Hunting Unicorns? Experimental Evidence on Exclusionary Pricing Policies [‡]

Aaron Edlin[§] Catherine Roux[¶] Armin Schmutzler[‖] Christian Thöni[**]

July 3, 2019

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. While both policies have less competitive outcomes after entry than laissez-faire does, they nevertheless both increase consumer welfare. For Edlin's proposal this consumer gain is at the cost of lower overall welfare from attracting inefficient entrants, while for Baumol, overall welfare is comparable to current U.S. policy.

JEL Classification: D21, K21, L12, L13, C91
Keywords: Exclusionary Pricing; Entry Deterrence; Firm Strategy; Antitrust Law; Experiment

[§]University of California, Berkeley, and National Bureau of Economic Research. E-mail: aedlin@berkeley.edu

[¶]University of Basel. E-mail: catherine.roux@unibas.ch

[‖]University of Zurich and CEPR, Vice-President, Swiss Competition Commission. E-mail: armin.schmutzler@econ.uzh.ch

[**]University of Lausanne. E-mail: christian.thoeni@unil.ch

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 *Brooke Group Ltd. v. Brown & Williamson Tobacco Corp.* (509 U.S. 209 [1993]). 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 Group 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. 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" (*United States v. AMR Corp.*, 335 F.3d 1109 at 5 [10th Cir. 2003]). 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.

Similar examples arise in other contexts. The incumbent cable company in Sacramento, California rebuffed entrants by signing up subscribers at steep discounts, though there is no indication that the discounted prices were below the incumbent's own cost (see Hazlett 1995). Pacific, which had a monopoly of mechanical snubbers for nuclear power plants, used above-cost price cuts to recapture business threatened by Barry Wright, an entrant (*Barry Wright Corp. v. ITT Grinnell Corp.*, 724 F.2d 227 [1st Cir. 1983]). Northwest drove an entrant, Spirit airlines, from the Detroit-Boston and Detroit-Philadelphia markets with deep price cuts that the District Court found to be above cost (*Spirit Airlines v. Northwest*, 431 F. 3d p. 925, 958 [2005]).[1] In 2014, Willamette Valley Company, an incumbent monopoly of "patch," a product that fills imperfections in plywood, faced an entrant who initially offered significantly lower prices and drove the entrant from the market with large discounts. The entrant lost its predatory pricing case, however, because the appellate court thought that Willamette's discounted prices might have exceeded its cost even assuming the allegations of the complaint were true (see *Clean Water Opportunities, Inc. D/B/A Engineered Polyurethane Patching Systems v. The Willamette Valley*

---

1. The appellate court thought whether costs were above or below cost depended upon whether low fare tickets were a market and thought a jury needed to decide that. No jury did.

Company, CV. No. 16-227-JWD-EWD at 4-5 [2018] and *Clean Water Opportunities v. The Willamette Valley Company*, WL 113681 [2019]).

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 so long as it is free to 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 incumbent can charge monopoly prices forever, or at least until a lower cost firm materializes. From the vantage of consumers, this is a bad deal.

In this paper, we call pricing "exclusionary" if its effect is to induce exit or discourage entry, regardless of the *intent* underlying 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 and experiment are constructed. Whether there can be benefits from regulating such behavior is a question of the paper.

Because of cases like those discussed above, there has been a debate about the legality of above-cost exclusionary prices in the legal literature,[2] as well as 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 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

---

2. See discussions in Edlin (2002, 2012, 2018), Salop (2005, 2006), Popofsky (2006), Hovenkamp (2005), and Elhauge (2003). In a famous predatory pricing case, (*Barry Wright*, 724 F.2d 227), 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.

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 percent. 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 in all periods with no entry: the policies make no link 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, but to ensure this, the monopoly must price low prior to entry, because it is not free to cut prices after entry.[3] In theory, Edlin's proposal thus leads to *both* higher consumer surplus and higher welfare because it makes the market contestable. The high-cost entrant plays 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.[4] Identifying such a problem in

---

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

4. 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 separate from actual entry. They find that incumbents cut

the field is challenging. How can we know that entry is "insufficient," and if we do know, how can we attribute it to exclusionary pricing?

In the experiment, under the laissez-faire and Brooke Group policies, the incumbent usually charges the monopoly price before entry, as theory predicts. However, contrary to theory, there is significant entry, so we get to observe the incumbent's reaction: post-entry, the incumbent typically charges exclusionary prices below the entrant's break-even level, but above the incumbent's own cost due to its cost advantage.

Entry is higher under both the Edlin and Baumol rules, with the effect particularly strong under the Edlin rule. We attribute this boost in entry to these policies protecting entrants from dramatic post-entry price cuts, with the Edlin rule simply banning them and Baumol making them more costly.

The experiment reveals several benefits for consumers from protecting entrants from dramatic price cuts: lower prices prior to entry under the Edlin rule, lower prices after exit with the Baumol policy, and additionally increased time spent with low duopoly prices because of the increased entry under both policies. The cost of these policies to consumers is higher prices (less intense competition) during periods of duopoly. Compared with the laissez-faire benchmark, consumers gain 17 percent in surplus under the Edlin rule and 11 percent under Baumol when subjects have experience with the game. However, the Edlin rule performs relatively poorly from a total welfare perspective, contrary to theory. The problem is that it increases entry, which leads to costly replication of fixed costs and inefficient production by the high cost entrant. Under the Baumol rule, total welfare is roughly the same as under the laissez-faire and Brooke policies, as the reduction in deadweight loss from lower prices roughly balances with the higher production costs.

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 and also whether consumer benefits ever or often outweigh production inefficiencies.[5]

Our results are subject to varying interpretations. Economists concerned exclusively with total surplus can read our results as supporting laissez-faire or the status quo: in particular, total surplus is lower under the Edlin rule than under either Brooke Group

---

fares significantly when threatened by Southwest's entry and that the price cuts are only on threatened routes.

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

or laissez-faire and the Baumol rule does no better than laissez-faire. On the other hand, competition policy analysts like Salop (2010) and Hovenkamp (1985, 2013) who think that competition policy should promote consumer gains can read the experiment as providing support for policies like Edlin and Baumol that use price drops or price increases to trigger liability.[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. 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, at least to those who are trying to protect consumers, a mandate that the U.S. and European competition authorities largely embrace.

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 improves welfare if it occurs. This finding is similar to ours, although, contrary to this literature, we consider situations with symmetric information.[7] 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

---

6. While there will always be room for debate, there is ample support for the idea that antitrust either is or should be mainly pursuing consumer welfare, or at least give consumer welfare more weight than producer welfare. The U.S. Supreme Court has stated that "Congress designed the Sherman Act as a consumer welfare prescription." (*Reiter v. Sonotone Corp.*, 442 U.S. 330, 343 [1979]). Salop (2010) argues that competition policy should focus exclusively on consumer gains and losses, or more accurately on the gains and losses to those on the other side of the market from the allegedly anticompetitive activity (i.e., focusing on the victims). Lande (1982) surveys the history of U.S. antitrust law finding, that "[t]he antitrust laws were enacted to become broad and flexible economic mandates to improve 'consumer welfare,' as Congress defined this term." at 151. Kirkwood and Lande (2008) argues that the courts have overwhelmingly adopted the consumer welfare standard. And, Hovenkamp (1985) and Hovenkamp (2013) concluded that "antitrust policy in the United States follows a consumer welfare approach" and that "Congress had no real concept of efficiency and was really concerned with protecting consumers from unfavorable wealth transfers".

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

experimental literature on predatory pricing (see, e.g., Isaac and Smith 1985; Harrison 1988; Jung, Kagel, and Levin 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 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. The legal interpretation differs from Edlin's policy in a way that will be meaningful to lawyers—in Edlin's case the low price is illegal whereas for Gilo and Spiegel the high price is illegal—but the fundamental economic mechanism is quite similar and so the Edlin rule and Gilo and Spiegel rule are kindred.

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.

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 both firms simultaneously decide whether to participate in the market. The firms then observe whether their competitor is in the market and simultaneously choose a price.

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.[8] We opted for per-period

---

8. 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

costs, rather than only one-shot set-up costs, because recurring fixed costs such as rents are realistic and also 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, its demand equals market demand, and it chooses its price as a monopolist. 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:

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

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 $c_H = 30$.

A firm is considered *dominant* in period t if it produced and served the entire market in period $t - 1$, either because it was a monopoly or a duopolist that undercut its rival in $t - 1$. 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 laissez-faire game, the dominant firm can also choose its price anywhere in $[0, 80]$.

In the Brooke Group game, the dominant firm cannot respond to entry with a price below its cost. In particular, if (i) a firm i is dominant in time period t (meaning that it had the whole market in $t - 1$, either as monopolist or as undercutting duopolist) and (ii) firm i is in a duopoly in t, then firm i cannot price in t below its marginal cost, that is $p_i^t \in [c_i, 80]$.[9]

The Edlin game limits deep price cuts of the dominant firm. The trigger for the restriction is identical to the Brooke Group game. If the restriction applies, then the dominant firm cannot price in t below 80 percent of its $t-1$ price, that is $p_i^t \in [0.8 \cdot p_i^{t-1}, 80]$.

In the Baumol game, a restriction on pricing is triggered after the exit of the non-dominant firm. If exit occurred in t, then at t and thereafter the dominant firm cannot

raise its price above its $t-1$ price, that is $p_i^{t+k} \in [0, p_i^{t-1}]$ for $k = 0, 1, \ldots, 4 - t$.

We implement games that are 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; and (d) a specific choice of the Edlin parameter (0.8). Our choice of the allowable price reduction (20 percent, 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 in order to earn protection.[10]

2.2 Predictions

We now describe the subgame-perfect equilibria (SPE) outcome and the most important features of the equilibrium strategies in a non-technical way. The online appendix OA contains the technical details and proofs. 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 $0.8 p^* = p_H^B$.

The break-even price is calculated by setting the economic profit equal to zero. An exclusionary price by an incumbent guarantees that an entrant loses money from entry.

Figure 1 HERE

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, we are studying a situation with a substantial cost advantage for the incumbent.[11] 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 binding Edlin restriction as discussed above.

---

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

11. Without this assumption, further equilibria could emerge.

2.2.1 Laissez-Faire and Brooke Group Games

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

Proposition 1. *In both the laissez-faire and Brooke Group games, the incumbent charges the monopoly price and there is no entry along the equilibrium path of the unique subgame perfect equilibrium. In the event of off-equilibrium entry, the incumbent responds with an exclusionary price, and the entrant loses money and exits.*

Both firms are essentially free to set arbitrary prices in both games; the Brooke Group ban on pricing below own costs is irrelevant because a rational incumbent does not choose such prices anyway. Prices therefore do not affect future choice sets, and historical prices do not matter for the equilibrium strategies. In each period, firms set short-term optimal prices. In particular, in duopoly periods, the incumbent undercuts the entrant charging an exclusionary price of 30. 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 will be an upper bound for future prices if the rival exits. This reduces the incumbent's incentives to fight with low prices, and might thereby protect entrants from exclusionary pricing. The incumbent must weigh the short-term benefits from undercutting against the long-term benefits from monopoly prices. As we show in the online appendix, in duopoly subgames this trade-off leads to multiple equilibria where prices do not necessary equal the rival's marginal cost. However, there is no entry in any equilibrium because prices in all these equilibria are exclusionary so that the entrant cannot break even. In short, Baumol discourages cutting price to Bertrand levels but does not prevent exclusionary pricing in SPE if there is off-equilibrium entry. The following proposition summarizes the equilibria, which are very much like the equilibria of laissez-faire and Brooke Group games.

Proposition 2. *In the Baumol game, the incumbent charges the monopoly price and there is no entry along the equilibrium path of all SPE. In the event of off-equilibrium entry, the incumbent responds with an exclusionary price, and the entrant loses money and exits.*

The equilibrium outcome is the same as in the laissez-faire and Brooke Group games. The difference exclusively concerns off-equilibrium behavior where exclusionary prices may be above the marginal cost of the high-cost firm but below its average cost.

2.2.3 Edlin Game

The Edlin game equilibrium involves lower pricing than the three previous cases.

Proposition 3. *In the Edlin game, although the incumbent charges the monopoly price during period 4, the incumbent charges the lower entry-deterring price p^* during periods 1–3 and there is no entry along the equilibrium path of all SPE. In the event of off-equilibrium entry, the incumbent responds with an exclusionary price, and the entrant loses money and exits.*

If the incumbent charges more than p^* during periods 1–3, then its rival engages in hit-and-run entry. Anticipating this, the incumbent has 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. The second option is more attractive. The Edlin rule links the pre-entry price with post-entry pricing possibilities, and the incumbent responds by investing in a lower price in order to be free to fight an entrant and in fact to credibly commit to fight an entrant. By limiting aggressive post-entry pricing (which does not occur on the equilibrium path) the Edlin rule shifts aggressive pricing to pre-entry states that do occur and matter for consumers and efficiency. Although the SPE does not involve entry, the Edlin rule has a desirable effect on pre-entry prices because of the threat of entry. This differs from the previous games where entry does not occur regardless the incumbent's pre-entry price.

2.2.4 Welfare

Figure 2 shows the equilibrium welfare results. For comparison, we plot the first-best regulation (low-cost monopoly under marginal cost regulation, where consumers compensate the incumbent for the loss of 250, and consequently enjoy a surplus of 1550 per period). Because the rival does not enter the market, it earns the payoff from the outside option (50) making total welfare 1600. At the other extreme, we consider an 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. If the regulator or court cannot observe the incumbent's cost it might seem this is the best that could be expected.

Figure 2 HERE

The Edlin game, however, does better than the other policies and unlike marginal cost regulation does not require the court or regulator to observe cost. 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. 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 production is equally efficient.

2.3 Experimental Design and Procedures

We apply a between-subjects design, so that each subject is assigned to one of the experimental treatments L'FAIRE, BROOKE, BAUMOL, or EDLIN. Each treatment consists of seven rounds of the respective four-period game described above. 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.[12] We provided written instructions which informed the subjects of all the features of the markets (for the detailed instructions see the online appendix OC). Similar to other studies on experimental oligopolies e.g., Huck, Normann, and Oechssler 2004; Roux and Thöni 2015, we used an economic framing, explaining the strategic situation in terms of firms, prices, and quantities.[13] 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.

---

12. The experiments were programmed in z-Tree (Fischbacher 2007); recruitment by hroot (Bock, Baetge, and Nicklisch 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.

13. 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.

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 when the incumbent needs to worry about future entry;[14] (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. Finally, we discuss the dynamics across rounds.

3.1   Exclusionary Pricing Under Laissez-Faire

Above, we defined 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.[15] The definition encompasses both below-cost and above-cost exclusionary pricing.

Prior to entry (in *PreEntry*), the incumbent is a monopolist and prices as such in L'FAIRE. The average observed price is 49.6, with 83 percent of the cases at exactly the monopoly price of 50. Entry lowers the average incumbent's price substantially to 34.9, which is in the exclusionary range of 37 and below.[16]

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 but 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 percent of the cases when they are in competition with an incumbent, with an average loss of 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 percent) leave the market at some point.

Figure 3 HERE

---

14. More precisely, we define *PreEntry* as any periods in which the rival has not so far entered, except period four. We exclude the final period, because the incumbent no longer can have any concerns about future market entry.

15. In the discrete version of the game, the rival cannot break even if the incumbent sets price at 37. It cannot profitably undercut the incumbent as $36 < p_H^B$; and the duopoly profit margin when both firms charge 37 does not cover fixed costs.

16. 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.

The other important effect of exclusionary pricing is that rivals do not contest the incumbent in the first place. Over the seven rounds, entry rates decline substantially from 96 percent at the outset to 42 percent by the final round. Once the rivals anticipate the incumbents' likely reaction, the majority of rivals no longer enter.

After the incumbent has pushed the entrant out, the game is in the *PostExit* structure. The incumbents essentially switch back to monopoly pricing with an average price of 50.7.[17]

Result 1. *In* L'FAIRE, *firms charge monopoly prices when alone. Upon entry, incumbents generally engage in above-cost exclusionary pricing. They usually 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 as subjects learn that entry is usually not profitable.

3.2   Policy Effects

The previous section showed that above-cost exclusionary pricing occurs under laissez-faire. Fear of such behavior may discourage entry, however, one cannot be sure without comparing the laissez-faire results to a situation in which regulation makes exclusionary pricing more difficult. In this section, we provide such a benchmark. We compare L'FAIRE with BROOKE, BAUMOL and EDLIN, respectively. If we see more entry under the alternative policies this will show that fear of price cuts by the incumbent discourages entry in L'FAIRE.

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, policy may affect prices under each market structure. We isolate these two effects below.

---

17. There are rare instances where the incumbent leaves the market, making the entrant a monopolist. The average price in these situations is 54.8, which is very close to the rival's monopoly price of 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 has substantially different results with 45 percent of the observations in the low price bin. The average price is at 46.2, very close to the theoretical prediction.[18] Thus, firms systematically respond to the Edlin rule and frequently choose entry-deterring prices as expected.

Figure 4 HERE

Duopoly: Advocates of strict exclusionary pricing rules want to reduce the frequency of exclusionary pricing, while laissez-faire and Brooke Group advocates worry about the consumer or efficiency losses from discouraging price wars. As there is some entry in all treatments, we can investigate the policy effects on exclusionary pricing.

The left panel of Figure 5 shows the frequency of exclusionary pricing (37 or lower) by incumbents in the periods where they compete with the rival. Spikes indicate standard errors, calculated with clustering on matching group. The frequency is 75 percent in L'FAIRE, 69 percent in BROOKE, 66 percent in BAUMOL and 50 percent in EDLIN. In EDLIN, the frequency is significantly lower than in any of the other treatments.[19] Incumbents in EDLIN are less apt to make exclusionary price cuts because the rule binds. When incumbents are not restricted by the rule, they make such exclusionary price cuts 88 percent of the time even in EDLIN.[20]

Figure 5 HERE

---

18. The differences across all treatments are significant at $p = .011$ (Kruskal-Wallis test).

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

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

These observations reflect our 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 *Duopoly* prices, followed by BAUMOL and EDLIN.[21] The differences between adjacent bars are not significant, but the comparison between EDLIN and the first two treatments is significant ($p < .004$). If we pool the observations from L'FAIRE and BROOKE and test against BAUMOL, the differences become significant at 0.043. 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 *PostExit* structure, the remaining firm has a monopoly and does not face the threat of 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 (98 percent) price at the Baumol price cap whenever the Baumol price restriction applies. The average *PostExit* price of the incumbents is 39.

To summarize:

Result 2. *A benefit of protecting entrants from dramatic price cuts is lower prices prior to entry (EDLIN) and lower prices after exit (BAUMOL) than in L'FAIRE and BROOKE.*

Result 3. *A cost of protecting entrants from dramatic price cuts is higher duopoly prices under both EDLIN and BAUMOL than under L'FAIRE and BROOKE.*

The first half of Result 2 is consistent with the predictions. Restrictions on post-entry price reductions like EDLIN can induce low pre-entry prices, while incumbents that can adjust prices freely after entry have no incentive to deviate from the monopoly price. In theory, BAUMOL's benefit of keeping price low after exit should only have been realized off the equilibrium path, but as entry and exit are both common, this benefit is frequently realized.

Result 3 reveals a cost of aggressive rules that ban or discourage post-entry price cuts: these rules raise price in duopoly periods by limiting price wars. This cost does not arise on the theoretical equilibrium path because entry never occurs. In the experiment, however, the fear of courts and commentators about chilling competition after entry becomes real and important. This finding lends support to the worries of Judge Breyer

---

21. 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 (Argenton and Müller 2012; Dugar and Mitra 2016). An important difference between our design and these studies is that, in our case, the entrant faces fixed costs.

in the Barry Wright case who worried about chilling post-entry price wars and commented that "[t]he antitrust laws very rarely reject such beneficial 'birds in hand' for the sake of more speculative (future low-price) 'birds in the bush'."(*Barry Wright*, 724 F.2d 227 at 24)

3.2.2 Market Structure Effects

We showed above how the price effects of policy depend on market structure. The overall policy effects also depend on how often each of the three market structures will arise under each policy.

Table 1 shows the percentage of periods in which the market is in a given structure for rounds 5–7, after firms have some experience with the game. There is substantially more entry under both EDLIN and BAUMOL than under L'FAIRE or BROOKE, and this corresponds with much higher fractions of time spent in *PreEntry* in both L'FAIRE or BROOKE. Over 70 percent of the time is spent in *PreEntry* under L'FAIRE and BROOKE compared to 40 percent under EDLIN and 57 percent under BAUMOL. Perhaps this is not surprising as both EDLIN and BAUMOL protect entrants by either banning (EDLIN) or discouraging (BAUMOL) deep price cuts. *PreEntry* is particularly rare in EDLIN.

Table 1 HERE

Consumers benefit from the extra time spent in the duopoly phase under EDLIN and BAUMOL because prices are lower in this phase. Justice Breyer is wrong to see the benefits of duopoly competition as analogous to birds in hand. The benefits from price wars only materialize after entry, and more time is spent in *Duopoly* under EDLIN and BAUMOL than under BROOKE and L'FAIRE.

Result 4. *A consumer benefit of protecting entrants from dramatic price cuts is significantly more entry and more time spent in the price-war state of Duopoly under both EDLIN and BAUMOL than under L'FAIRE and BROOKE.*

Overall, entry in period 2 is significantly more likely under EDLIN and BAUMOL than under L'FAIRE and BROOKE (73 percent and 61 percent vs. 52 percent and 45 percent). The additional entry under EDLIN arises mainly in cases where the incumbent has priced at monopoly levels instead of the predicted entry-deterring levels.

If we refer back to Figure 4, we see that under EDLIN incumbents charge low, entry-deterring prices about half the time, but because roughly half of incumbents continue to charge monopoly prices, EDLIN attracts more entry than the other policies.

3.3 Dynamics

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: To explore trends in prices from round 1 to round 7 ("time trends") we ran OLS estimates for the incumbents' pre-entry prices in the first period (Table OB1 in the online appendix OB). No statistically significant time trends emerge for these prices in L'FAIRE, BROOKE, and BAUMOL. In fact, in all rounds, pre-entry prices under L'FAIRE, BROOKE, and BAUMOL are close to the monopoly price, with an overall average of 81 percent of prices set at exactly the monopoly level.

In contrast, EDLIN has statistically significant time trends and prices come down meaningfully below monopoly levels in later rounds. In rounds 1–4, only 33 percent of the incumbents choose entry-deterring prices in *PreEntry*, whereas in rounds 5–7, this percentage increases to 59 percent. This difference suggests that subjects learn how to react to the strategic incentives provided by the Edlin rule over time.

Table OB1 also shows that market prices in *Duopoly* 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 6 shows the fraction of games in which the rival enters at some point. 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 contrast, under EDLIN entry rates drop slowly, with BAUMOL somewhere in between. Continued high entry under EDLIN and BAUMOL makes sense as these policies provide protection to entrants. In particular, the incremental entry in EDLIN over that in BROOKE and L'FAIRE is largely explained by rivals who rationally react to the monopoly prices of those incumbents who fail to realize that they should charge entry-deterring prices.

Figure 6 HERE

Because the strategic incentives set by the different policies require experience to understand, in our welfare analysis below, we emphasize the results of the games with experienced subjects and we will restrict analysis to the second half of the experiment (rounds 5–7).

3.4 Welfare Implications of the Policies

The welfare implications of the policy treatments flow from the observations above about price and market structure effects. EDLIN has lower prices prior to entry, and so dominates

the other policies in the *PreEntry* phase both in terms of consumer surplus and total welfare. Consumer surplus is 44 percent higher in this phase compared to a pooling of L'FAIRE and BROOKE, and the difference between EDLIN and each of the other three treatments is highly statistically significant for both consumer surplus and total welfare ($p < .002$, Wilcoxon rank-sum tests, rounds 5–7). In *PostExit*, BAUMOL has the lowest prices and offers significantly higher consumer surplus and welfare than the unregulated monopolies observed under the remaining treatment conditions ($p < .001$). In *Duopoly*, we observe the highest consumer surplus in L'FAIRE and BROOKE, but the differences across the four treatments remain insignificant ($p = .155$, Kruskal-Wallis test). To analyze the overall welfare implications we aggregate these policy effects across market structures. Figure 7 shows the average per-period consumer surplus and welfare for experienced subjects (rounds 5–7). Bars show averages over the four periods and all groups, spikes indicate standard errors (with clustering on matching group).

Both BAUMOL and EDLIN yield substantially more consumer surplus overall than the other two treatments.[22] EDLIN yields 23 percent more consumer surplus than a pooling of L'FAIRE and BROOKE (697 vs. 565 per period). We can decompose this gain into an increase to 651 from lower pricing, holding market structure frequencies as they were in L'FAIRE and BROOKE, with the rest of the gain from shifts in the frequency of the market structures (e.g., more entry and time spent in *Duopoly* price wars and less in high priced *PreEntry*).[23] A similar decomposition for BAUMOL has a small increase in consumer surplus to 578 from lower pricing with the remaining gain to 664 from market structure changes.

On the other hand, overall welfare is lowest under EDLIN with the other three policies clustered together. 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 more (undesired) production by the high-cost rival as well as (desired) competitive pressure.

Figure 7 HERE

Result 5. *EDLIN dominates L'FAIRE prior to entry, BAUMOL does so after exit, and both policies yield the benefit of increased entry and time spent in low-priced Duopoly. However, both policies come at the cost of weaker competition in Duopoly. The overall welfare effects depend on the frequency of these market structures. EDLIN is favorable from a consumer perspective with BAUMOL a close second when firms are sufficiently experienced*

---

22. Differences in consumer surplus relative to L'FAIRE and BAUMOL pooled are highly significant ($p = .010$) with BAUMOL and, even more so with EDLIN.

23. In decomposing this way, we are considering a thought experiment of first changing prices from L'FAIRE and BROOKE and then market structure. The decomposition would look different if the order were reversed and there is no natural order.

with the rule. Overall welfare is lowest in EDLIN, while the other three treatments produce very similar results.

Below we consider the implications of the experiment for policy.

4   Policy Discussion and Conclusion

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, as they are under Brooke Group and laissez-faire, 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 provides support for the idea that encouraging the entry of inefficient firms or the threat of their entry, by protecting entrants as the Edlin and Baumol rules do, could improve consumer welfare. It does not, however, provide support for the idea that exclusionary pricing policies can improve overall social welfare over laissez-faire or Brooke Group.

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 led 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. EU enforcement policy currently also assumes 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."[24] The preceding condition is satisfied if a firm prices above its own costs.

---

24. 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.

While a safe harbor for above-cost pricing is the general rule in the U.S., Europe,[25] and around the world, it is not entirely unchallenged, and there are exceptions. Indeed, in the American Airlines case, the U.S. Department of Justice argued (albeit unsuccessfully) that price cuts are predatory if they are unprofitable even if price remains above cost. Similarly the U.S. Department of Transportation (2001) issued an enforcement policy in the waning days of the Clinton administration declaring a similar standard for judging unfair competition under its own competition statute. In a few European cases—notably AKZO, Compagnie Maritime Belge, and Irish Sugar—the European Union has found abuse of dominance when above-cost price cuts had the purpose of eliminating an entrant.[26] Additionally, German and Korean competition authorities say that under their nation's laws prices above cost can be illegal. Indeed Korea appears to take an approach similar to the Edlin rule for dominant firms.[27]

Do our experimental results support proposals to change policy with respect to above-cost price cuts and to expand the cases where these cuts are deemed problematic? The interpretation of our results depend on the observer's point of view.

We do provide support for the plausibility of above-cost price cuts excluding firms from the market by limiting entry. In particular, exclusionary price cuts are a common reaction to entry in our experiment and when the Edlin rule bans deep post-entry price cuts, we observe substantially increased entry, so that roughly half as much time is spent in *PreEntry* states in EDLIN as in L'FAIRE or BROOKE. In BAUMOL, where exclusionary price cuts are more costly to the incumbent, the time spent in *PreEntry* lies in between EDLIN and BAUMOL. The fact that the Edlin and Baumol rules both encourage entry does not by itself make them superior to laissez-faire or Brooke Group rules, however.

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 because it has lower prices and equally efficient production, in the experiment, the Edlin rule performs considerably worse under a total welfare standard than laissez-faire and Brooke Group because the Edlin rule creates inefficient entry and high-cost production. In BAUMOL, the benefits from the low prices the Baumol rule produces is roughly balanced by the costs of inefficient entry and inefficiently high-cost production.

On the other hand, the experiment provides reason for consumer welfare advocates such as the antitrust authorities in the U.S. and Europe to support policies like the

---

25. See, e.g. OECD (2005)

26. Key cases in this line include *Compagnie Maritime Belge Transps. SA v. Commission*, 1996 E.C.R. II-1201 ¶¶ 138-153 (Ct. First Instance); aff'd by Joined Cases C-395/96 P & C-396/96 P, *Compagnie Maritime Belge Transps.* (European Court of Justice affirming that selective above-cost price cuts to meet an entrant were illegal when a firm with over 90 percent market share has purpose of eliminating entrant.); and *Irish Sugar PLC v. Commission*, 1999 E.C.R. II-2969 ¶¶ 173-193 (Ct. First Instance), aff'd on other grounds, C-497/99 P, 2001 E.C.R. I-5333 (E.C.J.)

27. OECD (2005) p.8, 134, 163. For predatory pricing by dominant enterprises, in Korea "[a]ctivities, which are likely to exclude their competitors by providing goods and services at lower prices than ordinary prices." are illegal (see p.163).

Edlin or Baumol rules as both rules do better under a consumer welfare standard than either laissez-faire or Brooke Group. The consumer welfare gains result because the rules promote entry and low prices. In Edlin roughly 60 percent of the incumbents charge low entry-deterring prices in later rounds and in Baumol price wars after entry lead to substantial and enduring consumer benefits.

Of course, one must recognize that our experiments necessarily rely on specific 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.[28] 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) and Besanko, Doraszelski, and Kryukov (2013). Finally, some results could be sensitive to the technologies and demand we assumed. For example, adding a sunk set-up cost might lower entry and tilt the outcome in favor of Edlin. Substantial product differentiation is likely to lower the impact, both positive and negative, of the Edlin and Baumol rules, as deterring entry is difficult with substantial product differentiation and as incumbents are correspondingly less apt to respond to entry with deep price cuts.

Much like an empirical study of an industry, our results are only about a particular industry. While concerns about specific parameters might be addressed by doing more experiments, other concerns 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, and when there are many prices (as with an airline) or when 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 are smaller than the problems of administering dynamic pricing restrictions. Traditional cost-based tests have the same problems of Edlin and Baumol in measuring price in a complex environment. Moreover, 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

---

28. It also seems likely that under the Baumol rule, equilibria with entry would emerge with sufficiently low fixed costs: it would be unattractive for the incumbent to reduce price sufficiently to induce exit; anticipating this, the rival would enter.

counted as costs and, if so, how to properly measure them.[29]

A key feature of both Edlin and Baumol rules is their dynamic nature: under these rules, pricing patterns can be illegal regardless of price level. Although our experiment makes the distinction between static rules and dynamic rules stark, existing law emphasizes a static price-cost comparison but incorporates similar dynamic considerations. In particular, under the Brooke Group precedent, a plaintiff needs to demonstrate both below-cost pricing, and also that the predator can raise price sufficiently to recoup the losses from below-cost pricing. In a sense this loss-recoupment requirement is like the Baumol rule. The differences are that any price increase is illegal under Baumol, whereas Brooke Group focuses only on large increases and only after below-cost pricing.[30] The price drops that the Edlin rule keys off of are likewise relevant under existing law. Although price drops are not an element of illegality under Brooke Group, price drops nonetheless are usually what precipitates an inquiry or complaint and then the focus becomes whether price is below cost.

Our results make one wonder whether other policies might be better than the four we consider. For example, one might consider a rule of reason approach that involved intertemporal linkages akin to those in the Edlin and Baumol policies but that limited the protection of inefficient entrants. 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. Similarly, a variant of the Baumol rule might have liability triggered by large price increases following near cost pricing. Future experiments might explore whether such policies could allow consumers to gain without significant losses in total welfare or even with increases in total welfare.

We see experiments like ours as a useful input for the design of competition policies. Admittedly, experiments have an obvious limitation: people outside the lab may behave differently than people inside the lab. And yet, a parallel critique can be made of the theoretical literature: people outside economic models may behave differently than agents inside the models. True behavior might lie somewhere between theory and experiment. It would be wonderful to simply rely on empirical work, but given that the Baumol and Edlin rules are not applied by antitrust authorities, such investigations are impossible. For this reason, wind-tunnel experiments like ours are an important complement to theoretical analyses and provide a relatively cheap way to investigate the functioning of different policies with real actors.

---

29. See Hemphill and Weiser (2018) and Edlin (2018) for recent discussions of the complexities of comparing price with cost under Brooke Group.

30. As we described when introducing the games, the experiment did not include the loss-recoupment prong of Brooke Group given its complexity, but this omission is likely without loss since the below-cost element *by itself* made Brooke Group indistinguishable from laissez-faire.

References

Argenton, Cédric, and Wieland Müller. 2012. "Collusion in experimental Bertrand duopolies with convex costs: The role of cost asymmetry." *International Journal of Industrial Organization* 30 (6): 508–517.

Baumol, William J. 1979. "Quasi-permanence of price reductions: A policy for prevention of predatory pricing." *Yale Law Journal* 89 (1): 1–26.

Besanko, David, Ulrich Doraszelski, and Yaroslav Kryukov. 2013. *Sacrifice Tests for Predation in a Dynamic Pricing model: Ordover & Willig (1981) and Cabral & Riordan (1997) Meet Ericson & Pakes (1995).* Working Paper. Carnegie Mellon University.

Besanko, David, Ulrich Doraszelski, Yaroslav Kryukov, and Mark Satterthwaite. 2010. "Learning-by-Doing, Organizational Forgetting, and Industry Dynamics." *Econometrica* 78 (2): 453–508.

Bock, Olaf, Ingmar Baetge, and Andreas Nicklisch. 2014. "hroot: Hamburg Registration and Organization Online Tool." *European Economic Review* 71:117–120.

Bolton, By Patrick, and David S Scharfstein. 1990. "A Theory of Predation Based on Agency Problems in Financial Contracting." *American Economic Review* 80 (1): 93–106.

Boone, Jan, María Jose Larraín Aylwin, Wieland Müller, and Amrita Ray Chaudhuri. 2012. "Bertrand competition with asymmetric costs: Experimental evidence." *Economics Letters* 117 (1): 134–137.

Bruttel, Lisa V, and Jochen Glöckner. 2011. "Strategic buyers and market entry." *Journal of Competition Law & Economics* 7 (2): 381–402.

Cabral, Luís M B, and Michael H Riordan. 1994. "The learning curve, market dominance and predatory pricing." *Econometrica* 62 (5): 1115–1140.

————. 1997. "The Learning Curve, Predation, Antitrust, and Welfare." *Journal of Industrial Economics* 45 (2): 155–169.

Capra, C Monica, Jacob K Goeree, Rosario Gomez, and Charles A Holt. 2000. "Predation, asymmetric information and strategic behavior in the classroom: An experimental approach to the teaching of industrial organization." *International Journal of Industrial Organization* 18 (1): 205–225.

Chiaravutthi, Yingyot. 2007. "Predatory pricing with the existence of network externalities in the laboratory." *Information Economics and Policy* 19 (2): 151–170.

Dugar, Subhasish, and Arnab Mitra. 2016. "Bertrand Competition With Asymmetric Marginal Costs." *Economic Inquiry* 54 (3): 1631–1647.

Easterbrook, Frank H. 1981. "Predatory Strategies and Counterstrategies." *University of Chicago Law Review* 48 (2): 263–337.

Edlin, Aaron S. 2002. "Stopping above-cost predatory pricing." *Yale Law Journal* 111 (4): 941–991.

———. 2012. "Predatory Pricing." Chap. 6 in *Research Handbook on the Economics of Antitrust Law,* edited by Einer Elhauge, 144–173.

———. 2018. "Predatory Pricing: Limiting Brooke Group to Monopolies and Sound Implementation of Price-Cost Comparisons." *Yale Law Journal Forum* 127:996–1012.

Edlin, Aaron, Catherine Roux, Armin Schmutzler, and Christian Thöni. 2017. "Hunting Unicorns? Experimental Evidence on Predatory Pricing Policies." University of Zurich, Department of Economics, Working Paper No. 258.

Elhauge, Einer. 2003. "Why above-cost price cuts to drive out entrants are not predatory—and the implications for defining costs and market power." *Yale Law Journal* 112 (4): 681–828.

Ezrachi, Ariel, and David Gilo. 2009. "Are excessive prices really self-correcting?" *Journal of Competition Law & Economics* 5 (2): 249–268.

———. 2010. "Excessive pricing, entry, assessment, and investment: Lessons from the Mittal litigation." *Antitrust Law Journal* 76 (3): 873–897.

Fischbacher, Urs. 2007. "z-Tree: Zurich toolbox for ready-made economic experiments." *Experimental Economics* 10 (2): 171–178.

Fudenberg, Drew, and Jean Tirole. 1986. "A "signal-jamming" theory of predation." *RAND Journal of Economics* 17 (3): 366–376.

Fumagalli, Chiara, and Massimo Motta. 2013. "A Simple Theory of Predation." *Journal of Law and Economics* 56 (3): 595–631.

Gal, Michal S. 2004. "Monopoly Pricing as an Antitrust Offense in the US and the EC: Two Systems of Belief About Monopoly?" *Antitrust Bulletin* 49:343–384.

Genesove, David, and Wallace P Mullin. 2006. "Predation and Its Rate of Return: The Sugar Industry, 1887-1914." *RAND Journal of Economics* 37 (1): 47–69.

Gilo, David, and Yossi Spiegel. 2018. "The antitrust prohibition of excessive pricing." *International Journal of Industrial Organization* 61:503–541.

Goeree, Jakob K., and Rosario Gomez. 1998. *Predatory Pricing in the Laboratory.* Working Paper. University of Virginia.

Goolsbee, Austan, and Chad Syverson. 2008. "How Do Incumbents Respond to the Threat of Entry? Evidence from the Major Airlines." *Quarterly Journal of Economics* 123 (4): 1611–1633.

Harrington, Joseph E. 1986. "Collusion and Predation Under (Almost) Free Entry." *International Journal of Industrial Organization* 7 (3): 381–401.

Harrison, Glenn W. 1988. "Predatory pricing in a multiple market experiment: A note." *Journal of Economic Behavior & Organization* 9 (4): 405–417.

Hazlett, Thomas W. 1995. "Predation in Local Cable TV Markets." *Antitrust Bulletin* 40 (3): 609–644.

Hemphill, C Scott, and Philip J Weiser. 2018. "Beyond Brooke Group: Bringing reality to the law of predatory pricing." *Yale Law Journal* 127 (7): 2048–2077.

Hovenkamp, Herbert. 1985. "Antitrust Policy after Chicago." *Michigan Law Review* 84 (2): 213–284.

———. 2005. "Exclusion and the Sherman Act." *University of Chicago Law Review* 72 (1): 147–164.

———. 2013. "Implementing Antitrust's Welfare Goals." *Fordham Law Review* 81 (5): 2471–2496.

Huck, Steffen, Hans-Theo Normann, and Jörg Oechssler. 2004. "Two are few and four are many: Number effects in experimental oligopolies." *Journal of Economic Behavior & Organization* 53 (4): 435–446.

Isaac, R Mark, and Vernon L Smith. 1985. "In Search of Predatory Pricing." *Journal of Political Economy* 93 (2): 320–345.

Jung, Yun Joo, John H Kagel, and Dan Levin. 1994. "On the existence of predatory pricing: An experimental study of reputation and entry deterrence in the chain-store game." *RAND Journal of Economics* 25 (1): 72–93.

Karlinger, Liliane, and Massimo Motta. 2012. "Exclusionary Pricing When Scale Matters." *Journal of Industrial Economics* 60 (1): 75–103.

Kirkwood, John B, and Robert H Lande. 2008. "The Fundamental Goal of Antitrust: Protecting Consumers, Not Increasing Efficiency." *Notre Dame Law Review* 84 (1): 191–243.

Kreps, David M, and Robert Wilson. 1982. "Reputation and imperfect information." *Journal of Economic Theory* 27 (2): 253–279.

Lande, Robert H. 1982. "Wealth Transfers as the Original and Primary Concern of Antitrust: The Efficiency Interpretation Challenged." *Hastings Law Journal* 34 (1): 65–151.

Lerner, Josh. 1995. "Pricing and financial resources: An analysis of the disk drive industry." *Review of Economics and Statistics* 77 (4): 585–598.

Melamed, A Douglas. 2005. "Exclusionary Conduct Under the Antitrust Laws: Balancing, Sacrifice, and Refusals to Deal." *Berkeley Technological Law Journal* 20 (2): 1247–1267.

Milgrom, Paul, and John Roberts. 1982. "Predation, reputation, and entry deterrence." *Journal of Economic Theory* 27 (2): 280–312.

Motta, Massimo, and Alexandre de Streel. 2006. "Excessive Pricing and Price Squeeze under EU Law." In *What is an abuse of a dominant position?,* edited by Claus-Dieter Ehlermann and Isabela Atanasiu, 91–126. Oxford: Hart Publishing.

OECD. 2005. *Predatory Foreclosure.* www.oecd.org/daf/competition/abuse/34646189.pdf.

Ordover, Janusz A, and Robert D Willig. 1981. "An Economic Definition of Predation: Pricing and Product Innovation." *Yale Law Journal* 91 (1): 8–53.

Podolny, Joel M, and Fiona M Scott Morton. 1999. "Social Status, Entry and Predation: The Case of British Shipping Cartels 1879–1929." *Journal of Industrial Economics* 47 (1): 41–67.

Popofsky, Mark S. 2006. "Defining Exclusionary Conduct: Section 2, the Rule of Reason, and the Underlying Antitrust Principles." *Antitrust Law Journal* 73 (2): 435–482.

Roth, Alvin E. 2002. "The economist as engineer: Game theory, experimentation, and computation as tools for design economics." *Econometrica* 70 (4): 1341–1378.

Roux, Catherine, and Christian Thöni. 2015. "Collusion among many firms: The disciplinary power of targeted punishment." *Journal of Economic Behavior & Organization* 116:83–93.

Saloner, Garth. 1987. "Predation, mergers, and incomplete information." *RAND Journal of Economics* 18 (2): 165–186.

Salop, Steven C. 2005. "Anticompetitive Overbuying by Power Buyers." *Antitrust Law Journal* 72 (2): 669–715.

Salop, Steven C. 2006. "Exclusionary Conduct, Effect on Consumers, and the Flawed Profit-Sacrifice Standard." *Antitrust Law Journal* 73 (2): 311–374.

———. 2010. "Question: What is the Real and Proper Antitrust Welfare Standard? Answer: The True Consumer Welfare Standard." *Loyola Consumer Law Review* 22 (3): 336–353.

Scharfstein, David. 1984. "A Policy to Prevent Rational Test-Market Predation." *RAND Journal of Economics* 15 (2): 229–243.

Scott Morton, Fiona M. 1997. "Entry and predation: British shipping cartels 1879–1929." *Journal of Economics & Management Strategy* 6 (4): 679–724.

U.S. Department of Transportation. 2001. *Enforcement Policy Regarding Unfair Exclusionary Conduct in the Air Transportation Industry.* Office of the Secretary, Department of Transportation, United States of America, Washington D.C.

Vasconcelos, Helder. 2015. "Is exclusionary pricing anticompetitive in two-sided markets?" *International Journal of Industrial Organization* 40:1–10.

Vickers, John. 2005. "Abuse of Market Power." *Economic Journal* 115 (504): F244–F261.
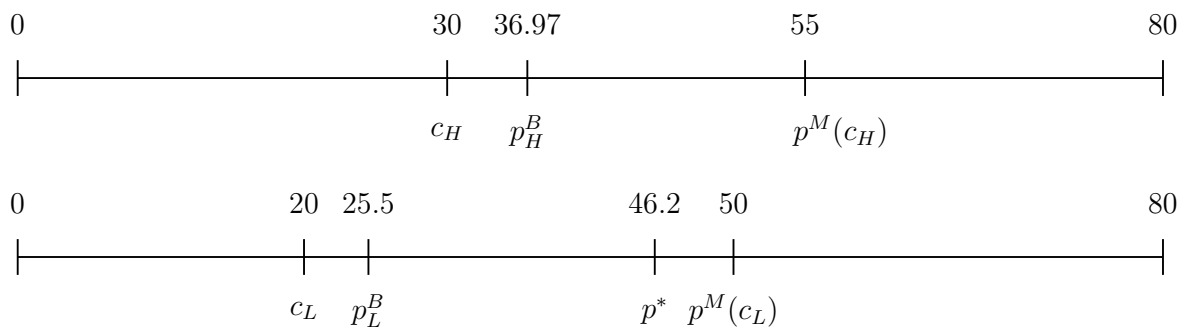
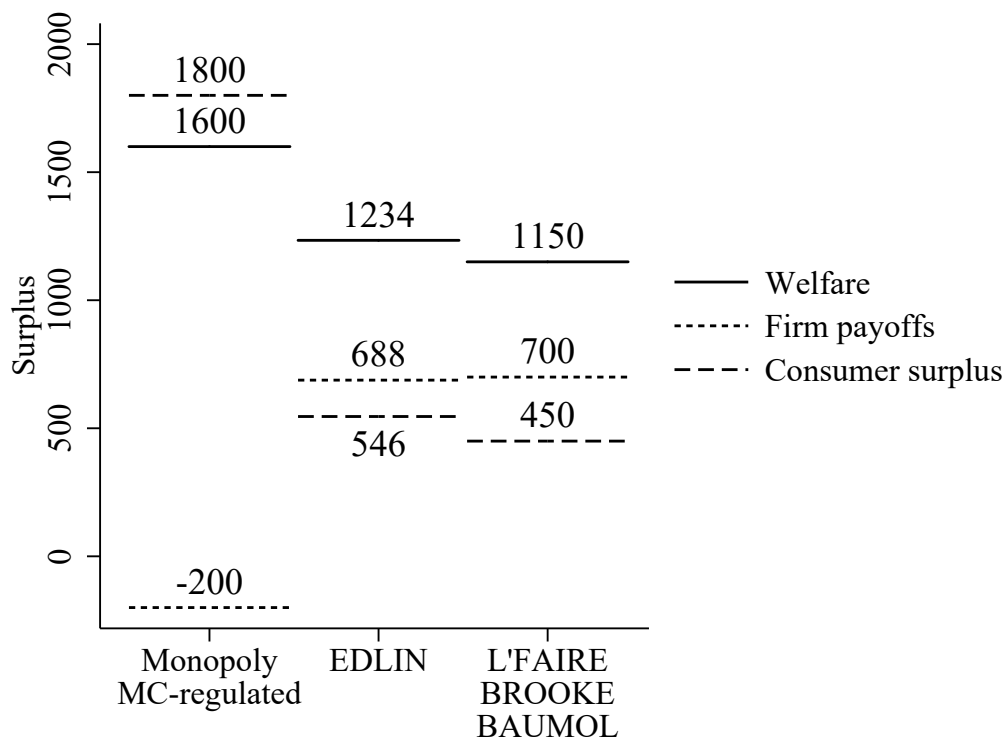Figure 1: Overview of the prices (for firm H and firm L)

Figure 2: Per-period welfare benchmarks of the four policies and a low-cost monopoly with marginal cost regulation.
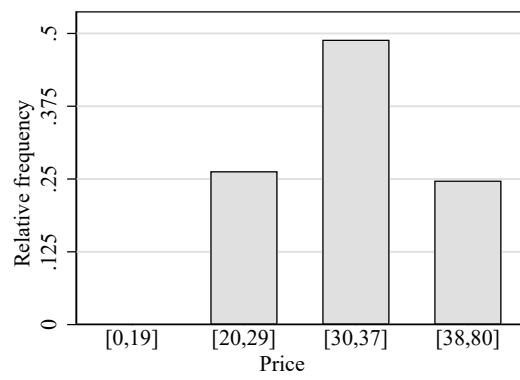
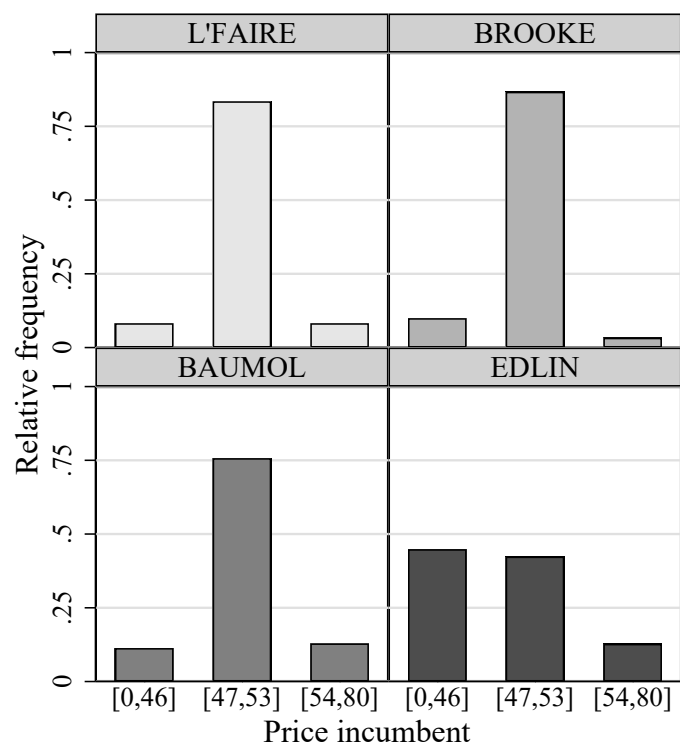Figure 3: Incumbent prices in *Duopoly* of L'FAIRE.

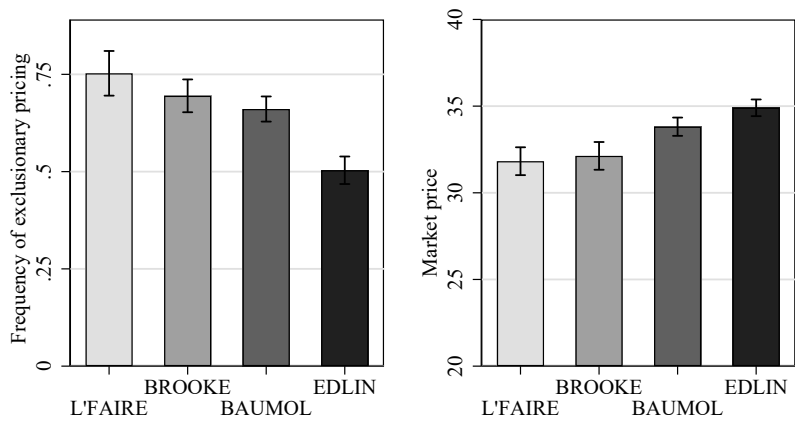Figure 4: Distribution of incumbent prices in the structure *PreEntry*.

Figure 5: Frequency of exclusionary pricing by the incumbents (left panel) and market prices (right panel) in *Duopoly*.
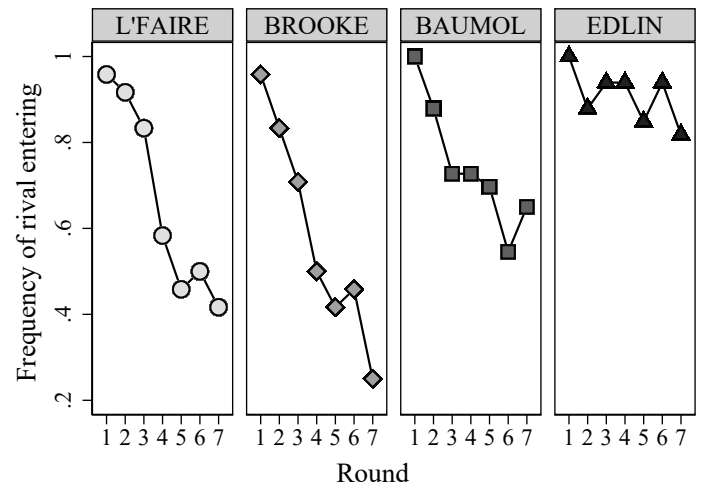
Figure 6: Frequency of rival entry in any period across the seven rounds and by treatment.
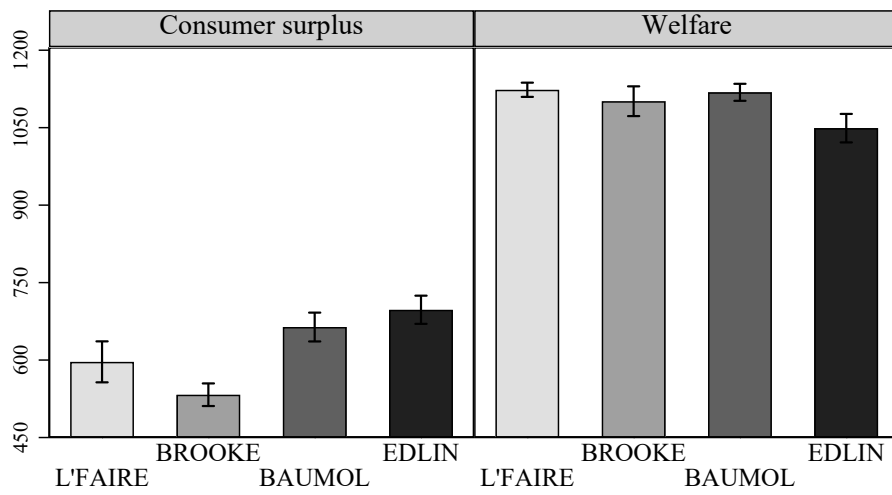
Figure 7: Consumer surplus and welfare in rounds 5–7.

Table 1: Frequency of market structures

Structure	L'FAIRE	BROOKE	BAUMOL	EDLIN
PreEntry	71	73	57	40
Duopoly	18	12	21	28
PostExit	11	15	22	32

Notes. Percentage of periods with a given market structure, separated by treatment in round 5–7. 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.