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"Competition Policy for Exclusionary Pricing: Experimental Evidence"

by

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<u>Note</u>: It is expected that you will have reviewed the speaker's paper before the seminar.

Competition Policy for Exclusionary Pricing: Experimental Evidence ‡

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Abstract

We study the effects of above-cost exclusionary pricing and the efficacy of three policy responses. We run a series of experiments involving a monopoly incumbent and a potential entrant. Our experiments show that under a laissez-faire regime, the threat of post-entry price cuts discourages entry, and allows incumbents to charge monopoly prices. Current U.S. policy (Brooke Group) does not help. In contrast, a policy suggested by Baumol (1979) lowers post-exit prices, while Edlin's (2002) proposal reduces pre-entry prices and encourages entry in the experiments. While both policies have less competitive outcomes after entry than Laissez-faire does, they nevertheless increase consumer welfare.

JEL Classification: D21, K21, L12, L13, C91

Keywords: Exclusionary Pricing; Entry Deterrence; Firm Strategy; Antitrust Law; Experiment

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1 Introduction

When should competition authorities or competition law worry about price cuts by an incumbent monopoly following entry? The standard legal approach is to view such price cuts as problematic, and call them "predatory pricing," only if they are below the incumbent's cost. In the U.S., this is the policy adopted by the Supreme Court in the Brooke Group (1993) case.[1] Relatedly, some authors, like Ordover and Willig (1981) or Melamed (2005), would condemn pricing as predatory only if it deviates from short-run optimal behavior and involves sacrifice.

The Brooke rule provides broad scope for an incumbent monopoly with a known cost or other advantage over potential rivals to exclude those rivals. Consider, for example, American Airlines flights to and from Dallas Fort Worth airport in the 1990s. Generally, American charged high prices, but when attacked by other carriers, American charged low prices and expanded capacity until they exited. After rivals exited, "American generally resumed its prior marketing strategy, reducing flights, and raising prices to levels roughly comparable to those prior to the period of low-fare competition."[2] The U.S. Department of Justice sued American for monopolization (predatory pricing) but lost because American's prices were found to be above its costs. American was able to drive other airlines out with "above-cost" prices because it enjoyed advantages: economies of scope from having a Dallas Fort Worth hub meant that the economic costs of other airlines—even so-called low-cost carriers—were higher for any given route.

Motivated by such competition policy cases, and the idea that incumbent advantages often explain monopoly, we depart from most of the theoretical literature on predatory pricing, in which asymmetric information looms large. Instead, we focus on situations where an initial cost advantage of the monopolist is common knowledge. In theory, a monopoly known to have low costs can charge high prices without fear of entry if it can respond to entry with prices below its rivals' cost but above its own. If those prices are an equilibrium of the short-run competition game, there is no issue of credibility, and so no rational firm will ever enter. That means the monopoly can charge monopoly prices forever, or at least until a lower cost firm materializes. From the vantage of consumers, this is a bad deal.

We call pricing "exclusionary" if its effect is to induce exit or discourage entry, regardless of the *intent* of the pricing. We avoid the term "predatory pricing" because many define predatory pricing to be pricing below the predator's cost or pricing that involves sacrifice, and that the predator implements *only* because of its exclusionary effects. Behavior can be exclusionary in our sense even if it is a short-run Nash response and involves no sacrifice or predatory intent; indeed, that is exactly the way our model

[1] Brooke Group Ltd. v. Brown & Williamson Tobacco Corp., 509 U.S. 209 (1993)

[2] United States v. AMR Corp. 335 F.3d 1109 (10th Cir. 2003).

and experiment are constructed. Whether there can be benefits from regulating such behavior is a question of the paper.

Because of cases like American Airlines, there has been a debate about the legality of above-cost exclusionary prices in the legal literature.[3] The literature also contains policy proposals that in theory could address this behavior. For instance, a policy suggested by Baumol (1979) would prevent an incumbent from raising prices after having fought off an entrant with price cuts (even above-cost price cuts). This rule clearly reduces an incumbent's incentives to cut prices. However, if entry takes place, it may still be in the incumbent's interest to reduce prices so much that entry would not be profitable. Anticipating this response, entry might not happen, in which case the incumbent can forever charge monopoly prices without fear of entry. To deal with such problems, Edlin (2002) suggests an alternative policy, which would prohibit incumbents from reducing prices by too much after entry. Edlin's proposal may improve welfare through two closely related channels. First, entry will take place if the incumbent sets price too high. Second, to avoid this, the incumbent may reduce prices in the first place.

Our paper's goal is to provide an experimental evaluation of these policies. To capture situations where the disadvantage of the entrant is common knowledge, we assume perfect information. There is an incumbent monopoly with low costs, and a rival with costs that are higher, but still below the incumbent's monopoly price. An unregulated monopolist can thus drive the rival from the market while still earning positive profits. In fact, the short-run equilibrium price for the monopoly (after entry) is to price below the rival's cost. This makes exclusionary pricing an entirely credible, and indeed predictable, reaction if no law intercedes. Our main questions are whether entry results, how firms price, and how entry and pricing depend upon the policy environment.

We consider dynamic Bertrand-style price competition over four market periods, allowing for four policy treatments: 1. "Laissez-faire," which has no regulation; 2. "Brooke Group," which bans below-cost pricing; 3. "Baumol," which makes post-entry price cuts permanent; and 4. "Edlin," which bans post-entry price cuts exceeding 20%. These policies affect entry and exit as well as pre- and post-entry pricing; thereby they influence consumer and total welfare.

Under policies 1–3, any equilibrium involves monopoly pricing for four periods with no entry: the policies make no connection between pre-entry prices and future prices, so that the incumbents will charge monopoly prices prior to entry. Moreover, the rival will not enter because the incumbent will respond with price reductions, driving the entrant from the market and making entry unprofitable. Under Edlin, there is likewise no entry,

[3]See discussions in Edlin (2002, 2012), Salop (2005, 2006), Popofsky (2006), Hovenkamp (2005), and Elhauge (2003). In a famous predatory pricing case, *Barry Wright*, Judge Breyer (as a district court judge before he joined the Supreme Court) acknowledged that above-cost price cuts could be undesirable but worried that problematic price cutting could not be distinguished from desirable limit pricing that discouraged entry but provided persistent low prices to consumers.

but to ensure this, the monopoly must price low prior to entry, because it is not free to cut prices after entry.[4] In theory, Edlin's proposal thus leads to higher consumer surplus and welfare because it makes the market contestable. Thus, the high-cost entrant can play an efficiency-enhancing role without entering the market.

To assess policies experimentally, we study exclusionary pricing and the effects of competition policies in a laboratory environment. While we acknowledge the well-known limitations of the laboratory approach for the analysis of firm behavior, it has the great advantage that it takes care of two central problems of any empirical approach to the subject. First, there is insufficient policy variation to study the effects of different regimes on entry or pricing. In practice, we mainly observe the Brooke Group rule, and not Baumol, Edlin or Laissez-faire; and without a point of comparison, it is impossible to gather empirical evidence on the consequences of even the Brooke Group rule that we observe. Second, and connectedly, it is difficult to identify exclusionary pricing at all. The prospect of such pricing may deter entry without exclusionary pricing ever being observed. Would-be entrants, willing to price much lower than a monopolist, do not enter for fear of being wiped out in a subsequent price war and the econometrician never observes the would-be entrant or the exclusionary price.[5] Identifying such a problem in the field is challenging. How can we say that entry is "insufficient", and if we can, how can we attribute it to exclusionary pricing?

The experiment implements the theoretical model described above, with one treatment corresponding to each of the four policy regimes. As expected, in Laissez-faire there tends to be monopoly pricing prior to entry, and there is often no entry (consistent with a fear of post-entry exclusionary pricing). When entry does arise, it usually is a mistake because nothing stops the incumbent from driving the entrant from the market. As a result, the entrant ends up losing the sunk cost of entry. While incumbents typically drive entrants from the market with prices below the entrant's break-even level, the incumbent does not price below its own cost. Therefore, the Brooke Group policy which bans below-cost pricing should have no effect in our setting. Indeed, as expected, behavior under Brooke Group in our experiment is indistinguishable from Laissez-faire and equally bad for consumers.

Edlin's policy has two consumer benefits in the experiment. It lowers the monopoly's pre-entry price and it increases the frequency of entry in instances where the monopoly sets a high price. The first is an equilibrium prediction and the second is a prediction of what happens off the equilibrium path. When the incumbent monopolist prices high

[4] An exception is the final period, when it charges the monopoly price due to end-game effects.

[5] A notable exception is Goolsbee and Syverson (2008). They investigate how incumbent airlines respond to announcements of Southwest Airlines—the most famous potential competitor in the industry—to begin operating a route. The announcements happen before Southwest starts flying the route and thus, the authors can identify the entry threat separably from actual entry. They find that incumbents cut fares significantly when threatened by Southwest's entry and that the price cuts are only on threatened routes.

prior to entry under Edlin, entry is typically profitable because the monopolist cannot immediately respond with low prices. However, as expected, duopoly prices are usually higher than in the other treatments.

Baumol's policy suffers from monopoly pricing prior to entry just as Brooke Group and Laissez-faire do. On the other hand, Baumol has the lowest prices after exit because price cuts are permanent. Baumol leads to more entry than Brooke Group and Laissez-faire, though less than Edlin.

The overall effect of the policies on consumer surplus differs considerably from the effect on total welfare. For sufficiently experienced players, Edlin and Baumol both deliver higher consumer surplus than the remaining policies, with Edlin the highest. Contrary to the theoretical prediction, however, total welfare is lower in Edlin than in the other three cases. This result is the downside of the entry-promoting effect of Edlin's policy, which implies duplication of fixed costs. To most economists, promoting total welfare is the ultimate objective, but for competition authorities, promoting consumer welfare or competition are often seen as more important when these goals diverge from total welfare as they do here.

We see our theoretical and empirical results as an initial step in improving the design of competition policies. Roth (2002) discusses the role of economists as engineers in market design, and calls for combining theoretical and experimental tools, because people in practice do not always follow theory and because experiments can offer more control than empirical observations of practice. Designing competition policies is a similar exercise. As airplane designers use wind tunnels, our "wind tunnel" provides evidence for advantageous effects of the Baumol and Edlin rules for consumer welfare under idealized conditions. Further studies may combine theoretical and empirical tools to investigate the robustness of these effects in the light of the various frictions of a real world scenario.[6]

Our findings point to a problem with the equally efficient competitor test for monopolization that has taken hold in both the U.S. and Europe. Consider, for example, a 2009 guidance paper of the European Commission which states: "If the data clearly suggest that an equally efficient competitor can compete effectively with the pricing conduct of the dominant undertaking, the Commission will, in principle, infer that the dominant undertaking's pricing conduct is not likely to have an adverse impact on effective competition, and thus on consumers, and will therefore be unlikely to intervene."[7] Our theoretical and empirical analysis suggests that exclusionary pricing can exclude less efficient competitors to the detriment of consumers, even if an equally efficient competitor would not be excluded by the same pricing. This consumer injury is a shortcoming of an equally-efficient-competitor test of legality.

[6]See Edlin (2002) or Elhauge (2003) for discussions of some administrability issues of both these rules and the Brooke Group rule.

[7]See http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52009XC0224(01), point 27, visited October 23, 2017.

1.1 Related Literature

Our paper is broadly related to the predatory pricing literature, though that literature tends to focus on below-cost exclusionary pricing. There are several ways in which predation can be rationalized in game-theoretic models. Examples include reputation-building (Kreps and Wilson, 1982), signaling models (Milgrom and Roberts, 1982; Scharfstein, 1984; Fudenberg and Tirole, 1986; Saloner, 1987) and financial constraints (Bolton and Scharfstein, 1990). These theories are mostly based on information asymmetries. In such models, the anticipation of predation can have an entry-deterrent effect even though entry is welfare improving if it occurs. This finding is similar to ours, although, contrary to this literature, we consider situations without asymmetric information.[8] Recent theoretical contributions focus on the exclusionary potential of different pricing practices (e.g., Karlinger and Motta (2012); Vasconcelos (2015)) but emphasize below-cost pricing.

There is also some systematic empirical work that identifies predatory pricing with field data (e.g., Lerner (1995); Scott Morton (1997); Podolny and Scott Morton (1999); Genesove and Mullin (2006)). This work does not, however, analyze policy effects. The experimental literature on predatory pricing (see, e.g., Isaac and Smith (1985), Harrison (1988), Jung et al. (1994), Goeree and Gomez (1998), Capra et al. (2000), Chiaravutthi (2007), Bruttel and Glöckner (2011)) focuses on whether predatory pricing exists, is credible, and induces exit. Contrary to our paper, this literature does not address above-cost price cuts and the policy proposals that are the focus of our analysis.

Our paper is closely linked to the literature that studies excessive pricing of dominant firms. This literature considers the legal treatment of excessive pricing (Motta and de Streel, 2006; Ezrachi and Gilo, 2009, 2010) and explains how and why legal approaches may differ across jurisdictions (Gal, 2004). In an innovative recent paper, Gilo and Spiegel (2018) examine excessive pricing when the following rule is adopted: if, after entry of a rival, the price of the dominant firm falls, its pre-entry price is deemed excessive and the firm has to pay a fine proportional to its pre-entry excessive revenue. Like the Edlin policy, such a rule may benefit consumers because the dominant firm would not only lower its pre-entry price but also increase its post-entry price thereby encouraging entry. Like Edlin's policy, this rule hinges liability on the relationship between the pre-entry price and the post-entry price. Unlike Edlin, where the pre-entry price serves as a benchmark to assess the post-entry price, in Gilo and Spiegel (2018), the mechanism goes the other way round.

The remainder of this paper is organized as follows. Section 2 introduces the model and experimental design, and derives theoretical predictions. Section 3 presents the results. Section 4 discusses policy implications and concludes.

[8] Theories of predation that do not rely on information asymmetries include Harrington (1986); Cabral and Riordan (1994, 1997); Motta and Fumagalli (2013).

2 Theory and Experimental Design

2.1 The Game

We now explain the four variants of the game used in the experiment —Laissez-faire, Brooke Group, Baumol, and Edlin. In all four cases, two firms, a low-cost incumbent L and a high-cost potential entrant H (henceforth, "the rival"), can produce a homogeneous good and participate in a four-period game. In period 1, only the incumbent is in the market. In periods 2–4, each firm decides whether to participate in the market or not.

A firm that stays out earns a payoff of 50 per period from an outside option. To participate in the market, a firm has to pay 250 per period. Thus, including the opportunity cost from the foregone outside option, the fixed costs are 300.[9] We opted for per-period costs, rather than only one-shot set-up costs, because recurring fixed costs such as rents are realistic and required to make exit different from zero production. We did not include additional set-up costs to reduce the complexity of the experiment. For simplicity, we do not allow firms to re-enter after exit.

Market demand is given by $D(p) = 80 - p$. If only one of the firms $i = L, H$ is active in the market, it chooses its price as a monopolist. Its demand function coincides with the market demand. If both firms are active, they simultaneously and independently choose a price p_i. Their action sets are integers in an interval $[\underline{p}, \overline{p}]$ with treatment-specific boundaries. Consumers buy at the lowest price. Hence, each firm faces the following demand:

$$D_i(p_i, p_j) = \begin{cases} 80 - p_i & \text{if } p_i < p_j, \\ \frac{1}{2}(80 - p_i) & \text{if } p_i = p_j, \\ 0 & \text{if } p_i > p_j. \end{cases}$$

A firm is considered *dominant* in period t if it produced and served the entire market in period $t - 1$.[10] Firm i's duopoly payoff in a given period is

$$\pi_i = (p_i - c_i) D_i(p_i, p_j) - 250$$

where c_i is the marginal cost. Marginal costs are $c_L = 20$ and $c_H = 30$.

The four game variants differ with respect to the interval $[\underline{p}, \overline{p}]$ in which the dominant firm can choose its price. A firm which is not dominant can choose its price in the entire interval $[0, 80]$. In our baseline game, Laissez-faire, the dominant firm can also choose its price in $[0, 80]$. In the Brooke Group game, a dominant firm in a duopoly in period

[9] We chose to work with a positive outside option to avoid a possible framing bias in favor of entry: subjects who are confronted with an outside option of 0 might think of staying outside the market as particularly unattractive, which might be less salient in our (formally equivalent) formulation with an outside option of 50.

[10] This includes both the case that the firm was a monopolist and the case that it undercut the competitor in duopoly. Moreover, it applies to the incumbent as well as to the rival.

t cannot choose a price below its own marginal cost, that is, it is restricted to choosing $p_i^t \in [c_i, 80]$. In the Baumol game, both firms can choose the price in the entire interval $[0, 80]$ before and after entry. After exit of the competitor, however, the dominant firm cannot choose a price above its price in $t-1$ in period t or any subsequent period. Hence, $p_i^{t+k} \in [0, p_i^{t-1}]$ for $k = 0, 1 \ldots, 4-t$. Finally, in the Edlin game, in period t the dominant firm faces a price floor such that it cannot choose a price below 80% of its price in $t-1$, that is, $p_i^t \in [0.8 \cdot p_i^{t-1}, 80]$. This restriction applies only if the market in t is a duopoly.

To sum up, we implement a game that is as simple as possible, but rich enough to study the strategic incentives created by the policies. Thus, we made the following design decisions: (a) no re-entry; (b) a finite time-horizon; (c) asymmetric marginal costs; (d) a specific choice of the Edlin parameter (0.8). Our choice of the allowable price reduction (20%, as suggested by Edlin (2002)) was guided by the consideration that it should give incentives for the incumbent to reduce pre-entry prices to deter entry as well as incentives to an entrant to meaningfully undercut the prices of a high price incumbent.[11]

2.2 Predictions

We now describe the subgame-perfect equilibria of the four games, assuming continuous price sets. We first introduce some terminology.

1. The *break-even price* p_θ^B for $\theta \in \{L, H\}$ is given by $\left(p_\theta^B - c_\theta\right) D(p_\theta^B) = F$.

2. An incumbent's post-entry price is *exclusionary* if it is below the entrant's break-even price p_H^B.

3. The *entry-deterring price* p^* of L in the Edlin game is defined by $0.8p^* = p_H^B$.

The break-even price is calculated by setting the economic profit equal to zero rather than the payoffs (that do not account for the opportunity cost). An exclusionary price by an incumbent guarantees that an entrant loses money from entry.

Figure 1 gives an overview of the relevant prices and marginal costs. While most aspects of the ordering depicted there hold for all conceivable parameterizations, two comparisons are specific to our parameterization: first, the break-even price p_L^B of firm L is below the marginal cost c_H of firm H. Thus, our assumptions on demand, marginal and fixed costs reflect a situation with a substantial cost advantage of the incumbent.[12] Second, the entry-deterring price p^* is below the monopoly price of the low-cost firm $(p^M(c_L))$. This reflects the choice of a sufficiently rigid Edlin restriction as discussed above.

[11] It will be clear from the analysis below that, with a sufficiently large allowable reduction, the incumbent could keep the price at the monopoly level and still fight off the entrant.

[12] Without this assumption, further equilibria would emerge.

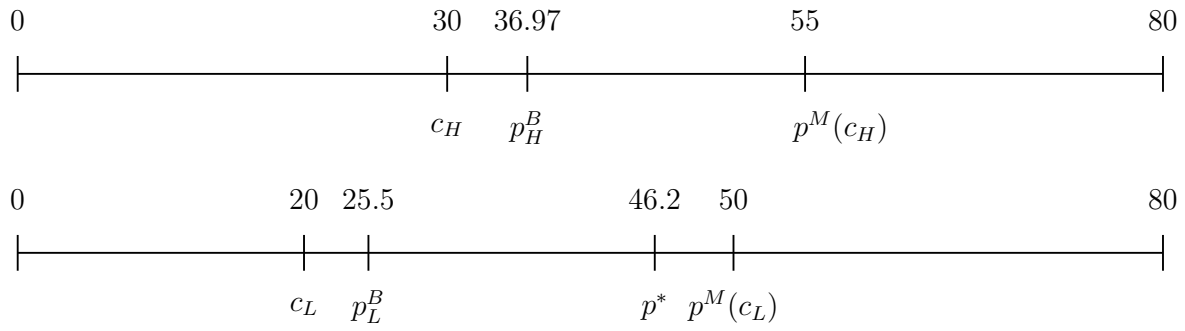

Figure 1: Overview of the prices (for firm H and firm L)

We now describe the equilibrium outcome and the most important features of the equilibrium strategies in a non-technical way. [13]

2.2.1 Laissez-Faire and Brooke Group Games

The analysis for the Laissez-faire and Brooke Group is essentially the same.

Proposition 1. *The Laissez-faire and Brooke Group games both have a subgame-perfect equilibrium (SPE) in pure strategies. In the SPE, there is no entry. The incumbent charges its monopoly price. The equilibrium strategies in each period are such that pricing in any period is independent of previous prices. Moreover, the rival will exit from duopoly immediately after any off-equilibrium entry. Finally, any SPE has these properties.*

Intuitively, in both games, both firms are essentially free to set arbitrary prices.[14] Prices therefore do not affect future behavior. Thus, in each period, firms set short-term optimal prices. In particular, in duopoly periods, the incumbent undercuts the entrant. Anticipating this, the rival will not enter. Proposition 1 does not depend on the parameterization: it holds whenever prices today do not affect prices and entry tomorrow.

2.2.2 Baumol Game

The Baumol game is more complex. After entry, the incumbent knows that, if it undercuts the rival, its duopoly price is an upper bound for future prices if the rival exits. This reduces the incumbent's incentives to fight with low prices. It must weigh the short-term benefits from undercutting against the long-term benefits from monopoly prices. As we show in the appendix, in duopoly subgames this trade-off leads to multiple equilibria where prices do not necessary equal the rival's marginal cost. However, none of these equilibria yields prices that are high enough for the entrant to break even, and there is no entry in any equilibrium. The following result summarizes the equilibrium. [15]

[13] The online appendix contains the technical details and proofs.

[14] In the Brooke Group game, prices below own costs are not allowed, but the incumbent does not rationally choose such prices anyway.

[15] It relies on tie-breaking rules that are stated in more detail in the appendix.

Proposition 2. *The Baumol game has a SPE without entry in which the incumbent sets its monopoly price in all periods. In this SPE, in any subgame with a duopoly, the asymmetric Bertrand equilibrium where both firms charge the high cost c_H is played in periods 2–4. In addition, there are other SPE yielding the same outcome, with prices in period 2 above c_H, but below the rival's break-even point. All SPE are of this type.*

The equilibrium outcome is thus the same as in the Laissez-faire and Brooke Group games.[16] The difference exclusively concerns off-equilibrium behavior. Thus, while Proposition 2 does not predict entry, it suggests that exclusionary pricing might be less likely to emerge under Baumol's policy.

2.2.3 Edlin Game

The equilibrium prediction of the Edlin game and the off-equilibrium behavior differ from the two previous cases.

Proposition 3. *The Edlin game has a SPE without entry, in which the incumbent sets the entry-deterring price p^* except in period 4 where it charges the monopoly price. The equilibrium strategies involve hit-and-run entry in the off-equilibrium path where the incumbent prices above p^*: the entrant prices just below the incumbent's Edlin restriction and exits in the next period. Any equilibrium has these properties.*

Crucially, after sufficiently high incumbent prices, the entrant can earn positive net profits for one period by undercutting the Edlin restriction. Anticipating this, the incumbent faces two options. First, it can choose the monopoly price, which will attract entry. Second, it can choose an entry-deterring price, thereby avoiding entry, but earning lower pre-entry profits. For our parameterization the latter option is more attractive. Thus, though the SPE does not involve entry, the Edlin rule has a desirable effect on prices.

However, the Edlin rule seems more conducive to entry than the alternatives: after high incumbent prices, the rival should enter because it is protected from competition. This differs from the previous games where entry does not occur in any SPE.

2.2.4 Welfare

Figure 2 shows the equilibrium welfare results. For comparison, we plot the welfare results for a low-cost monopoly under marginal cost regulation, assuming that consumers compensate the incumbent for the loss of 250, and consequently enjoy a surplus of 1550. Because the rival does not enter the market, it earns the payoff from the outside option (50). We also plot the welfare results for the Bertrand duopoly, in which the low-cost firm

[16] An open issue here is to which extent the equilibrium structure depends on the parameters. For instance, with a longer interaction, the incumbent may be more reluctant to fight after entry, which could, in turn, lead to greater entry incentives.

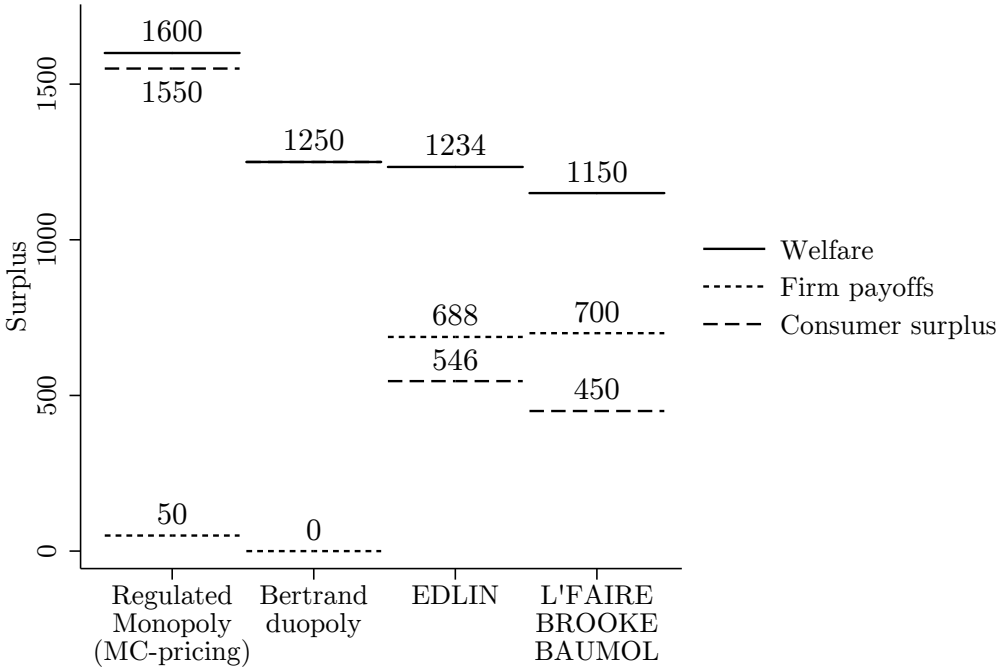

Figure 2: Welfare benchmarks of the four policies, a low-cost monopoly with marginal cost regulation, and Bertrand competition.

serves the market at a price equal to the high-cost firm's marginal cost. In this case, the former's payoff of 250 is exactly offset by the loss of the latter, such that the sum equals zero and overall welfare is equal to consumer surplus. At the other extreme, we consider a completely unregulated low-cost monopoly, resulting in low consumer surplus and total welfare, but high firms' payoffs. This corresponds to the outcome of the Laissez-faire, Brooke Group and Baumol games.

The SPE of the Edlin game predicts no entry and entry-deterring prices in periods 1–3. In the discrete version of the game, the price is thus 46, which results in firms' profits of 684 (including the 50 of the rival), and a consumer surplus of 578. The numbers in Figure 2 take into account that this outcome only applies to periods 1–3, while in period 4 the outcome of the Edlin game is identical to the other three policies. Thus, if the first-best is not available, there are several alternatives that might increase welfare: The Edlin game results in a higher level of consumer surplus and total welfare than Laissez-faire, Brooke Group and Baumol, because pre-entry prices are lower and there is no adverse effect on market structure. Bertrand competition is desirable for different reasons: even if it comes with a duplication of the fixed costs, it guarantees low duopoly prices.

2.3 Experimental Design and Procedures

We apply a between-subjects design, so that each subject is assigned to one of the treatments L'FAIRE, BROOKE, BAUMOL, or EDLIN. Each treatment consists of seven rounds of

the respective four-period game. At the beginning of each round, groups of two subjects are randomly drawn from the subjects in a matching group (stranger matching). In each group and each round, the roles (incumbent or rival) are randomly reassigned within the groups. When a new round starts and the subjects are newly matched, neither subject knows anything about the previous decisions of the other firm. Within a round, the firms and their roles remain the same. At the end of each period, subjects are informed about the market price, the output sold, and the payoffs realized by each firm in their group.

The sessions were run in the WiSo experimental research laboratory of the University of Hamburg in July 2015.[17] We provided written instructions which informed the subjects of all the features of the markets (for the detailed instructions see the online appendix). Similar to other studies on experimental oligopolies (e.g., Huck et al. (2004)), we used an economic framing, explaining the strategic situation in terms of firms, prices, and quantities.[18] At the beginning of the session, subjects were endowed with 1500 units of an experimental currency ("points") to cover potential losses. The subject payments consisted of a €5 show-up fee plus the sum of the payoffs over the course of the experiment. The sessions lasted for about 90 minutes, with average earnings of €16.80. We conducted ten sessions—two per treatment for L'FAIRE and BROOKE and three per treatment for BAUMOL and EDLIN—with a total of 228 participants. The subjects were undergraduate students from the University of Hamburg.

3 Results

We first show that in L'FAIRE above-cost exclusionary pricing is common. As a result, many participants do not enter, and those who do often exit. After that, we investigate the potential of the three policies to improve the situation. We distinguish between three market structures: (i) *PreEntry*, the phase before entry which captures all situations in which the incumbent needs to worry about future entry;[19] (ii) *Duopoly*, after the rival has entered and the two firms compete (the phase where exclusionary behavior might arise); and (iii) *PostExit*, after one of the two firms—typically the rival—has left the market and, thus, no entry threat exists.[20] Finally, we discuss the dynamics across rounds.

[17]The experiments were programmed in z-Tree (Fischbacher, 2007); recruitment by hroot (Bock et al., 2014). Subjects were randomly allocated to computer terminals in the laboratory so that they could not infer with whom they would interact. Throughout the experiment, communication was not allowed.

[18]Prior to the start of the treatment, subjects had to answer control questions. Subjects had access to a payoff calculator allowing them to calculate the payoff of hypothetical combinations of their actions and the actions chosen by their competitors.

[19]More precisely, we define *PreEntry* as consisting of all periods in which the rival did not yet enter, except period four. We exclude the final period, because the incumbent no longer can have any concerns about future market entry.

[20]The three market structures are typically encountered in this specific order. In very few cases, we observe that the incumbent exits and the rival enters in the same period or later. In this case, the group moves directly from *PreEntry* to *PostExit*.

3.1 Exclusionary Pricing Under Laissez-Faire

We define pricing as exclusionary if it prevents a rival from breaking even; such pricing provides rivals with the incentive to exit a market or not to enter in the first place. By this definition, when the incumbent charges 37 or below, pricing is exclusionary because the entrant cannot help but lose money by being in the market.[21] The definition thus encompasses both below-cost and above-cost exclusionary pricing.

Prior to entry (in *PreEntry*), the incumbent is a monopolist and prices as such. The average observed price is 49.6, with 83 percent of the cases at exactly the monopoly price of 50.[22] Entry lowers the average incumbent's price substantially to 34.9, which is in the exclusionary range of 37 and below.[23]

Figure 3 shows the frequency of incumbents' duopoly prices for different price ranges. No incumbent prices below its own marginal cost of 20, so that there is no below-cost exclusionary pricing. However, most incumbents (75 percent) respond to entry with above-cost exclusionary pricing: 26 percent of the prices are above the incumbent's marginal cost and below the rival's marginal cost, while around half of the observations (49 percent) are between the rival's marginal cost and his break-even point. Thus, entrants only earn a positive profit in 13.4 percent of the cases when they are in competition with an incumbent. The average profit is −235 per period. Most entrants leave the market: among the 93 cases where rivals join the duopoly market in periods two or three, 57 (61.3 percent) leave the market at some point.

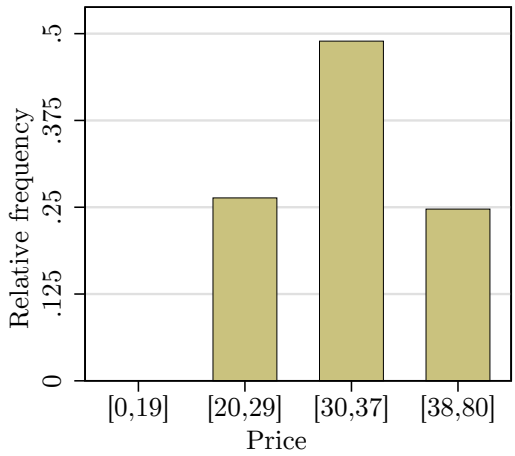

Figure 3: Incumbent prices in *Duopoly* of L'FAIRE.

[21] In the discrete version of the game, the rival cannot break even if the incumbent sets 37. It cannot profitably undercut the incumbent as $36 < p_H^B$; and the variable duopoly profits obtained when both firms charge 37 do not suffice to cover fixed costs.

[22] The frequent choice of the price 50 might partly be explained by the fact that 50 is a prominent number. However, in the cases when the rival becomes a monopolist, we also observe the monopoly price (55) frequently (70 percent), indicating that most subjects are able to find payoff maximizing solutions.

[23] The decrease is highly significant ($p = .008$, exact Wilcoxon signed-rank test). This and all subsequent non-parametric tests are based on independent matching group averages.

Aside from the fact that entrants exit the market, the most important effect of exclusionary pricing is that rivals do not contest the incumbent in the first place. Over the seven rounds, entry declines substantially. While in the first round 95.8 percent of the rivals enter the market, the percentage drops to 41.7 percent in the final round. Thus, by the time the rivals anticipate the incumbents' likely reaction, most do not enter.

After the incumbent has pushed the entrant out, the game is in the *PostExit* structure. The incumbents switch back to monopoly pricing with an average of 50.7.[24]

Result 1. *In* L'FAIRE*, incumbents generally engage in above-cost exclusionary pricing. They mostly succeed in pushing the entrants out of the market and apparently dissuade the majority of experienced rivals from entering.*

These observations largely match the predictions, except for the prevalence of entry when theory predicts no entry. There are several potential explanations of the entry behavior. Rivals may initially be completely naive about the possibility of exclusionary pricing. Slightly more sophisticated rivals may be concerned about post-entry price reductions, but they may not understand how much they need to earn to profitably enter the market, as they have to keep track of different notions of costs: variable costs (30 per unit), fixed operating costs (250) and opportunity costs (50). Finally, rivals may be aware of the potential problem, but hope that the incumbent tries to get away with high prices. All of these possibilities are consistent with the observation that entry becomes far less common over time, because subjects learn that entry is usually not profitable.

3.2 Policy Effects

The results in the previous section show that above-cost exclusionary pricing occurs under Laissez-faire. They also suggest that fear of such behavior may discourage entry. However, one cannot be sure about this without comparing the Laissez-faire results to a situation in which exclusionary pricing is impossible or restricted. In this section, we provide such a benchmark. We compare L'FAIRE with BROOKE, BAUMOL and EDLIN, respectively. The Edlin policy is particularly important, because it directly limits above-cost exclusionary pricing by design: if we see more entry in EDLIN than in L'FAIRE, this will show that fear of price cuts by the incumbent prevents entry in the latter case.

Policy can potentially affect market outcomes via two channels. First, it may influence entry and hence the frequency of the three market structures (*PreEntry*, *Duopoly*, *PostExit*). Second, it may affect prices under each market structure. We will now isolate the two effects. We start by showing how the policies affect prices under each market structure. Then, we investigate the policy effects on market structure.

[24] There are a few instances where the incumbent leaves the market, making the entrant a monopolist. The average price in these situations is 54.8 which is basically identical to the rival's monopoly price (55).

3.2.1 Prices Under Different Market Structures

***PreEntry*:** Theory predicts that in L'FAIRE, BROOKE, and BAUMOL, the incumbent charges the monopoly price of 50 in *PreEntry*, because its price does not affect entry. In EDLIN the incumbent charges 46 in order to deter entry. Motivated by our theoretical analysis, Figure 4 bins the observed prices into three categories. The intermediate category $[47, 53]$ contains the monopoly price as well as slightly higher and lower prices; as predicted for the first three treatments. Low prices in $[0, 46]$ are those that qualify as entry-deterring under the Edlin rule, because the incumbent can ensure that the entrant loses money in the following period. High prices in $[54, 80]$ are not predicted by our theoretical model for any treatment.

Figure 4 shows that in L'FAIRE, BAUMOL, and BROOKE, the incumbent usually prices in the intermediate category at or near the monopoly level. The average price we observe in the *PreEntry* structure is close to the monopoly price of 50 in the first three treatments, with 49.6 in L'FAIRE, 49.1 in BROOKE, and 50.0 in BAUMOL. EDLIN produces substantially different results with 44.9 percent of the observations in the low price bin. The average price is at 46.2, very close to the theoretical prediction.[25] Thus, firms systematically respond to the Edlin rule and frequently choose entry-deterring prices as expected.

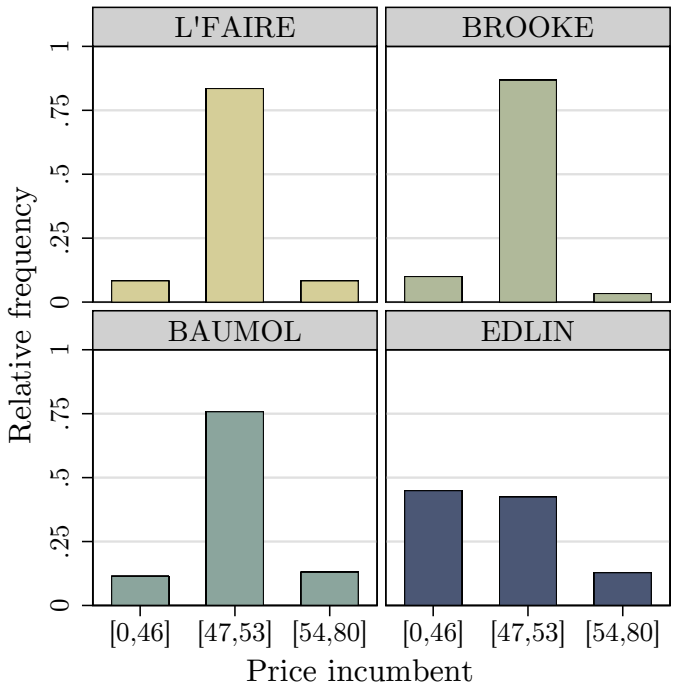

Figure 4: Distribution of incumbent prices in the structure *PreEntry*.

***Duopoly*:** Advocates of strict exclusionary pricing rules want to reduce the frequency

[25] The differences across all treatments are significant at $p = .011$ (Kruskal-Wallis test). The bilateral difference between EDLIN and L'FAIRE (BAUMOL) is significant at $p = .033$ ($p = .002$). For two-group tests, we report p-values of exact Wilcoxon rank-sum tests.

of exclusionary pricing, while Laissez-faire and Brooke Group advocates worry about the consumer loss from discouraging price wars. As there is some entry in all treatments, we can investigate the policy effects on exclusionary pricing.

The bars in the left panel of Figure 5 show the frequency of exclusionary pricing (37 or lower) by incumbents in the periods where they compete with the rival. The frequency is 75.3 percent in L'FAIRE, 69.5 percent in BROOKE, 66.1 percent in BAUMOL and 50.3 percent in EDLIN. In EDLIN, the frequency is significantly lower than in any of the other treatments.[26] The lower frequency of exclusionary pricing in EDLIN reflects policy restrictions. When incumbents are not restricted by the rule, we observe a very high frequency of above-cost exclusionary prices (88.0 percent) even in EDLIN.[27]

These observations reflect expectations. In L'FAIRE and BROOKE, nothing prevents the incumbents from setting above-cost exclusionary prices, and it is optimal for them to do so. In BAUMOL, firms can set duopoly prices freely, but they must worry about the adverse consequences for post-exit prices. Finally, in EDLIN, incumbents are not allowed to pursue exclusionary pricing after high pre-entry prices.

The right panel of Figure 5 is essentially the mirror image of the left panel. It shows the market prices in *Duopoly*. L'FAIRE and BROOKE produce the most competitive prices, followed by BAUMOL and EDLIN.[28] The differences between adjacent bars are not significant, but the comparison between EDLIN and the first two treatments is ($p < .004$). If we pool the observations from L'FAIRE and BROOKE and test against BAUMOL, the differences become significant at $p = .043$. Thus, while BROOKE does not have an effect, the two other policies lead to higher prices than L'FAIRE when entry happens.

***PostExit*:** In the structure *PostExit*, the remaining firm has a monopoly and does not face the threat of market entry. As expected, such firms set the monopoly price: Incumbents' average prices are very close to 50, with 78 percent or more at exactly 50 in L'FAIRE, BROOKE, and EDLIN. In BAUMOL, we observe significantly lower prices due to the price cap. Virtually all firms (97.8 percent) price at the Baumol price cap whenever it applies. The average *PostExit* price of the incumbents is 38.7.

Result 2. *In PreEntry and PostExit, average prices are close to the monopoly level. Lower prices only occur in EDLIN in PreEntry and in BAUMOL in PostExit. In Duopoly, above-cost exclusionary pricing is frequent in L'FAIRE, BROOKE, and BAUMOL. EDLIN substantially reduces the frequency of exclusionary pricing. When both firms are in the*

[26] $p < .003$, Wilcoxon rank-sum test on average frequency in the matching group. All other bilateral comparisons are insignificant ($p > .128$).

[27] Incumbents are not restricted when either no rule applies to them or the rule allows exclusionary prices.

[28] In all treatments, prices are clearly above the entrant's marginal cost. This is in contrast to the results of Boone et al. (2012), who find prices close to the marginal cost of the less efficient firm, while other experimental studies on Bertrand oligopolies with asymmetric costs find prices above the Nash equilibrium (Dugar and Mitra, 2016; Argenton and Müller, 2012). An important difference between our design and these studies is that, in our case, the entrant faces fixed costs.

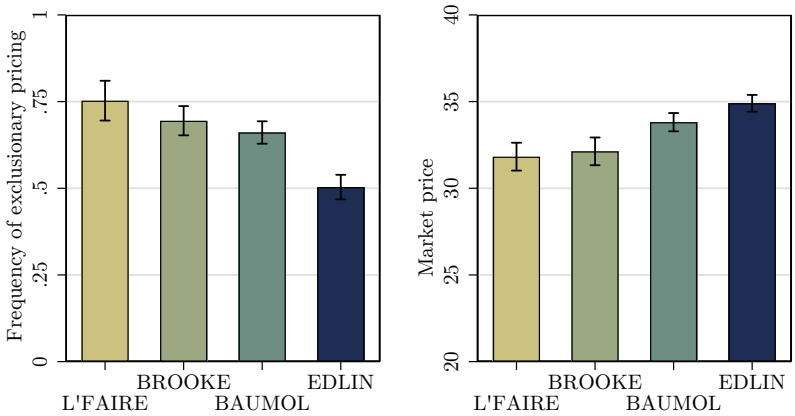

Figure 5: Prices in *Duopoly*. Left panel: frequency of exclusionary pricing by the incumbents across treatment. Right panel: market prices across treatment. Spikes indicate standard errors, calculated with clustering on matching group.

market, L'FAIRE *and* BROOKE *yield the most competitive pricing.*

The results are broadly consistent with the predictions. Incumbents that are not challenged by potential entry or know they can adjust prices freely after entry have no incentive to deviate from the monopoly price. It takes restrictions on post-entry price reductions (EDLIN) to induce low pre-entry prices, whereas low post-exit prices only obtain when price increases after exit are prohibited (BAUMOL). In duopoly, above-cost exclusionary pricing is expected in all treatments—with the obvious caveat that in EDLIN the incumbent might be limited in its ability to price low by its earlier pricing decisions.

3.2.2 Market Structure Effects

Result 2 shows how the price effects of policy depend on market structure. However, the overall policy effects also depend on how often each of the three market structures will arise under each policy. We now show how policy affects these frequencies.

Entry: We first compare the overall entry frequency under the different policies. There is no equilibrium entry under any rule, and there is no entry in L'FAIRE, BROOKE, or BAUMOL in any SPE, even after off-equilibrium prices. In EDLIN, there is no entry on the equilibrium path, but entry occurs following incumbent prices above 46.

Unlike predicted, there is entry in all regimes. In period 2, 51.8 percent enter in L'FAIRE, and 45.2 percent in BROOKE. BAUMOL (60.6 percent) seems to encourage entry, presumably because rivals hope that the incumbent is reluctant to fight: anticipating the Baumol restriction, incumbents know they have to continue to price low after exit. As suggested by our off-equilibrium analysis, entry is highest in EDLIN with 72.7 percent.[29]

[29]Differences across all treatments are significant at $p = .005$, differences between EDLIN and L'FAIRE or BAUMOL are significant at $p < .003$.

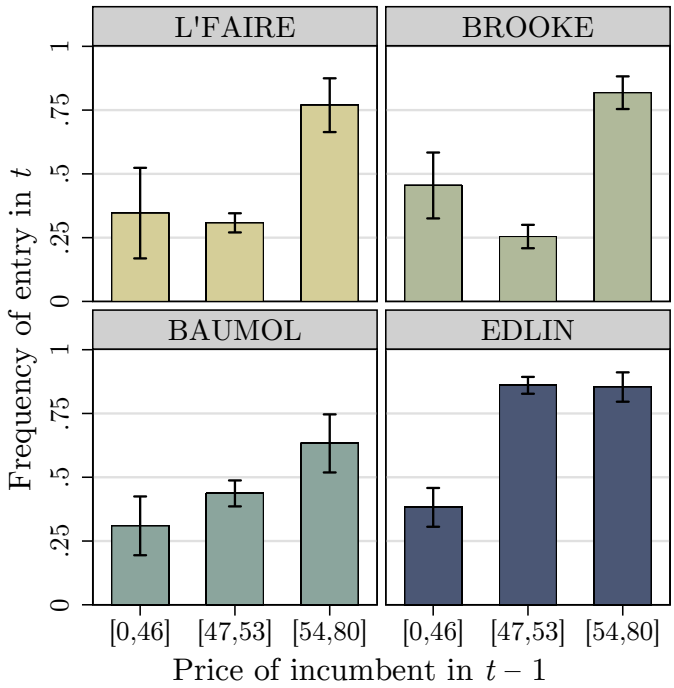

Figure 6: Frequency of entry for different incumbent prices in the previous period. For this figure, we use all periods in which the rival can enter. We use the same bins for the incumbent price in the previous period as in Figure 4. Spikes indicate standard errors (with clustering on matching group).

Incumbent Price and Entry: We now show that policy not only affects the frequency of entry, but also the circumstances under which entry occurs. According to Proposition 3, under the Edlin rule, entry is the best response to prices above the entry-deterring price of 46, whereas under the other rules, entry is usually a poor choice regardless of the incumbent's pre-entry price.

Figure 6 shows the fraction of rivals entering, conditional on the incumbent's price in the previous period. In all treatments, above-monopoly prices seem to encourage entry, ranging from 63.3 percent in BAUMOL to 85.4 percent in EDLIN. However, for intermediate prices, entry behavior differs across policies. For prices near the monopoly level, entry is quite rare in L'FAIRE and BROOKE (30.8 and 25.4 percent), and somewhat higher in BAUMOL (43.7 percent). For all these treatments, there is a significant difference between entry after monopoly prices (middle bin) and after above-monopoly prices (right bin) at $p < .032$. In stark contrast, EDLIN produces more than twice as much entry as the other treatments after incumbent prices near the monopoly level, with 86.0 percent of rivals entering the market. The entry frequency for low incumbent prices is similar in all treatments. To conclude, incumbent prices above the monopoly price encourage entry in all treatments, whereas prices close to the monopoly price typically discourage entry just as much as lower prices, unless the Edlin rule is in place.

The differences in the circumstances under which rivals enter are closely related to post-entry experiences. In L'FAIRE, 67.0 percent of the entrants are undercut by the incumbent in the first period after entry, and around half of the entrants who experience undercutting after entry exit immediately. The numbers for BROOKE and BAUMOL are similar, with slightly less undercutting but even more exit. On the other hand, in EDLIN, 78.6 percent of the *entrants* undercut the incumbent in the first period after entry, but nevertheless 50.9 percent exit. Thus entry is typically of a hit-and-run type. Contrary to the L'FAIRE and BROOKE cases, entry in EDLIN is often profitable.

Frequency of Market Structures: Table 1 shows the percentage of periods in which the market is in a given structure in each of the four treatments.

Table 1: Frequency of market structures

Structure	L'FAIRE	BROOKE	BAUMOL	EDLIN
PreEntry	55.1	59.1	47.3	37.0
Duopoly	27.7	22.9	25.2	31.4
PostExit	17.3	18.0	27.5	31.6

Notes. Percentage of periods with a given market structure, separated by treatment. In addition to the cases defined at the beginning of Section 3, category *PreEntry* also contains those Period 4 interactions for which the rival has not previously entered in the round under consideration, and *PostExit* contains the few cases when both firms exited the market.

In line with our observations on the frequency of entry, we find that *PreEntry* is most common in L'FAIRE and BROOKE, and particularly rare in EDLIN. Duopoly periods are more common in EDLIN than in the remaining treatments. However, the particularly anti-competitive *PostExit* situation is most frequent for EDLIN.[30]

Result 3. *We observe frequent market entry in all treatments, particularly in EDLIN and, to a slightly lesser extent, in BAUMOL. Consistent with the predicted off-equilibrium path behavior, entry in EDLIN mainly happens if the incumbent does not set entry-deterring prices. With experience, entry drops considerably in L'FAIRE and BROOKE, but much less so in the two other treatments.*

The relative entry frequencies match the differences in protection given to entrants under the different policies. In L'FAIRE and BROOKE, there is no protection whatsoever, in EDLIN, it is provided directly by the downward price freeze for the incumbent. In BAUMOL, there is some indirect protection, because post-entry price reductions are costly for the incumbent if the rival exits.

[30]It is also quite frequent for BAUMOL, but, in this case, the adverse effect is mitigated by the Baumol rule. The treatment differences are significant ($p = .000$, χ^2 test with correction for clusters).

3.3 Dynamics

So far, we considered all seven rounds. Investigating the dynamics across the rounds gives us an indication of whether play converges towards the theoretical predictions once subjects become more experienced with the strategic environment. We first study the dynamic in prices and then in market structure.

Prices: In all rounds, average prices in *PreEntry* for L'FAIRE, BROOKE, and BAUMOL are close to the monopoly price. In particular, in the last round, more than 85 percent of the incumbents set the monopoly price. To explore the time trend in prices we ran OLS estimates for the incumbents' pre-entry prices in the first period (Table A1 in the appendix). The results suggest that in early rounds pricing is similar across treatment, but, contrary to the other treatments, EDLIN shows a negative time trend. The incumbents' prices in EDLIN are initially close to the monopoly price, but then drop sharply to averages around 45 in rounds 5–7. In the first half of the rounds (1–4), 32.8 percent of the incumbents choose entry-deterring prices in *PreEntry*. In the second half of the rounds, this percentage increases to 59.2 percent, suggesting that it took some time for the subjects to learn how to react to the strategic incentives provided by the Edlin rule.

We also estimated market prices in *Duopoly* (Table A1 in the appendix). Prices are significantly higher in BAUMOL and EDLIN than in L'FAIRE and BROOKE. The time trend is significantly negative, suggesting that competition becomes fiercer in later rounds.

Market structure: Figure 7 shows the fraction of games in which the rival enters at some point across the seven rounds. Across all treatments, we observe that there is less entry when subjects gain experience. The drop is particularly strong in L'FAIRE and BROOKE. In both cases, the rival almost always enters in the first round, but less than 50 percent of the time in the second half of the experiment (rounds 5–7). In combination with the fact that incumbents' *PreEntry* prices do not vary importantly, this suggests that a substantial part of the entry decisions is motivated by learning about the pricing of the incumbent in *Duopoly*. While there is also a drop in entry as experience increases, entry remains substantially more frequent in BAUMOL (63.0 percent) and in particular in EDLIN (86.9 percent) in the rounds 5-7.[31]

The observations confirm the impression that, at least in L'FAIRE and BROOKE, subjects initially enter because they ignore or at least underestimate the risk of exclusionary pricing, whereas they tend to assess it correctly in later rounds. For the other policies, it is less clear that entry is a mistake, because the rules offer some protection for the entrant. Consequently, there is a smaller reduction in entry with increasing experience.

Result 4. *During the seven rounds there is no time trend in the prices when incumbents hold the monopoly, with the exception of PreEntry in EDLIN, in which subjects converge on*

[31] The difference in entry between inexperienced and experienced subjects is significant for L'FAIRE ($p = .008$), BROOKE ($p = .016$), and BAUMOL ($p = .010$), but not for EDLIN ($p = .129$), Wilcoxon signed-rank test on matching group averages.

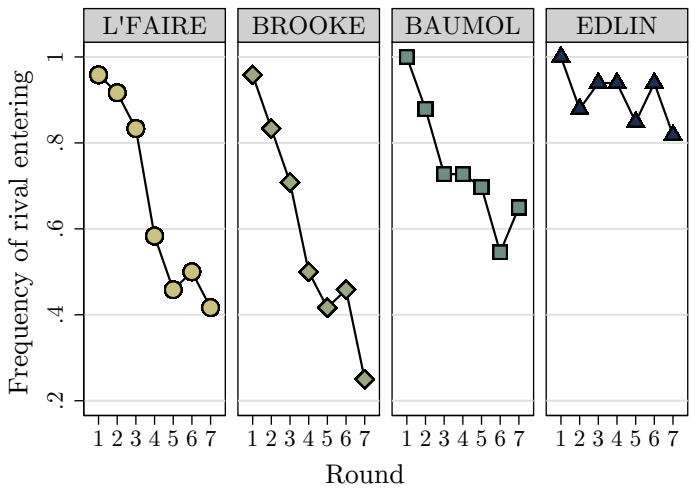

Figure 7: Frequency of rival entry across the seven rounds and by treatment.

average to the entry-deterring prices only in the second half of the rounds. Price wars in Duopoly tend to become fiercer in later rounds. As subjects gain experience, entry becomes less frequent in all treatments, but the drop is much more pronounced in the treatments which offer least protection for the entrant (L'FAIRE and BROOKE).

The dynamics suggests that some of the strategic incentives set by the different policies require experience to become effective. In our welfare analysis below, we therefore emphasize the results of the games with experienced subjects and we will restrict some of the analysis to the second half of the experiment, i.e., rounds 5–7.

3.4 Welfare Implications of the Policies

The results presented so far illustrate that two of the three alternative policies result in significantly different market outcomes than the laissez-faire approach. While the outcome of BROOKE is very similar to L'FAIRE, EDLIN results in lower prices prior to entry, and BAUMOL results in substantially lower prices after exit. The welfare implications for a given market structure are straightforward. In the *PreEntry* phase EDLIN clearly dominates the other policies, both in terms of welfare and consumer surplus.[32] In *Duopoly*, we observe the highest consumer surplus in L'FAIRE and BROOKE, but the overall treatment differences are not significant ($p = .155$, Kruskal-Wallis test). In *PostExit*, only BAUMOL offers significantly higher consumer surplus and welfare than the unregulated monopolies observed under the remaining treatment conditions ($p < .001$).

To analyze the overall welfare implications we consider policy effects on market structure and not only on prices conditional on market structure. Figure 8 shows the average

[32]In the second half of the rounds the difference between EDLIN and each of the other three treatments is highly significant for both measures ($p < .002$, Wilcoxon rank-sum tests).

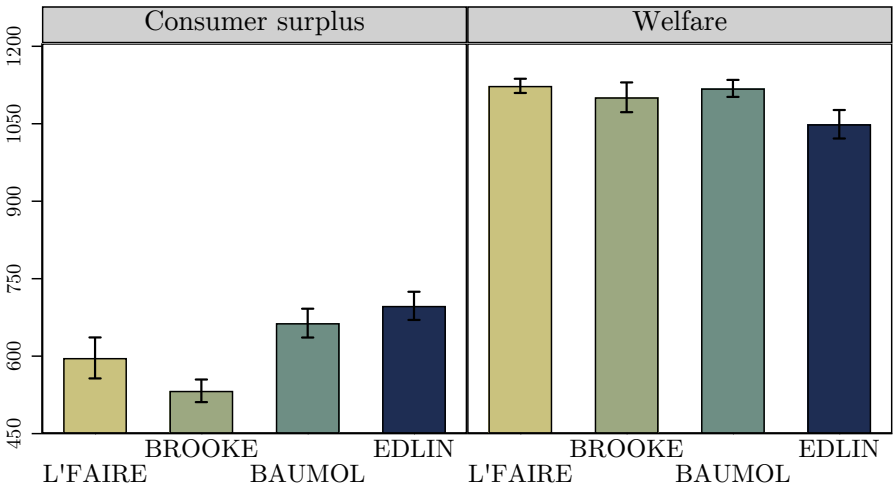

Figure 8: Consumer surplus and welfare in rounds 5–7. Bars show averages over the four periods and all groups, spikes indicate standard errors (with clustering on matching group).

consumer surplus and welfare over the four periods of the game for experienced subjects (rounds 5–7). The numbers aggregate the policy effects on pricing and market structure. In rounds 1–4 (not shown in the figure), there are no significant overall differences across treatments in consumer surplus ($p = .105$, Kruskal-Wallis test). In rounds 5–7, differences in consumer surplus become significant ($p = .005$) with BAUMOL and, even more so, EDLIN generating more consumer surplus than the other two treatments.

Given our results conditional on market structure we can decompose the changes of the policies relative to L'FAIRE. For example, EDLIN offers a consumer surplus gain relative to L'FAIRE of 43 percent during *PreEntry*. Some of it is eaten away during *Duopoly*, where consumer surplus is 13 percent lower, reducing the overall advantage of EDLIN to 17 percent. The surplus under BAUMOL is ten percent lower than under L'FAIRE in *Duopoly*, which is compensated by a large advantage in *PostExit* of 109 percent, leading to an overall advantage of 11 percent relative to L'FAIRE. [33]

For welfare, we observe significant differences across the four treatments in rounds 1–4 ($p = .000$), with the lowest welfare in EDLIN. When subjects gain experience in EDLIN (rounds 5–7), the differences in welfare across treatments become insignificant ($p = .229$).

Result 5. *Edlin's policy proposal dominates a laissez-faire approach prior to entry, and Baumol's policy does so after exit. Both policies come at the cost that competition tends to be weaker in duopoly. The overall welfare effects depend on the frequency of these market structures. EDLIN is favorable from a consumer perspective when firms are sufficiently experienced with the rule. Overall welfare is lowest in EDLIN, while the other three treatments produce very similar results.*

[33] All percentages refer to the observations with experienced subjects (round 5–7).

The low consumer surplus in L'FAIRE and BROOKE is essentially in line with expectations and mostly driven by the lack of entry and the high pre-entry prices. The higher consumer surplus in BAUMOL is not predicted by the SPE. It directly reflects the greater frequency of entry and the lower post-exit prices. Finally, the high consumer surplus in EDLIN reflects both the frequent entry and the low pre-entry prices.

The low total welfare in EDLIN is the downside of particularly pronounced (off-equilibrium) entry. Entry not only leads to duplication of fixed costs, but also to low variable profits reflecting (undesired) production by the high-cost rival as well as (desired) competitive pressure. This leads to the observed deviations from the predictions.

3.5 Summary of Results

In summary, this paper studies above-cost price cuts in a multi-period interaction between a low-cost monopolistic incumbent and a high-cost potential entrant. We compare a laissez-faire setting with three different policy interventions: the legal standard of the Brooke Group rule, according to which below-cost pricing is prohibited; a policy that prohibits certain post-entry price cuts (Edlin, 2002); and a policy that prohibits post-exit price increases (Baumol, 1979).

In subgame-perfect equilibrium, there is no entry in any of these settings. Under the Laissez-faire, Brooke Group and Baumol policies, this is true even though the incumbents choose monopoly prices. Under the Edlin rule, the incumbent prices below the monopoly level because this is needed to prevent entry. In theory, nothing resembling exclusionary pricing occurs on the equilibrium path.

The observations of the experiment differ from our theoretical predictions. Neither L'FAIRE nor BROOKE— which capture the essence of the current policy in the U.S. and Europe—place any relevant constraints on post-entry price cuts. Despite this, there is some entry in both treatments, which is followed by price wars and often exit. Both pre-entry and post-exit prices tend to monopoly levels. In both L'FAIRE and BROOKE, the incumbent frequently responds to entry with prices too low for the entrant to break even. As these prices are low enough to induce exit and discourage entry, they are exclusionary and we call them above-cost exclusion.

Edlin's (2002) restrictions on post-entry price cuts substantially encourage entry, particularly in later rounds when people understand the game better. Put differently, the anticipated price cuts in L'FAIRE and BROOKE must have discouraged entry and been exclusionary in practice. The incumbent's price cutting not only induces exit, but its prospect discourages entry. In EDLIN, prices are substantially lower prior to entry. This makes sense. The incumbent cannot discourage entry with the threat to price low after entry unless it prices low prior to entry. While the massive entry in EDLIN benefits consumers, it has the downside that it involves a replication of fixed cost and higher cost

production by the entrant.

Baumol's post-exit price restrictions lead to an intermediate frequency of entry and lower post-exit prices. However, pre-entry prices are as high as in L'FAIRE and BROOKE, and duopoly prices are slightly higher than in those cases.

The welfare comparison in the theoretical model is trivial. Because there is no entry in any treatment and pricing in the Edlin policy is low while it is monopoly in the other three regimes, Edlin's policy dominates whether from a consumer or a total welfare perspective. The experimental analysis, however, reveals a more complex picture. Since policies differ with respect to the effects on entry, as well as on duopoly and post-exit prices, a full welfare judgment needs to take all these effects into account. For the specific parameter values of our model, these effects mean that both lenient approaches to above-cost exclusion, L'FAIRE and BROOKE, and BAUMOL all perform well with respect to total welfare and substantially better that EDLIN. From a consumer perspective, however, EDLIN is preferable.

4 Policy Discussion and Concluding Remarks

While he was chairman of the U.K. Office of Fair Trading, John Vickers asserted: "Clearly there are circumstances in which the entry of less-efficient rivals can improve social welfare because the gain in allocative efficiency through lower prices can outweigh the loss in productive efficiency through higher costs." He further argued that "there is little basis in economic theory for a rule that always permitted above-cost price discrimination by dominant firms in response to competition" (Vickers 2005, p. F256). Indeed, if firms are always free to charge any price above their cost, then a monopoly with advantages over would be entrants can charge monopoly prices with little fear of entry because entrants know that they will not survive post-entry price wars. Our experiment does not provide support for the idea that policies can improve overall social welfare by encouraging the entry of inefficient firms or the threat of their entry. However, our experiment does provide some support for the idea that encouraging their entry or the threat of their entry as Edlin does could improve consumer welfare. Likewise, if we interpret price discrimination as charging different prices for the same product at different times, then the limits that Baumol places on above-cost price discrimination can improve consumer welfare.

In the 1980s courts began to think that low prices were so unlikely to be anticompetitive (i.e., predatory) that anticompetitive low pricing was as common as unicorns. Such skepticism lead the U.S., Europe and many other jurisdictions, to give firms either an outright safe harbor (the U.S.), or a nearly free pass (Europe), so long as a firm prices above its cost. The leading case in the U.S. is Brooke Group which requires plaintiffs to prove both below-cost pricing and also the prospect of recovering losses with higher

prices later on to successfully attack an incumbent's price cut. [34] EU enforcement policy is currently to assume that above-cost prices are not problematic. A guidance note on the Commission's application of Article 82 of the Treaty establishing the European Community (now Article 102 of the Treaty on the Functioning of the European Union) says: "If the data clearly suggest that an equally efficient competitor can compete effectively with the pricing conduct of the dominant undertaking, the Commission will, in principle, infer that the dominant undertaking's pricing conduct is not likely to have an adverse impact on effective competition, and thus on consumers, and will therefore be unlikely to intervene."[35] The preceding condition is satisfied if a firm prices above its own costs.

While a safe harbor for above-cost pricing is the general rule, it is not entirely unchallenged. The U.S. Department of Justice in the American Airlines case tried unsuccessfully to argue that any price cut that is unprofitable can be predatory even if price remains above cost. And in a few cases, the European Union has found abuse of dominance when above-cost price cuts had the purpose of eliminating an entrant.[36]

Do our experimental results support proposals to change policy? The interpretation of our results may well depend on the observer's point of view.

On the one hand, proponents of Laissez-faire or Brooke Group rules can take heart from our experiment. Whereas theory suggests that the Edlin rule dominates, in the experiment, the Edlin rule is only superior from the vantage of consumer welfare and performs considerably worse under a total welfare standard than Laissez-faire and Brooke Group. The reason is that there is significant entry in the experiment even though entry is unprofitable both in theory and in the experiment. This excessive entry implies that the Edlin rule suffers higher production costs from inefficient entrants who are protected and allowed to produce under the price umbrella that the rule provides. Baumol also has more inefficient entry than Brooke Group or Laissez-faire. It is plausible that entry by high-cost firms is a significant drawback of the Edlin and Baumol rules in practice, one that does not arise in our simple theoretical setup. Discovering such a problem is a virtue of an experimental approach.

On the other hand, antitrust authorities in the U.S. and Europe hold consumer welfare up as the goal they seek to promote, and Edlin and Baumol both do better under a consumer welfare standard. This observation partly reflects expectations, as the Edlin rule achieved the predicted gains in lower prices prior to entry. In addition, however, the positive consumer surplus effect is the flip-side of the excessive entry.

Of course, one must also recognize that our experiments necessarily rely on specific

[34] Bolton et al. (2000) report that, in the six years following the Brooke Group decision, plaintiffs have not prevailed in any of the 39 reported cases in the federal court.

[35] Communication from the Commission–Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings, OJ C 45, 24.02.2009, paragraph 27, p.11.

[36] Key cases in this line include AKZO, Compagnie Maritime Belge, and Irish Sugar.

parameterizations. If the game were longer than four periods those pricing improvements might come to be more important, whether before entry (as in the Edlin case) or after entrants eventually leave the market (as under the Baumol rule). Another factor in favor of the Edlin rule that does not appear in the experiment is that entrants may become more efficient over time through learning by doing such as in Cabral and Riordan (1994) and Besanko et al. (2010, 2013).

The design-related issues could, in principle, be addressed with further experiments, but other issues cannot. The experiment, by design, does not shed any light on administrability issues of the rules nor on how the rules would fare in a more complex Hayekian environment which conceded that much information is controlled by the parties and unavailable to courts. For the Edlin and Baumol policies, identifying price cuts and price increases is critical; when there are many prices (as with an airline) or product quality varies over time, this can be problematic. Entry is also not necessarily easy to identify in practice. There is finally the question of how long price restrictions are imposed under Edlin or Baumol. Such administrability concerns push many commentators to favor dovish predatory pricing policies (see, e.g., Easterbrook (1981)), but it is not entirely clear that the problems of administering the dovish Brooke Group rule is less than the problems with dynamic pricing restrictions. Traditional cost based tests have the same problems of Edlin and Baumol in measuring price in a complex environment. To this, cost based tests add the difficulty of measuring cost and of deciding what cost is relevant to compare with price (marginal cost, average variable or avoidable cost, average incremental cost or average total cost), and whether opportunity costs should be counted as costs and, if so, how to properly measure them. Finally, in spite of possible administrative concerns, we have seen that some competition authorities have developed some (limited) experience with above-cost pricing cases. Moreover, one important feature of the Baumol program also exists in American courts in practice, even though not in theory. U.S. law requires that plaintiffs prove both below cost pricing, and also the prospect of profit recoupment. In principle, the recoupment prong does not depend upon the firms actual pricing after the predatory period, but in practice, the best way to prove that recoupment is possible is to show that prices rose enough in fact to recover past losses. Thus, as required by the Baumol rule, American courts, in practice, use price increases to trigger liability, though only in below-cost cases. All told therefore, the administrative hurdles do not seem prohibitively high when compared with the status quo. Having said this, one might obviously argue for the laissez-faire approach on the grounds that without any law, there is no need for administration in the first place.

Our results make one wonder whether other policies might be better than the four policies we consider. For example, one might consider a rule of reason approach that involved intertemporal linkages but limited the possibility of the protection of inefficient entrants be sensible. For instance, liability might depend upon some combination of the

size of the price cut and how close prices get to below-cost pricing. That could limit the possibility of inefficient entry while still providing some incentives for incumbents to price low prior to entry. Future experimental tests might explore whether such policies could allow consumers to gain without significant losses in total welfare or even with increases in total welfare.

At a more general level, our paper addresses the risks and benefits of protecting inefficient entrants, and it asks whether courts should focus on price levels or consider the dynamics of pricing. These questions arise in broader contexts than the one addressed in our paper. For example, they arise when considering price squeeze cases such as Linkline, where a dominant telephone provider was accused of selling wholesale DSL services at a price so high relative to its own retail ISP services that independent ISPs could not profitably survive using its DSL. They also can arise in cases of bundled pricing such as PeaceHealth where a dominant provider of tertiary medical services is alleged to discount its price so much when insurance companies buy primary and secondary services from it that providers who only sell primary and secondary services cannot compete. Even though our experiment does not directly speak to these issues, it seems conceivable that excessive entry would also be present in those settings, thereby weakening the adverse effects of potentially abusive behavior by dominant firms.

We see our results as a useful input for the design of competition policies. So far, the literature on policies addressing exclusionary conduct relied on theoretical arguments and anecdotal evidence. We provide the first systematic empirical comparison of different policy responses. Our results are derived under idealized conditions, and it remains a question as to what extent they carry over to the real world. Studying these policies in the field would, however, require that we observe jurisdictions in which the respective policies are implemented. Given that the Baumol and Edlin rule are not (yet) applied by antitrust authorities, such investigations are impossible. We argue that wind-tunnel experiments like ours are an important complement to theoretical analyses and provide a relatively cheap way to investigate the functioning of the policies with real actors.

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