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REGULAR ARTICLE

Are low-price promises collusion guarantees? An experimental test of price matching policies

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Abstract In a symmetric differentiated experimental duopoly we test the ability of Price Matching Guarantees (PMG) to raise prices above the competitive levels. PMG are introduced both as a *market rule* (the selling price is always the lowest posted price) and as a *business strategy* (subjects decide whether or not to offer them). Our results show that PMG lead to a clear collusive outcome as markets quickly and fully converge to the collusive prediction if PMG are imposed as a market rule. Whenever subjects are allowed to decide whether to adopt PMG or not we observe that almost all subjects decide to adopt them and prices get very close to the collusive ones.

Keywords Price-matching guarantees · Experimental economics

JEL Classification C91 · L11

Introduction

It is rather common for firms to guarantee their prices by promising to match their competitors' prices. Price Matching Guarantees (PMG) are intended to make customers confident that they are being charged the lowest prices; a clear

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pledge of competitive prices.[1] As Edlin (1997) suggests, "a price matching policy seems the epitome of cutthroat competition: what could be more competitive that sellers' guaranteeing their low prices by promising to match the prices of any competitor?".

Despite the competitive nature of these clauses, an extensive economic literature starting with Salop (1986) has argued that, contrary to conventional wisdom, PMG facilitate tacit collusion for at least three reasons. First, they act as an incentive-management device discouraging price-cutting by rival firms. Secondly, PMG provide the customer with an incentive to report competitors' price cuts, so they become an exchange information device for firms. Last, firms offering PMG can profitably discriminate between informed and uninformed customers. Whilst some customers with both the time and the incentive to search may invoke the guarantee, the uninformed customers will provide additional revenue to the firm as they face the highest prices.

The effect of PMG has been extensively analyzed in the theoretical literature.[2] Bertrand competition between symmetric firms with a differentiated good is intensely altered by the introduction of PMG, as equilibria with prices higher than the ones corresponding to the Bertrand–Nash equilibrium emerge. Even when all symmetric equilibria are pareto rankable, it is not obvious which equilibrium would emerge in such a complex competition.[3] Moreover, the market effect of price guarantees depends on their specific features. Hviid and Shaffer (1999) extend the analysis of PMG by removing the traditional assumption that it is costless for consumers to activate the guarantee. They introduce the notion of hassle costs[4] and show that the introduction of these costs can limit the ability of price matching guarantees to support supra-competitive prices.

Relative to PMG, Dixit and Nalebuff (1991) and Sargent (1993) conclude that *price-beating guarantees* are even more effective than PMG at supporting high prices. On the basis of these analyses, they claim that antitrust actions should be taken against this class of guarantees. However, Corts (1995), and Hviid and Shaffer (1994) argue in the opposite direction. If firms can promise to beat as well as match posted prices, then the competitive outcome re-emerges. These models restore the Bertrand intuition because firms can offer effective prices that are, in practice, unmatchable. In recent contributions to this debate, Edlin (1997) and Kaplan (2000) show that monopoly pricing is restored if both effective and posted prices can be matched or beaten.

The empirical analysis of the collusive effect of PMG is scarce and far from conclusive, most probably because sellers try to hide competition restraining

[1] Arbastkaya et al. (1999) survey evidence on patterns of PMG adoption.

[2] For a more in depth theoretical analysis of PMG see Png and Hirschleifer (1987), Belton (1987), Doyle (1988), Logan and Lutter (1989), Zhang (1995) and Edlin and Emch (1999).

[3] Broseta et al. (2003) surveys the recent experimental literature on equilibrium selection. Croson et al. (2005) is a good example of the difficulties of Pareto dominant equilibrium to emerge even when only symmetric equilibria are available.

[4] They define these costs as "any cost run by the client to make effective the price guarantee: time, discomfort of asking for the reimbursement, need of visiting two shops, etc".

activities from buyers (and antitrust authorities). The actual effects on prices of these practices are eventually difficult to prove, so it is usually impossible to assess what prices would have prevailed without collusion, at least in the absence of precise cost and demand conditions. Even when markets seem to alternate between collusive and non-collusive phases, the price differences are difficult to interpret since, for instance, a breakdown in collusion may have been caused by a demand decrease that would have reduced prices in any case.

On the one hand, some studies suggest that PMG allow firms to tacitly collude with the result of prices increasing to supra competitive levels, as Hess and Gerstner (1991) studying the effect of a PMG offered by a single supermarket. Smith et al. (1999) examine pricing patterns on digital markets relative to conventional ones and find that price matching may provide a price discrimination tool for Internet retailers, in line with Corts (1996).[5] On the other, Arbatskaya et al. (2004) study the effects of various kinds of PMG on advertised prices using retail tire prices collected from U.S. Sunday newspapers. They conclude that price-matching or even price-beating guarantees do not have any effect on firms' own prices, although they point out that this result could be due to firm, market or guarantee heterogeneity. Milyo and Waldfogel (1999) exploit a natural experiment (the 1996 removal of Rhode Island ban on advertising prices of alcoholic beverages) to investigate stores' pricing responses to rivals' price advertising. In their sample, price-matching stores' prices are significantly lower both before and after the law change; however, there is weak evidence of a chilling effect of matching guarantees on other stores' prices. Finally, Mañez (2006) using data on UK supermarkets analyses the effect of a price-beating guarantee and concludes that it was not a collusive device leading to higher prices but rather an advertising tool to signal the adopting supermarket low prices.

The complexity of the theoretical setting and the lack of definite empirical results make the laboratory an appropriate ground to test the effect of PMG on market prices. Experimental methods can consider the role of information not available in standard empirical analysis, which can be critical from policy point of view. Experimental methods have been used extensively to evaluate industrial organization issues.[6] In fact, a well-established result in the experimental economics literature is that market-trading institutions are crucial in determining whether or not collusion will be successful in raising prices above competitive levels.

To the best of our knowledge, there is no specific experimental test on the collusive effects of PMG. Jain and Srivastava (2000) analyze how consumers view and interpret price guarantees to develop a theoretical model of price discrimination between informed and uninformed consumers.[7] In the experiment, subjects answer a questionnaire and their final payment is not dependent upon

[5] Even in a digital market activation is not cost free as it is a time consuming task (they are not permanent and are only available for the individual transaction).

[6] See Plott (1989), Davis and Holt (1993) or Holt (1995) for an overview.

[7] See Srivastava (2001) and Srivastava and Lurie (2004) for parallel analyses.

their answers. Additionally, the paper only focuses on the effect of PMG on the buyers' quality perception of stores.

Along this line, the recent paper by Deck and Wilson (2003) is the first experimental study on an issue related to price guarantees. They simultaneously test the impact of an assorted variety of price guarantees and pricing algorithms when firms can track customers' search behavior to find that they may act for sellers as a device to manage internet competitive pressures. They find the striking result that even when PMG help to increase median prices while price beating guarantees lead prices near the static Nash equilibrium prediction, most subjects tend to elude the use of the more profitable PMG.[8]

In a parallel paper to this one, Fatas et al. (2005) analyze the effect of price beating guarantees in a Bertrand competition between symmetric firms. They find that, though in most cases price beating policies lead to higher posted prices, effective prices remain close or even below non-cooperative (Bertrand) levels. Contrary to Deck and Wilson (2003), subjects realize about the pro-competitive effects of price beating guarantees, and adopt them in less than half of the cases.

Our experimental design allows for the very first time for a specific comparison of different market environments. We study PMG both as a market rule and as a business strategy relative to a baseline setup in which no price commitment is available. This way, we cover markets in which price matching is totally absent (Treatment I), globally present (Treatment II) and voluntarily adopted by subjects (Treatment III). Therefore, data availability on different combinations of prices and pricing policies do not depend on endogenously determined adoption rates.

Our results show that PMG produce a clear and almost perfect collusive effect in experimental markets, even if PMG is just an additional strategy. This result is stronger in Treatment II, where PMG are imposed as a market rule: complete convergence to the collusive equilibrium occurs at very early rounds. But it is also robust in Treatment III, since prices are significantly higher than prices in Treatment I. The remainder of this paper is organized as follows. The experimental design section describes our theoretical background together with the experimental design and procedures. The next section analyzes the experimental results. The last section is devoted to the Concluding remarks.

Experimental design

The model

Consider a price-setting duopoly in which two firms (i and j) simultaneously choose a posted price $\left(p_i^p, p_j^p\right)$ and a price policy (δ_i, δ_j):

[8] Our conjecture about why subjects keep on offering the non-profitable undercutting guarantee, abandoning the profitable PMG is the experimental design: subjects simultaneously chose the guarantee and its extent. Complexity might play a role.

$$\delta_i = \begin{cases} \text{NPM} = \text{No PMG} \\ \text{PM} = \text{PMG} \end{cases} \tag{1}$$

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

$$p_i^e = \begin{cases} p_i^p \quad \text{if} \quad \delta_i = \text{NPM} \\ p_i^p - \alpha\left(p_i^p - \min\{p_i^p, p_j^p\}\right) \quad \text{if} \quad \delta_i = \text{PM} \end{cases} \tag{2}$$

The parameter α 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 first of the two cases. Each one of two firms, i and j, sells one of the two varieties of a differentiated product, knowing that the demand for each variety is given by:

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

V is the demand intercept, while $-\beta$ and γ 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:

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

We consider the following salient solutions:

1. The Bertrand (competitive) solution (BS) of the one-shot game, satisfying the first order conditions:

$$\frac{\partial \Pi_i}{\partial p_i} = 0 \text{ and } \frac{\partial \Pi_j}{\partial p_j} = 0.$$

2. The Collusive Solution (CS), satisfying the first order conditions: $\frac{\partial \Pi}{\partial p} = 0$, where $\Pi = \Pi_i + \Pi_j$ and $p = p_i = p_j$

This game has multiple Nash equilibrium (NE). It is always a NE for both firms to set the Bertrand price and not to adopt PMG. But, if both firms offer PMG a continuum of NE emerges, from Bertrand to the collusive solution.[9] On top, equilibrium effective prices are limited by the collusive price; unilateral price cutting, even if automatically matched by the rival, would result in higher profits. Analogously, equilibrium effective prices are bottom bounded by the Bertrand price, as any firm could obtain higher profits by increasing its posted price (with no PMG). There is even an additional equilibrium in which only one firm adopts PMG and both firms set the Bertrand price.[10]

[9] In symmetric markets all firms must adopt PMG for prices to rise above the Bertrand price.

[10] Both firms cannot increase profits by setting a different price (or adopting PMG). See Proposition 1.B in Doyle (1988)

Table 1 Theoretical values of prices, demand and profits

	Bertrand Solution (BS)	Collusive Solution (CS)
p_i	310	380
q_i	420	350
Π_i	117,600	122,500

In Table 1 we present both competitive and collusive solution values for prices, demands and profits for the parameter values used in our experimental analysis: V = 730, β = 1.5, γ = 0.5 and c = 30. These parameter values were chosen so the predicted prices were not focal points in any way[11].

The experimental treatments

In order to study the effects of PMG on prices, we consider three different treatments. In all treatments, each firm (represented by an experimental subject) sells one of the two varieties of a differentiated product during 50 rounds. Treatment I (T-I) is a standard Bertrand duopoly, so subjects' unique decision is to choose a posted price. In this simultaneous move game, the unique equilibrium is the Bertrand–NE for differentiated products, in which both firms satisfy the usual FOCs.

In the other two treatments, PMG are introduced using two different implementation rules. In Treatment-II (T-II), PMG is exogenously imposed as a compulsory *market rule*; and in Treatment-III (T-III), PMG are offered to subjects as an option (what we call, a *business strategy*). In this last treatment, each firm's selling price depends both on own and rival posted prices as well as on own and rival's price-guarantee decisions. In T-II, following Hviid and Shaffer (1999), a continuum of NE arise as any symmetric price from the Bertrand solution (BS) to the collusive solution (CS) is an equilibrium.[12] As it was mentioned before, there are multiple NE in the T-III game, ranging from the Bertrand to the collusive solution.

In all treatments, subjects were randomly paired in each round using a strangers matching mechanism.[13] This matching mechanism implies an unfavorable environment for the emergence of collusion and provides a kind of stronger test for the collusive effect of PMG.

The time structure of the game is as follows. At each round of T-I and T-II, subjects choose 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, demand and profits. A complete history of these

[11] Prices ranged from 30 to 1,000 in the experimental sessions.

[12] See Hviid and Shaffer (1999), Proposition 1, for a proof of equilibria boundaries.

[13] As the number of rounds (50) exceeds the number of subjects (18), this mechanism does not prevent subjects from being matched with the same opponent more than once along a session, but the relative figures keep the frequency rather low.

results and the corresponding actions is also available to them. In T-III, each firm decides simultaneously both on its posted price and whether they offer or not a PMG. While firms decide their posted prices every round, they decide whether to offer or not PMG only every five rounds. This design proxies the fact that in real world prices may be changed more frequently than price guarantee decisions. Furthermore, as price guarantee decisions remain unchanged for a sequence of five rounds, learning about optimal pricing strategies is more feasible. In addition to the information received in T-I and T-II, in each round of T-III subjects receive information regarding own and rival price guarantee decisions. Subjects are not aware of the underlying demand model and have equal and common information about the rules of the game.[14]

Subjects could post any price between 30 (below-unit-cost pricing was not allowed) and 1,000 (including non-integer prices in steps of 0.1 monetary units) expressed in experimental currency units (ECU).

From the theoretical point of view, there are some similarities between our treatment T-II and previous experimental analysis of games with multiple equilibria. Van Huyck et al. (1990) show that coordination critically depends on the structure of the game and the repeated interaction with the same opponent.[15] In this sense, our design is a strong test for the collusive properties of PMG as in all treatments subjects were randomly paired in each round (using a so called *strangers matching mechanism*). Given the previous results, it is far from clear that subjects would converge to the Pareto dominant equilibrium, due both to the strategic complexity of the underlying game[16] and to the random re-matching.

Experimental literature in oligopoly recalls that compatibility of interests is not easily recognizable by players, so they likely treat competitive situations as zero-sum games. As a result some collusive equilibria predicted by the oligopoly theory are rarely observed in experiments (Plott 1982; Holt 1995 is still the most cited survey on market experiments). However, this same literature acknowledges that experience can play an important role in moving prices towards the one stage-game collusive equilibrium level (Friedman and Hoggatt 1980 and Benson and Faminow 1988). Capra et al. (2002) is a recent experimental analysis of learning in Bertrand price competition. Notwithstanding, both absence of recognition of common interests and experience should play a similar role in the experiments we propose. Therefore, different results among treatments

[14] That is, subjects did not know the precise parameter values. A complete set of translated instructions are included in the Appendix.

[15] In their Experiment C, full coordination is reached more than half of the times when subjects repeatedly interact with the same opponent while it is never observed when interacting with a different one each round.

[16] Another main difference with van Huyck et al. (1990) is that (i) our subjects have no information about the demand function (relative to their complete information setting), (ii) all salient solutions of our game are interior, (iii) our strategy space is a quasi-continuum (it exactly includes 4,710 different choices; theirs had only seven choices) and (iv) subjects had never interacted before. See Fatas et al. (2006) for a review of recent experimental results on coordination games.

can only be attributed to their unique difference in experimental design: the availability of PMG.

Inexperienced subjects were recruited among undergraduate students from different degrees (mainly Economics and Business) using the standard recruitment procedures at the University of Valencia.[17] Before the beginning of each session subjects were given written instructions, the experimenter read aloud the instructions and all questions were answered before the experiment began. At the end of each session subjects were privately paid in cash. A typical session lasted for 60–80 min (depending on the experimental treatment). Subjects average earning was €17.65, the standard deviation of the earnings is 0.68, and the variation coefficient 0.0385. Minimum and maximum earnings were €15.59 and € 18.98, respectively. All sessions were computerized and carried out at LINEEX.[18] Specific software was developed for all three treatments using the Z-Tree toolbox.[19]

As Table 2 shows, two experimental sessions of 18 subjects were held for each treatment, so 108 subjects participated. Henceforth, we will refer to each experimental session as S-IJ, where I = 1, 2, 3 stands for treatment and J = 1, 2 stands for session number within each one of the treatments, e.g., S-11 stands for the first experimental session of T-I.

Experimental results

Descriptive statistics and figures

Table 3 shows the general characteristics of our experimental results. It is a general feature of these results that, in all sessions, price dispersion decreases over time. In Table 3, we see that the standard deviation of prices is lower in the second half of a session than in the first half of it.[20] Figures 1, 2, and 3 show average per round prices (effective, in the case of treatments II and III) for each of the experimental sessions. The Bertrand Solution (BS, 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. Figure 1 shows that in the BSL sessions average prices per round are

[17] By means of specific public advertisements and by phone using LINEEX subjects data base.

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

[19] See Fischbacher (1999).

[20] Similar results are obtained (detailed results are available upon request) by regressing for each experimental session per-round standard deviation on a dummy variable that takes the value of 1 for the last 25 rounds and 0 otherwise. All coefficients estimated are negative and significant (depending on the treatment, they range between −21.9 and −89.1) 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 2 Summary table

Treatment	PMG	Treatments label	Sessions label	Markets	Subjects
T-I	–	BSL	S-11, S-12	18	36
T-II	Market rule	PMG-M	S-21, S-22	18	36
T-III	Business strategy	PMG-B	S-31, S-32	18	36

Table 3 Observed price averages (Av), standard deviations (SD) and percentage of subjects' profits in a +/ − 1% interval of the BS (PER^B) and CS (PER^C) profits for rounds 1 to 25 and rounds 26 to 50

		Av_{1-25}	SD_{1-25}	Av_{26-50}	SD_{26-50}	$\%PER^B_{1-25}$	$\%PER^C_{1-25}$	$\%PER^B_{26-50}$	$\%PER^C_{26-50}$
T-I									
S-11	p_i	280.70	67.29	284.13	36.65	2.67	2.22	3.56	1.33
S-12	p_i	303.18	70.25	294.07	28.86	3.77	4.22	8.44	4.00
T- II									
S-21	p_i^p	399.04	167.69	421.01	114.89	5.78	40.89	0.89	96
	p_i^e	316.84	120.29	380.60	21.42				
S-22	p_i^p	438.68	167.42	401.12	89.31	4.50	50.00	0.00	97.50
	p_i^e	363.66	122.08	379.33	11.18				
T-III									
S-31	p_i^p	456.71	182.52	412.07	96.57	4.44	32.78	4.44	63.11
	p_i^e	382.07	140.76	373.83	41.72				
S-32	p_i^p	420.70	130.58	384.19	89.91	6.22	41.11	6.22	52.67
	p_i^e	378.83	85.66	353.96	43.31				

p_i^p: posted price ; p_i^e: effective price

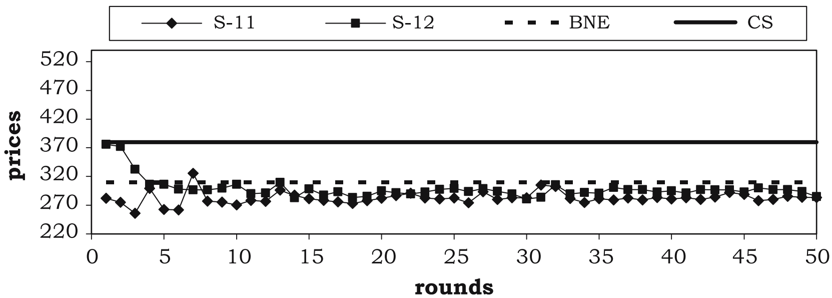

Fig. 1 Evolution of average per round prices, BSL sessions

systematically below the BS price, with a convergence to the non-cooperative equilibrium similar to the reported in other experiments.[21] As a consequence of these low prices, profits in the BSL sessions are systematically below the BS profit (for the last 25 rounds only 6 and 11.33% of the S-11 and S-12 profits are

[21] The best known reference in this aspect is probably Dufwenberg and Gneezy (2000), they find the Bertrand solution is not a too good predictor in duopolies with homogeneous good. García-Gallego and Georgantzís (2001) show a similar pattern of behavior in duopolies with differentiated goods.

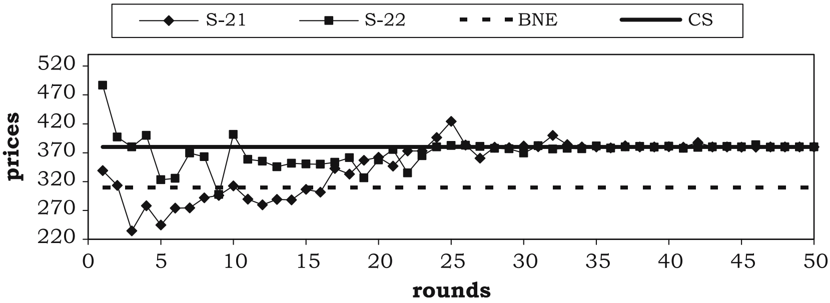

Fig. 2 Evolution of average per round effective prices, PMG-M sessions

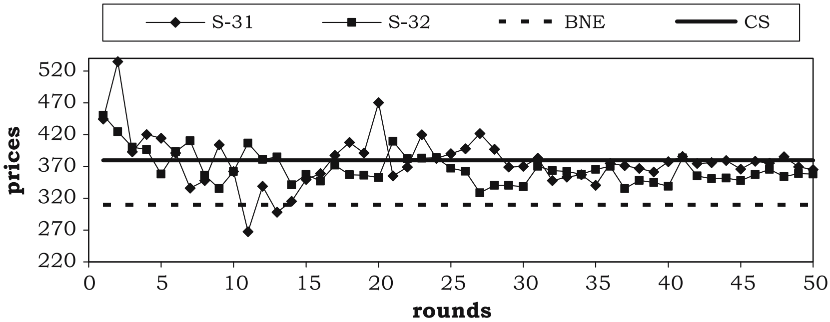

Fig. 3 Evolution of average per round effective prices, PMG-B session

above the BS profit, respectively). For the sessions in which PMG is a market rule (Fig. 2), average effective prices per round begin between the BS and CS prices, although as the number of rounds increases prices converge to the CS price.

Average profits in the last 25 rounds for S-21 and S-22 sessions are virtually at the CS level (96 and 97.50% of the profits are in a 1% interval of CS profit, respectively). In the sessions with PMG as a business strategy (Fig. 3), effective prices are above the competitive ones and closer to collusive than to Bertrand levels. As for profits, whereas only 4.44% of S-31 profits and 6.22% of S-32 profits are in a 1% interval of the BS profits, these percentages raise to 63.11 and 52.67% if we consider instead a 1% interval of the CS profit.[22]

Aggregating individual observations in the last 25 rounds, we estimate the density functions presented in Fig. 4. Whereas the effective price distribution corresponding to the BSL treatment is skewed around prices slightly lower than the BS price, the price distributions corresponding to T-II and T-III are skewed around the CS price. Furthermore, the PMG-M price distribution is much more concentrated around the CS price than the PMG-B one.

[22] Very likely, the observed drift to the CS is conditioned by our demand structure as the CS dominates any other equilibria in which the two firms adopt PMG. However, for instance the consideration of activation costs could modify substantially our results as in a symmetric model with positive activation costs PMG do not have any ability to raise prices above competitive levels

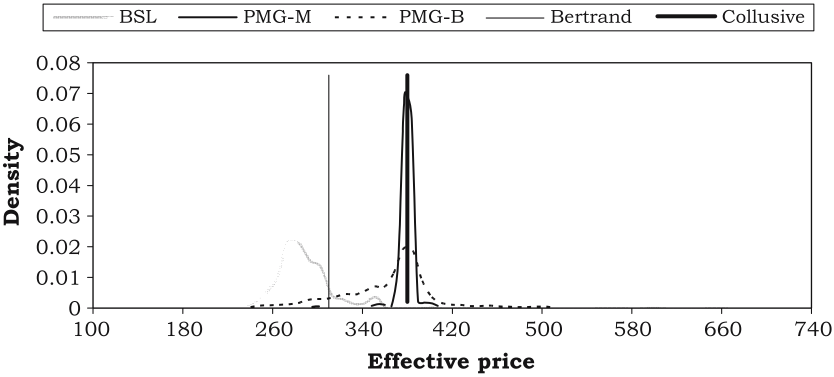

Fig. 4 Density function corresponding to effective prices in BSL, PMG-M and PMG-B against the BS (*thin vertical line*) and the CS (*thick vertical line*) predictions

Comparison of prices and profits across treatments

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

$$s_{it} = \beta_0 + \beta_1 D_M + \beta_2 D_B + \mu_{it} \tag{5}$$

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

By construction, β_0 is the mean price (profit) for the BSL sessions. β_1 and β_2 are the average price (profit) differentials between T-II and T-I ($\Delta^{\mathrm{PMG}-M/\mathrm{BSL}}$) and T-III and T-I ($\Delta^{\mathrm{PMG}-B/\mathrm{BSL}}$), respectively.

The panel data estimates[23] of (5) for posted prices, effective prices and profits appear in Table 4. To facilitate interpretation, beside each variable appears in parentheses the average price differential that the coefficient of the variable estimates. Thus, for example, the coefficient of the D_M term is an estimate of $\Delta^{\mathrm{PMG}-M/\mathrm{BSL}}$. In Table 5 we show the χ^2 (1) tests comparing each one of the estimated average prices (profits) to the BS price (profit) and CS price (profit).

[23] In this case there is no difference between the estimates of the fixed and random effects models. The reason is that given the way we have constructed all the independent variables they do not show any between-groups variation (in our case each subject is a group). As the fixed effects model estimates are obtained from the within-group estimator, and the random effects model estimates are a weighted average of the within and between-group estimators, if there is no between-group variation the estimates of both models are identical.

Comparison of average effective prices

The estimates indicate that the average effective price in the baseline sessions (289.10) is significantly below the Bertrand–Nash prediction (see Tables 4 and 5). The introduction of PMG results in average effective prices significantly higher, as both $\Delta^{\text{PMG}-M/\text{BSL}}$ and $\Delta^{\text{PMG}-B/\text{BSL}}$ are positive and significant (90.90 and 74.79, respectively). Furthermore, the average price increase produced by the introduction of PMG as a market rule is significantly larger than the one we observe when PMG is a business strategy. As a result of these different price increases, whereas the average price in the T-III sessions (363.89) is significantly higher than the BS price but lower the CS price, the average price in the T-II sessions (380.00) is not significantly different to the CS price.

The results on effective prices can be summarized as follows:

Result 1: *If* PMG *is not included among the alternatives, the average effective price is below the* BS.

Table 4 Price differentials for effective prices, posted prices and profits

	Effective prices		Posted prices		Profits	
Constant	289.10	(0.000)	289.10	(0.000)	112,308.7	(0.000)
$D_M\left(\Delta^{\text{PBG}-M/\text{BSL}}\right)$	90.90	(0.000)	122.55	(0.000)	9,889.68	(0.000)
$D_B\left(\Delta^{\text{PBG}-B/\text{BSL}}\right)$	74.79	(0.000)	129.03	(0.000)	7,866.77	(0.055)
Number of obs	2,700	2,700	2,700			
R^2	58.42	30.70	10.55			

Note: p values within brackets

Table 5 Comparison of average effective prices, average posted prices and average profits to the BS and CS (BS price =310; BS profit = 117,600; CS price = 380; CS profit = 122,500)

		Comparison BS		Comparison CS	
	Average	χ^2 (1)	p value	χ^2 (1)	p value
Effective prices					
BSL-S	289.10	71.40	0.000	1,350.52	0.000
PMG-M	380.00	756.41	0.000	0.00	0.999
PMG-B	363.89	474.42	0.000	42.40	0.000
Posted prices					
BSL-S	289.10	7.28	0.007	137.77	0.000
PMG-M	411.65	162.70	0.000	15.77	0.000
PMG-B	398.13	129.49	0.000	5.48	0.019
Profits					
BSL-S	112,308.7	260.98	0.000	968.17	0.000
PMG-M	122,198.4	186.16	0.000	0.80	0.371
PMG-B	120,175.5	61.83	0.000	50.37	0.000

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

Result 2: *The introduction of* PMG *as a business strategy increases significantly average effective prices. As a result, with* PMG *as a business strategy average prices are higher than the* BS *price but lower than the* CS *price.*

Result 3: *The introduction of* PMG *as a market rule increases average prices more than the introduction of* PMG *as a business strategy. As a result average prices when* PMG *is a market rule are at the level of the* CS *price.*

Firms' demands are determined by effective prices and, in turn, demand and effective prices determine firms' profits. Thus, profits patterns for each one of the three treatments exactly reproduce those observed for effective prices.[24]

Comparison of average posted prices

In T-I (effective and selling) prices are significantly below the BS price. The introduction of PMG increases posted prices, as both $\Delta^{\mathrm{PMG}-M/\mathrm{BSL}}$ and $\Delta^{\mathrm{PMG}-B/\mathrm{BSL}}$ are positive and significant (their estimates are 122.50 and 129.03, respectively).[25] As a result, average posted prices both for the PMG-M and the PMG-B sessions are not only above the BS price but also above the CS price.

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

Result 4: *Average posted prices when* PMG *is available to the subjects are higher than when it is not and higher than the* CS *price.*

Adoption rates, prices and profits

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

$$s_{it} = \beta_0 + \beta_1 D_A + \mu_{it} \tag{6}$$

where the endogenous variable, s_{it}, is posted price or profit of subject i in period t (for t = 26,. . .,50). D_A is a dummy variable set equal to 1 if the subject adopted PMG, and $\mu_{it} = \alpha_i + \varepsilon_{it}$ where α_{i} are the individual effects that are considered as random effects and $\varepsilon_{\mathrm{it}}$ is the error term.

By construction, β_0 is the mean price (profit) for the subjects that did not adopted PMG and $\beta_1 (\Delta^A)$ is the average differential between the prices (profits) of the subjects who adopted PMG and those that not adopted.

The panel data estimates of (6) for posted prices and profits appear in Table 6. The subjects adopting PMG set, on average, higher posted prices and obtain higher profits, as Δ_P^A is positive and significant both in the posted prices and profits regressions (estimated average increases for posted prices and profits

[24] For T-I average profit is below the BS profit, for T-III average profit is higher than the BS profit and lower than the CS profit, and for T-II average profit is at the level of the CS profit.

[25] These two average price increases are not significantly different.

Table 6 PMG adoption and prices

	Posted prices		Profits	
Constant	350.76	(0.000)	117,771.3	(0.000)
$D_A\left(\Delta^A\right)$	65.09	(0.000)	3,030.47	(0.000)
Number of obs	900	900		
R^2	5.27	4.81		

Note: *p* values within brackets

are 65.09 and 3,030.47, respectively). Hence the effects of PMG adoption on posted prices and profits can be summarized in the following way:

Result 5: *When* PMG *is a business strategy, posted prices and profits of adopters are higher than those of non-adopters*

Figure 5 presents the percentage 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 PMG adoption–decision rounds.

Figure 5 shows that from the first adoption decision, the percentage of subjects adopting PMG is larger than the percentage of subjects that do not adopt. This is especially evident from round 36 on, as the percentage of subjects adopting is three times the percentage of subjects not adopting. Overall, the exit rate that shows a decreasing trend is much lower than the entry rate uncovering a trend of incorporation and permanence in the group of subjects adopting PMG. Furthermore, both the decreasing trend that shows the exit rate and the low exit rates in the final rounds of the experiment (for the last three adoption decisions the entry rate is on average 46% higher than exit rate) suggest that PMG adoption evolves as a stable business strategy.

To analyze this predominant and stable adoption of PMG, we estimate a panel data model (with the data of S-31 and S-32) using the following reduced form equation:

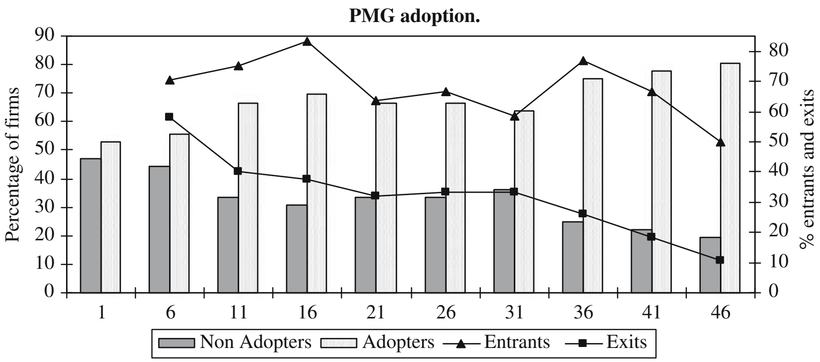

Fig. 5 PMG adoption patterns

$$\Pi_{it} = \beta_0 + \beta_1 D_i + \beta_2 D_j + \beta_3 D_{ij} + \mu_{it} \tag{7}$$

where the endogenous variable Π_{it}, is profit of subject i in round t for ($t = 26, \ldots, 50$). D_i is a dummy variable set equal to 1 if subject i adopted PMG in round t and his competitor (subject j) did not do it, D_j is a dummy variable set equal to 1 if subject i did not adopted PMG in round t and j did it, and D_{ij} is a dummy variable set equal to 1 if both firms i and j adopted PMG in round t. Finally, $\mu_{it} = \alpha_i + \varepsilon_{it}$ where α_i are the individual effects considered as random and ε_{it} is the error term. This reduced form equation allows us to compare subject i profits as a function of subject i and subject j adoption decisions.

By construction, β_0 is the mean profit of subject i when neither subject adopts, and $\beta_1(\Delta_i)$ is the average variation to this profit when subject i adopts and subjects j does not do it. Analogously, $\beta_2(\Delta_j)$ and β_3 (Δ_{ij}) are the average differential between the profits of subject i when neither firm adopts PMG and the situations in which firm i does not adopt and j adopts and both firms adopt, respectively.

The estimates of (7) appear in Table 7. Regardless of whether or not subject j adopts PMG, subject ***i*** is always better off adopting. If subject j does not adopt profit of subject i is larger adopting than not adopting, as Δ_i (3,654.57) is positive and significant. Analogously, if firm j adopts, the profit of subject i is greater with adoption than without it, as $\Delta_{ij} - \Delta_j$ (3,163.14) is positive and significant at 1% level.

Thus, it seems that subjects realizing the convenience of adopting PMG decide to adopt, and as a consequence PMG adoption becomes a predominant and stable business strategy. Furthermore, we can establish the following result:

Result 6: *When* PMG *is a business strategies subjects are always better off adopting than not adopting*

Concluding remarks

Although conventional wisdom tends to support the idea that low price guarantees have a competitive effect, we find very little support for this view. Financially motivated subjects quickly and easily collude when PMG are implemented as a market rule and subjects were solely asked to fix a posted price (see our Result 3). This full convergence outcome is qualified by at least three

Table 7 Profit differentials and PMG adoption

	Profits	
Constant	118,351.2	(0.000)
D_i (Δ_i)	3,654.57	(0.000)
D_j (Δ_j)	−790.84	(0.457)
D_{ij} (Δ_{ij})	2,372.29	(0.009)
Number of obs	900	
R^2	5.41	

Note: p values within brackets

design features: subjects were inexperienced, they were randomly paired in each round (by means of a *strangers* matching mechanism) and no information was provided about actual demand and supply functions to avoid an explicit calculation of joint-profit maximizing outcomes. These very same subjects were entirely unable to reach this collusive outcome in the absence of PMG (Result 1). Our Result 2 suggests that when PMG are included in the space of available strategies, BS proved to be a poor predictor of subjects' behavior. Posted prices are also significantly higher when PMG is available (Result 4).

Profits and the adoption rate suggest that subjects identify PMG as a profitable strategy. Almost all subjects eventually offer PMG as they realize profits (Results 5) are significantly higher. In this sense, the Result 6 confirms that when PMG is a business strategy subjects are always better off adopting that not adopting.

Our paper confers experimental support to the theoretical analysis initiated by Salop's (1986) seminal work that recognizes the anti-competitive effects of PMG. In the absence of wider empirical evidence, the experimental analysis of PMG confers antitrust authorities with a valuable instrument to discriminate between the sellers' claims of PMG as an instrument favoring competition and the academic view of these guarantees as tools facilitating tacit collusion, as PMG can generate sizeable price effects in markets that parallel many important features commonly found in natural markets.

Lessons from this research are twofold. On the one hand, PMG can generate sizeable price effects in markets that parallel many important features commonly found in natural markets. On the other, as our Result 2 insinuates (no full convergence to the collusive prediction is reached under T-III), the relevance of this effect may be sensitive to more subtle institutional alterations. It is not our findings that any price guarantee is sufficient to attain a collusive outcome in real markets. Instead, its existence may be sensitive to institutional features as the existence of activation costs.[26]

Together with the results of Fatas et al. (2005), where the posted prices of adopters of price beating guarantees were higher than those posted by non-adopters, a clear policy recommendation emerge. Following the 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), some price guarantees – like the price matching policy studied here – may have collusive effects. 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. 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).[27]

[26] Further experimental analysis should consider the impact of activation costs on the effectiveness of price-matching guarantees to raise prices above competitive levels.

[27] See Moorthy and Winter (2002).

Appendix: Translated instructions

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 participants is strictly forbidden.

1. This experiment lasts for 50 rounds. In each round, you will be randomly matched with another subject in groups of two subjects. You will never know the identity of the other participant.
2. In this experiment you are a firm. Each round you make a decision on the price of the only product you produce. The available price range comes from 30 to 1,000 ECU (an experimental currency unit).
   a. (*For Treatments II and III*) We will call this price the posted price.
   b. (*Only for Treatment III*) You also have to decide whether you will offer a price-matching guarantee. If you do so and your posted price exceeds the posted price of the other firm, your effective selling price will be the other firm's posted price.
3. (*Only for Treatment II*) Your posted price may differ from the effective selling price as there is a legal pricing rule in the market called price-matching guarantee. This rule compares posted prices in the market and allows consumers to buy the product at the lowest price in the market. So, whenever your posted price exceeds the posted price of the other firm, your effective selling price will be the other firm's posted price.
4. (*Only for Treatment III*) There are two different kinds of rounds in this experiment:
   a. Round 1, 6, 11,...,46, in which you have to make a decision about both your posted price and whether or not you offer a price-matching guarantee.
   b. All other rounds, in which you just make a decision on your posted price.
5. Every time you make a decision, you will receive information about the current and past values of:
   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, demands and profits and the posted price, effective selling price, demand and profits of each firm with which you compete in each round.
   c. *(Treatment III)* Your posted price, effective selling price, demands and profits and the posted price, effective selling price, demand and profits of each firm with which you compete in each round. You will also receive information on whether you offer a price matching guarantee and whether the other firm in the market offers it.
6. Demand in each round depends only on your firm's decisions and the decisions of the other firm in the market. Once these two decisions have been

made, you will know your product's demand and your firm's profits in the round.

7. At the end of the experiment, you will receive a monetary reward equal to your firm's profits exchanged at a rate of 320,000 ECUs for €1.

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