners sessions, the introduction of PB either as a market rule or as a business strategy results in lower average profit. In fact, average profits for the sessions in which PBG is available are always below the BNE profit (independently of the matching protocol and whether PBG is a market rule or a business strategy). Besides, average profit is significantly lower in the sessions in which PB is a market rule.

When a strangers protocol is used, average profits in the PBG-M and in the PBG-B sessions are respectively 12811 ($-\Delta_S^{PBG-M/BSL}$) and 5492 ($-\Delta_S^{PBG-B/BSL}$) lower than in the corresponding BSL sessions. For the partners sessions, profits are 27685 ($-\Delta_P^{PBG-M/BSL}$) and 16516 ($-\Delta_P^{PBG-B/BSL}$) lower than in the corresponding BSL session.

Furthermore, the negative and significant $\Delta_{P/S}^{PBG-M} = \Delta^{BSL-P/BSL-S} + \bar{\Delta}^{PBG-M/BSL}$ and $\Delta_{P/S}^{PBG-B} = \Delta^{BSL-P/BSL-S} + \bar{\Delta}^{PBG-B/BSL}$[13] ($-10743$ and $-6532$, respectively) indicate that average profits for the partners protocol PBG-M and PBG-B sessions are lower than the corresponding strangers protocol average profits.

The results on profits can be summarized as follows:

*Result 6:* If PBG is not included among the alternatives, the average profit of the strangers sessions is below the Bertrand-Nash equilibrium profit, and the average profit of the partners session is not significantly different from it.

*Result 7:* When PBG is included among the alternatives, independently of the matching mechanism and whether PBG is a market rule or a business strategy, average profits are lower than when PBG is not available to the subjects.

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[12] This result is due to the fact BSL-P the average profit (114878) is in an intermediate situation with respect to the lower BSL-M average profit (110747) and to the higher BNE profit (117600).

[13] It is significant only at 10% level.

*Result 8:* Independently of whether PBG is a market rule or a business strategy, when PBG is included among the alternatives, average profits are in higher in strangers sessions than in partners sessions.

## 3. Adoption Rates, Prices and Profits

To analyse the effect of PB adoption on posted prices and profits in the sessions in which PB is a business strategy, we estimate a random effects model using the following reduced form equation:

$$\mathcal{S}_{it} = \beta_0 + \beta_1 D_{\mathrm{A}} + \beta_2 D_{\mathrm{P}} + \beta_3 D_{\mathrm{A}} D_{\mathrm{P}} + \mu_{it} \tag{6}$$

where the endogenous variable, $\mathcal{S}_{it}$, is posted price or profit of subject $i$ in period $t$ (for $t = 26, \ldots, 50$). $D_{\mathrm{A}}$ is a dummy variable set equal to 1 if the subject adopted PB, $D_{\mathrm{P}}$ is a dummy variable set equal to one for prices (profits) of the sessions in which subjects are matched using a partners protocol, and $\mu_{it} = \alpha_i + \delta_t + \varepsilon_{it}$ where $\alpha_i$ are the individual effects that are considered as random effects, $\delta_t$ are the time effects that are considered as fixed effects and $\varepsilon_{it}$ is the error term.

By construction, $\beta_0$ is the mean price (profit) for the subjects that did not adopted PB in a strangers protocol session, $\beta_2$ is the average variation to this price (profit) due to the change from a random to a partners protocol. Further, $\beta_1(\Delta_{\mathrm{S}}^{\mathrm{A}})$ and $\beta_1 + \beta_3(\Delta_{\mathrm{P}}^{\mathrm{A}})$ are the average differential between the prices (profits) of the subjects who adopted PB and those that not adopted PB in the strangers and partners sessions, respectively.

The estimates of (6) for posted prices and profits appear in Table VI. For posted prices, different results are obtained from strangers and partners sessions. Whereas, in partners sessions, subjects adopting PB post significantly higher prices than subjects not adopting ($\Delta_{\mathrm{P}}^{\mathrm{A}} = 110.96$ is significant at 1 % level), in the strangers sessions there is no significant difference between the prices posted by adopters and non-adopters ($\Delta_{\mathrm{S}}^{\mathrm{A}}$ is not significantly different from 0).

*Table VI.* PB adoption and prices

| | Posted prices | Profits |
|---|---|---|
| Constant | 301.25 (0.000) | 103987 (0.000) |
| $D_{\mathrm{A}}$ | 4.29 (0.553) | −4220 (0.036) |
| $D_{\mathrm{P}}$ | 14.83 (0.363) | 3198 (0.387) |
| $D_{\mathrm{A}} D_{\mathrm{P}}$ | 106.67 (0.000) | −18534 (0.000) |
| Number of obs | 1350 | 1350 |
| $\mathrm{R}^2$ | 30.40 | 32.38 |

Independently of the matching rule, profits are lower for adopters than for non adopters, as both $\Delta_S^A$ and $\Delta_P^A$ are negative and significant (these are −4220 and −22755, respectively).

Hence the effects of PBG adoption on posted prices and profits can be summarized in the following way:

*Result 9:* When PB is a business strategy, posted prices of adopters are higher than those of non-adopters only in partners sessions.

*Result 10:* When PB is a business strategy and independently of the matching mechanism, profits of non adopters are higher than profits of adopters.

Result 10 serves to explain the patterns of PBG adoption shown in Figures 9 and 10. These figures present the number of subjects adopting the guarantee in each one of the periods in which the option is available. Also "entry" and "exit" results indicate the percentages of subjects changing from non adoption to adoption (the former) and from adoption to non adoption (the latter) across consecutive PBG adoption–decision rounds.

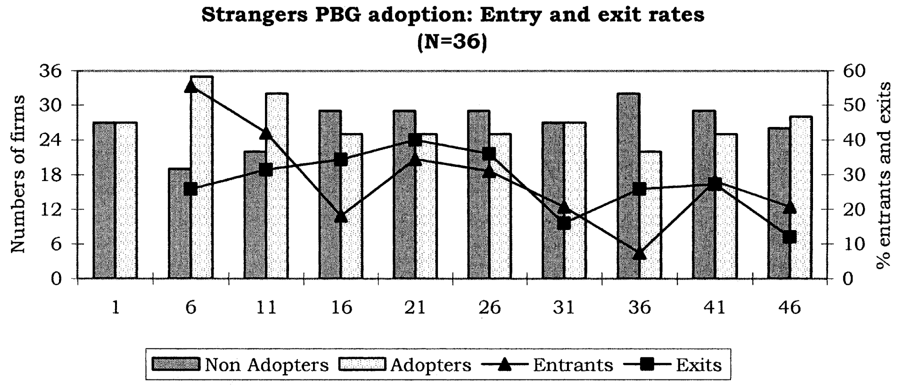


*Figure 9.* PBG-S adoption patterns.

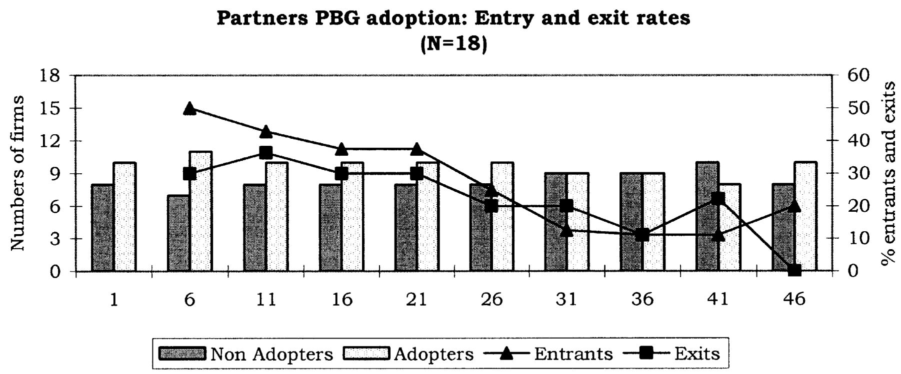


*Figure 10.* PBG-P adoption patterns.

Overall, a relatively stable pattern of adoptions is observed dividing the subjects almost equally between adopters and non adopters. Furthermore, entry and exit rates exhibit a moderately declining trend over time, which indicates that the mobility of firms from adoption to no adoption and vice versa decreases over time.

This finding contrasts with excessively high and certainly counterintuitive percentages of adoption (over 90%) obtained in Deck and Wilson (2003). Our control for the effects of endogenous guarantees indicates that the negative effects of PBG's on profits are perceived by the subjects and this is reflected on a low frequency of PBG adoption.

## IV. Conclusions

In this paper, we analyze the effects of price beating guarantees in an experimental differentiated Bertrand duopoly. We consider treatments where price beating is introduced in two different ways: as a market institution (Treatment II) and as a market variable (Treatment III). The two Treatments are then compared to a baseline Treatment (TI) which is run in the absence of any price guarantee. All sessions are replicated under two different matching protocols: *partners* and *strangers*. On the one hand, the matching protocol effect is significant and in the expected direction: repeatedly playing with the same rival leads to higher (although not collusive) prices. Furthermore, our results suggest that PB guarantees yield effective prices which are not significantly higher to those obtained in the absence of any price guarantee.

Our guarantee-adoption data can be used to explain why some firms may be adopting price beating guarantees, despite the fact they have a negative impact on profits. On one hand, we have already said that aggressive guarantees like the ones studied here have no impact on effective prices. On the other, the posted prices of adopters are higher than those posted by non-adopters, but only when interaction is repeated among permanent pairs of rivals. Therefore, a clear pattern seems to exist: Subjects may adopt price beating guarantees as a costly pre-commitment or signal for collusion among repeatedly interacting oligopolists, reflected on higher posted prices, but the result is a more competitive environment, yielding close-to-competitive effective prices and lower profits.

Opposite to policy recommendations based on theoretical work by Dixit and Nalebuff (1991), Sargent (1993) and Baye and Kovenock (1994), and in accordance with results obtained by Hviid and Shaffer (1994) and Corts (1995), we have argued that some types of low price guarantees -like the price beating policy studied here- may have pro-competitive effects (without ruling out possibly anti-competitive intentions). Although our experiment takes place in an environment which is different to those assumed in all these papers, the conclusion of the need for a case-by-case consideration emerges as a common feature. In that case, a *per se* attitude by the authorities could have clearly undesirable effects. Of course, a case-by-case consideration is always easy to recommend but rather difficult to implement in practice. We would agree with Edlin's (1997) recommendation of maintaining a cautious policy towards the socially undesirable sources of low price guarantees (the collusive or the discriminatory, which is receiving increasing support in the marketing literature[14]) rather than totally prohibiting this possibly pro-competitive business strategy.

## Appendix A

### A.1. Instructions (translated from Spanish)

The aim of this experiment is studying decision-making in economic environments. The rules are pretty simple. You will be privately paid in cash at the end of the experiment according to your accumulated earnings. Feel free to any questions regarding these instructions. Any communication among the participants is strictly forbidden. Below is some useful information:

1. This experiment lasts 50 Rounds. In each round, you will be randomly matched with another subject to create pairs of subjects. You will never know the identity of your partner.
2. In the experiment you are a firm and, in each round, you have to decide about the selling price of the only product you produce. The available price range is between 10 and 1000 ExCUs (an Experimental Currency Unit).
3. *(For Treatments II and III)* We will call this price the posted price.
4. *(Only for Treatment III)* You also have to decide whether you will offer a price beating guarantee. If you do so and your posted price exceeds the posted price of the other firm, your effective selling price will be your price minus twice the difference between your price and the other firm's posted price. Then, your effective selling price will be calculated in the following way:

   $$p_1^{\mathrm{e}} = p_1^{\mathrm{p}} - 2(p_1^{\mathrm{p}} - p_2^{\mathrm{p}})$$

5. *(Only for treatment II)* Your posted price may differ from the effective selling price as there is a pricing rule in the market called price beating guarantee. This rule compares posted prices in the market and allows consumers to buy the product at the firm offering the

[14] See Moorthy and Winter (2002).

lowest price, so that if your posted price exceeds the posted price of the other firm, your effective selling price will be your price minus twice the difference between your price and the other firm's posted price.

6. *(Only for treatment III)* There are two types kinds of rounds in this experiment:

   a. Round $1, 6, 11, \ldots, 46$), in which you have to make a decision about both your posted price and whether you offer a price beating guarantee.
   b. All other rounds, in which you have to decide on your posted price.

7. For each round, the time structure of the experiment is the following. Every time you make a decision, you will receive information concerning:

   a. (Treatment I) Your price, demand and profits and the price, demand and profits of each firm with which you compete in each round.
   b. (Treatment II) Your posted price, effective selling price, demand and profits and the posted, effective price, demand and profits of each firm with which you compete in each round.
   c. (Treatment III) Your posted price, effective selling price, demand and profits and the posted, effective price, demand and profits of each firm with which you compete in each round.You will also receive information concerning the price guarantees of both firms.

8. Demand in each round depends only on your firm's decision and the decision of the other firm in the market. Once these two decisions have been made, you will know your product's demands and your firm's profits in the round.
9. At the end of the experiment, you will reveive a monetary reward equal to your firm's profits exchanged at a rate of 3000 ExCUs for 1 Spanish peseta (or 500,000 ExCUs=1 €).

## A.2. Appendix II: The Kernel Function

We smooth last 25 period price distributions using a kernel function $K$ which satisfies:

$$\int_{-\infty}^{\infty} K(x)dx = 1 \tag{7}$$

Among multiple options for the kernel selection, we have chosen the Gaussian Kernel because of computing straightforwardness. The expression of the function used is:

$$K(t) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}t^2} \tag{8}$$

Kernel smoothing consists of estimating the following density function:

$$\hat{f}(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left[\frac{x - X_i}{h}\right] \tag{9}$$

where $h$ is a smoothing parameter (window width or bandwidth), $n$ is the number of observations and $X_i$ is the ith-observation of the variable under study. This kernel estimator is a sum of bumps placed at the observations and determines the shape of the bumps while the window width $h$ determines their width. Bandwidth selection is much more important than the selection of kernel's. If $h$ is chosen too small, then an excessive number of bumps is generated and spurious fine structure become visible. If $h$ is chosen too large, then some features of the data are lost. In order to offer a reasonable balance between these two extremes, we choose the $h$ proposed in Sheather and Jones (1991) from the study by Park and Marron (1990) due to its proved superior performance.

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