

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

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Abstract

We study the anticompetitive effects of predatory pricing and the efficacy of three policy responses. In a series of experiments where an incumbent and a potential entrant interact, we compare prices, market structures and welfare. 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. 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 show outcomes after entry that are less competitive than under Laissez-Faire, they nevertheless increase consumer welfare.

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1 Introduction

Incumbent monopolies often respond aggressively to entry. Names for this behavior vary, depending upon context or upon whether the name caller thinks it is desirable. The aggressive response could be called “vigorous competition” or “predatory pricing” when there is a single product, or it might be called a “bundled discount” or a “price-squeeze” when there are multiple products. Regardless of the context, an important question is whether entrants should ever be protected from such exclusionary pricing if they cannot survive on their own and if so how? Typically, in a predatory pricing case, aggressive response to entry is tested by comparing some measure of the monopoly’s price to cost, and entrants are only protected from below-cost pricing. Increasingly, litigants, legal scholars, and courts extend below-cost pricing tests to multiproduct pricing conduct and some argue that nonprice aggression like exclusive dealing should be handled the same way (Eilat et al., 2016).¹

We study the question of when aggressive responses to entry should be regulated in the specific context of the one-product predatory pricing debate, but we believe our analysis has wider implications. In particular, we ask when, if ever, unrestricted price cutting by a monopoly is undesirable either because it drives entrants from the market or because its prospect discourages entry. Our experimental approach suggests that there may be consumer or competition gains from regulating price cutting, at least when a monopoly incumbent has cost advantages.

Previous literature has focused mainly on below-cost predatory pricing. Skeptical commentators have variously compared this pricing behavior to unicorns (Baker, 1994, p.586), dragons (Easterbrook, 1981, p.264), and basketball players scoring sixty four points in a game (Elzinga and Mills, 2001, p.2479). They argue that price cutting is generally good for consumers and they contend that it is bad only in fairy tales told by theorists or in extremely rare circumstances in practice.² This argument would support a laissez-faire policy to predatory pricing.

¹For a discussion on how the approaches to predatory pricing and to margin squeeze are related see, for example, OECD, Margin Squeeze DAF/COMP(2009)36 and Gaudin and Mantzari (2016). See also FTC and DOJ, Workshop Transcript on Conditional Pricing Practices: Economic Analysis & Policy Implications (June 23, 2014) on the predatory pricing standard for conditional pricing practices.

²In the wake of this view, a comprehensive theoretical literature developed to rationalize

It has been used by the U.S. Supreme Court to justify a test for legality that bans only price cuts which leave prices below marginal or average variable cost (Brooke Group, 1993).³

We think the focus on below-cost pricing may be misguided. Incumbent monopolies often have cost or other advantages, which may be the reason why they are monopolists. Such advantages are difficult to offset by potential entrants in the short term. In such settings, above-cost price cuts are the real threat (see e.g. Farrell and Saloner (1986)): it is entirely credible that an incumbent monopoly will react to entry by pricing below an entrant's cost but above its own cost. Such pricing, though indistinguishable from static equilibrium play, has undesirable effects: like below-cost predatory pricing, it will drive the entrant from the market. Because of these exclusionary effects, it has been called "above-cost predatory pricing". Our aim is not to determine what motivates the firm's aggressive pricing, i.e., to pin down predatory intent, but rather to study the exclusionary effects of such pricing behavior. In particular, we ask whether price drops after entry discourage entry, or eliminate the threat of entry in a way that hurts consumers or overall welfare, and whether policies can improve the situation. We call such exclusionary pricing "above-cost predatory pricing" if it is above the monopoly's cost, and "below-cost predatory pricing" if it is below the monopoly's cost.⁴

A typical view of the tradeoff in predatory pricing policy, be it above or below cost, is that condemning these low prices sacrifices a beneficial price war (a bird in hand) in the speculative hope of promoting lower prices in the future (a bird in the bush). The beneficial price war is, however, equally speculative and will

predatory pricing by means of 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 and center on the idea that the incumbent has an incentive to influence the entrant's beliefs about future profits. We study a simpler setting without any information asymmetries. Theories of predation that do not depend on information asymmetries include Harrington (1986); Cabral and Riordan (1994, 1997); Motta and Fumagalli (2013).

³*Brooke Group Ltd. v. Brown & Williamson Tobacco Corp.* 509 U.S. 209 (1993).

⁴Edlin (2002, 2012), Salop (2005, 2006), Popofsky (2006) and Hovenkamp (2005) all discuss above-cost exclusionary conduct. 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.

only happen if there is entry. And lack of entry is the big problem in a monopoly market. If a high-cost rival fears predatory pricing, it will not challenge a low-cost incumbent even if the latter charges high prices. The consequence can be persistent high pricing without entry. To remedy this, Edlin (2002) proposes that an incumbent should not be allowed to lower its prices substantially to avoid being undercut by an entrant. The idea is to encourage low pricing by the incumbent prior to entry and to encourage entry if the incumbent charges high prices. This policy is thus dynamic, focusing on price patterns, in contrast to Brooke Group which focuses on price level.

Baumol (1979) likewise proposed a dynamic policy to combat predatory pricing. The Baumol policy would prevent an incumbent from raising prices after having fought off an entrant with price cuts. This policy might have better properties than Edlin's conditional upon entry because then price competition is not restricted, but it does not appear to offer entrants as much protection and could in theory still allow persistent high prices if it does not manage to facilitate entry.

This paper serves two purposes. First, we provide an experimental test for the existence of above-cost predatory pricing. Second, we compare the effectiveness of different policy rules (Brooke Group, Baumol and Edlin) in mitigating its effects.

To date, there is mainly anecdotal evidence for predatory pricing. For instance, in the American Airlines case in the U.S., several entrants were driven from the Dallas-Fort Worth market by American. American priced high before entry and after exit. The entrants brought significantly lower prices, but only for short periods before they were driven from the market. The Department of Justice introduced evidence showing that American priced low to drive entrants out, but could not win their case under the prevailing policy (Brooke Group rule) because American did not price below its variable cost. Although there is some systematic empirical work to identify predatory pricing (e.g., Lerner (1995); Scott Morton (1997); Podolny and Scott Morton (1999); Genesove and Mullin (2006)), this work does not analyze policy effects.

To go beyond anecdotal evidence, we use a laboratory approach. Existing experiments focus on below-cost pricing trying to settle the debate about whether it exists, is credible, and induces exit. The seminal paper in this literature is Isaac and Smith (1985), which defines predatory pricing as pricing below marginal cost

(at p. 330), and searches for it in vain, thereby supporting the unicorn view.⁵ Overall, the evidence on below-cost pricing in the laboratory is mixed: while Harrison (1988) reports numerous cases of below-cost pricing in an experiment with multiple markets, Goeree and Gomez (1998), replicating Harrison’s study, find virtually no evidence of below-cost pricing. However, in a modified design with entry prior to pricing decisions and a simpler demand schedule, a reliable pattern of below-cost predation emerges (Goeree and Gomez, 1998; Capra et al., 2000). Likewise, Chiaravutthi (2007) finds substantial evidence of below-cost predatory pricing in markets with network externalities.⁶

We study predatory pricing in the lab because of a central problem with any empirical approach to the subject: such pricing may deter entry without 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 (Ezrachi and Gilo, 2009, 2010). Identifying such a problem in the field is challenging. If we see “insufficient entry,” when can we attribute it to predatory pricing?⁷ Without policy variation, we cannot reliably know what would happen under alternative policies. Would there be more entry? Would prices be lower? In the lab, we can exogenously vary policy, while leaving everything else fixed. We can compare a laissez-faire environment with one where price cuts are restricted. Behavioral differences between the two settings can thus unambiguously be attributed to the possibility of predatory pricing. Moreover, the experimental approach allows us to identify the causal effects of different policies in a particularly clean fashion, as it is straightforward to implement *ceteris paribus* policy variations in the lab.⁸

We study a setting with perfect information and without financial constraints. There is an incumbent monopoly with low costs, but a rival might be tempted

⁵Isaac and Smith (1985) hypothesize that as there is no predatory pricing, antitrust intervention will ironically limit competition. They study the Baumol policy and find that Baumol’s policy leads to cooperatively shared monopoly. They neither study Edlin nor Brooke Group.

⁶Jung et al. (1994) report instances of predatory behavior in an experimental chain store signaling game where they allow reputations to develop. Their results are somewhat difficult to put in our context as there is no information of firms’ prices and quantities.

⁷An interesting approach to the related problem of not being able to empirically identify the threat of entry separately from actual entry is Goolsbee and Syverson (2008). They show that incumbents respond to entry announcements in the passenger airline industry.

⁸Another reason for taking predatory pricing to the laboratory is the difficulty to apply cost-based tests in practice (Normann and Ricciuti, 2009; Gomez et al., 2008).

to enter because the incumbent's monopoly price exceeds the rival's cost. An unregulated monopolist can thus drive the rival from the market while still earning positive profits. Our basic question is whether entry results and how this depends 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 certain post-entry price cuts. 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 firms 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.⁹ 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.

Our experiment shows that 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 predation). 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 amounts to hunting unicorns and should have no effect in our setting. This turns out to be true. As expected, behavior under Brooke Group is indistinguishable from Laissez-faire and equally bad for consumers.

Edlin's policy has two consumer benefits. It lowers the monopoly's pre-entry price and it increases the frequency of entry in instances where the monopoly sets

⁹An exception is the final period, when it charges the monopoly price due to end-game effects.

a price that is not exclusionary. The first is a prediction of theory and the second is a prediction of what happens off the equilibrium path. When the incumbent monopolist prices high 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.

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

2 Theory and Experimental Design

2.1 The Game

In this subsection, we explain the general framework and the four game variants—Laissez-faire, Brooke Group, Baumol, and Edlin—used in the experiment.

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 present in the market. In periods 2–4, each firm decides whether to participate in the market or to stay out. A firm that chooses to stay 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 per period. Once a firm decides to exit, it cannot re-enter in subsequent periods.

We opted for per-period costs, rather than only one-shot set-up costs, because having recurring fixed costs such as rent is typically realistic and is required to make exit meaningful and different from zero production. We chose not to include set-up costs in addition to per-period costs, because this would have increased the complexity of the experiment for subjects substantially. For simplicity, we also excluded a re-entry option.

In each period, the market demand is given by

$$D(p) = 80 - p.$$

If only one of the firms $i = L, H$ is active in the market in a given period, its demand function coincides with the market demand. Facing this demand, it chooses its price as a monopolist. Suppose now both firms are active in the market in a given period. They simultaneously and independently choose a price p_i for the production of the homogeneous good. Their action sets are integers in an interval $[\underline{p}, \bar{p}]$ 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 a given period t if it produced and served the entire market in the prior 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. The incumbent has a technological advantage over the rival and thus produces the good at a lower marginal cost. Marginal costs are $c_L = 20$ for the incumbent and $c_H = 30$ for the rival.

The games differ with respect to the interval $[\underline{p}, \bar{p}]$ in which the dominant firm can choose its price. A firm which is not dominant can always choose its price in

¹⁰This includes both the cases 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.

the entire interval $[0, 80]$. In our baseline game, Laissez-faire, the dominant firm can choose, on an equal footing with the entrant, its price in the interval $[0, 80]$.

In the Brooke Group game, a dominant firm in a duopoly in period t cannot choose a price below its own marginal cost in that period, that is, it is restricted to choosing $p_i^t \in [c_i, 80]$.

In the Baumol game, a restriction in pricing in period t applies only after exit of the competitor of the dominant firm. In this case, the firm is not allowed to choose a price above its price in $t-1$ in period t and all subsequent periods. Hence, $p_i^{t+k} \in [0, p_i^{t-1}]$ for $k = 0, 1, \dots, 4-t$. If the other firm has not left the market in t , the dominant firm can choose its price in the entire interval $[0, 80]$.

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 an experimental game that is as simple as possible, but still sufficiently rich to study the strategic incentives created by the policies. Thus, we made the following design decisions: (a) no re-entry possibility; (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 underlying our experimental treatments. For simplicity, we carry out the analysis for continuous price sets. Moreover, we define the total fixed cost F so that it includes the opportunity cost of 50 from the foregone outside option. Hence, $F = 300$. We first introduce some self-explanatory terminology.

1. The *break-even price* p_θ^B for $\theta \in \{L, H\}$ is given by $(p_\theta^B - c_\theta) D(p_\theta^B) = F$.
2. The *entry-deterring price* p^* of L in the Edlin game is defined by $0.8p^* = p_H^B$.

¹¹It 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.

It is important to note that 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 of the foregone outside option).

Figure 1 gives an overview of the relevant prices and marginal costs. Most

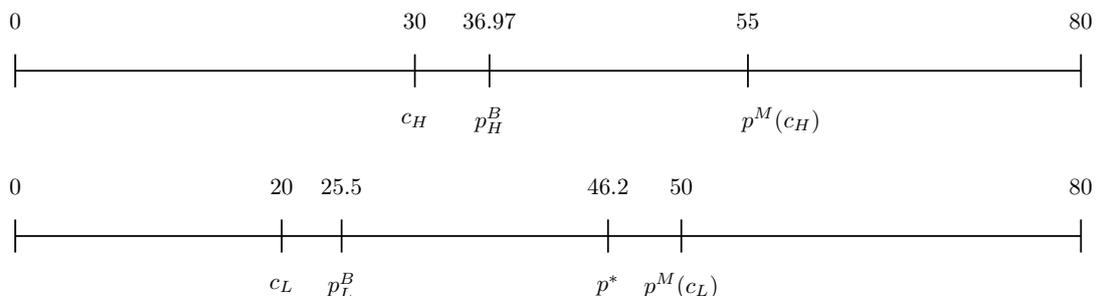


Figure 1: Overview of the prices (for firm H and firm L)

aspects of the ordering depicted in this figure hold for all conceivable parameterizations, not just for those chosen for the experiment. However, 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-detering 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.

We formulate the results in a non-technical way. We confine ourselves to describing the equilibrium outcome and the most important features of the equilibrium strategies. Apart from the proofs, the online appendix contains precise formal statements of equilibrium strategies and tie-breaking rules.

2.2.1 Laissez-Faire and Brooke Group Games

We treat the Laissez-faire and Brooke Group games together, as the analysis is essentially the same.

Proposition 1. *The Laissez-faire and Brooke Group games both have a subgame-perfect equilibrium (SPE) in pure strategies. The SPE outcome is that there is no*

¹²Without this assumption, further equilibria would emerge.

entry and 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.

The intuition is straightforward. In both games, both firms are essentially free to set arbitrary prices.¹³ Prices therefore do not affect future behavior. Thus, in each period, firms set prices that are optimal in the short term. In particular, in any duopoly situation, the incumbent undercuts the entrant in equilibrium. Anticipating this, the rival will not enter.

It is intuitively clear that Proposition 1 does not depend on the details of our parameterization: the only thing that matters is that prices today do not affect prices and entry behavior tomorrow.

2.2.2 Baumol Game

The Baumol game is much 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. Intuitively, this reduces the incumbent's incentives to fight against the rival with low prices. It must weigh the short-term benefits from undercutting against the long-term benefits from being allowed to charge the monopoly profit. As we show in more detail in the appendix, in duopoly subgames the resolution of this trade-off leads to the occurrence of multiple equilibria where prices do not necessarily equal the rival's marginal cost. However, none of these equilibria yields prices that are high enough for the entrant to break even. As a result, there is no entry in any equilibrium. The following result summarizes the equilibrium. It relies on tie-breaking rules that are stated in more detail in the appendix.

Proposition 2. *The Baumol game has an 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*

¹³In the Brooke Group game, prices below own costs are not allowed, but the incumbent does not rationally choose such prices anyway.

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.¹⁴ 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 an SPE without entry, in which the incumbent sets the entry-detering 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.*

Intuitively, the crucial aspect of the Edlin game is that, 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-detering price, thereby avoiding entry, but earning lower pre-entry profits. Given 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.

Note, however, that there also is a sense in which the Edlin rule seems to be more conducive to entry than the alternatives: after high prices of the incumbent, the rival will rationally enter because it is protected from competition. This differs from the previous games where entry does not occur in any subgame equilibrium.

¹⁴An open issue here is to which extent the equilibrium structure depends on 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.

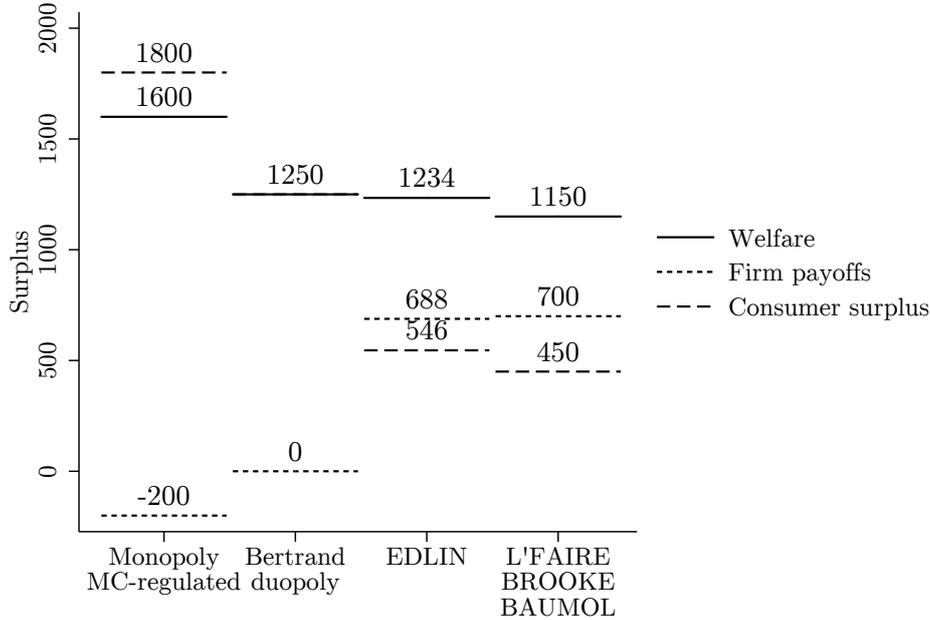


Figure 2: Welfare benchmarks of the four policies, a low-cost monopoly with marginal cost regulation, and Bertrand competition.

2.2.4 Welfare

Figure 2 shows the welfare results in the equilibria of our four games. For comparison, we plot the welfare results for a low-cost monopoly under marginal cost regulation. In this case, the incumbent makes a loss of 250. Because the rival does not enter the market it earns the payoff from the outside option (50), which brings the sum of the firms' payoffs to -200 . We also plot the welfare results for the Bertrand duopoly case, in which the low-cost firm 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-detering prices in periods 1–3. In the discrete version of the game, this means setting a price of 46, which results in firms’ profits of 684 (including the 50 of the rival), and a consumer surplus of 578. The numbers shown in Figure 2 take into account that this outcome is only predicted for periods 1–3, while in period 4 the outcome of the Edlin game is identical to the other three policies. The results show that—if the first-best is not available—there are several alternatives that might increase welfare: among the equilibria of our four games 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 outlined above. In all treatments, we use a stranger matching protocol such that, at the beginning of each round, groups of two subjects are randomly drawn from the subjects in a matching group. In each group and in 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 decisions of the other firm in prior rounds. Within a given round, the roles and the firms 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 of the firms in their group.

The sessions were run in the WiSo experimental research laboratory of the University of Hamburg in July 2015 and were programmed in z-Tree (Bock et al., 2014; Fischbacher, 2007). 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. We provided written instructions which informed the subjects of all the features of the markets (see Appendix B). Similar to other studies on experimental oligopolies, we used an

economic framing (see, e.g., Huck et al. (2004)), where we explain the strategic situation in terms of firms, prices, and quantities. Prior to the start of the treatment, subjects had to answer control questions. When answering the control questions and when choosing their actions during the game, 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.

We calculated the payoffs in the experiment in an experimental currency unit called points. At the beginning of the session, subjects were endowed with 1500 points to cover potential losses. The payments to the subjects 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, and the average earnings were €16.80. We conducted ten sessions—two sessions per treatment for L'FAIRE and BROOKE and three sessions 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 predatory pricing occurs frequently. 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. Throughout our analysis, we distinguish between three market structures: (i) *PreEntry*, the phase from period one until entry which captures all situations in which the incumbent needs to worry about future entry;¹⁵ (ii) *Duopoly*, after the rival has entered the market and the two firms compete, namely, the phase in which we may observe exclusionary behavior; and (iii) *PostExit*, after one of the two firms—typically the rival—has left the market and, thus, no entry threat exists.¹⁶ Finally, we discuss the dynamics across the seven rounds of the game.

¹⁵More 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.

¹⁶The 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 Predatory Pricing Under Laissez-Faire

In this section, we first show that above-cost predatory pricing is prevalent under Laissez-faire. We define pricing as predatory (or 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, it is predatory pricing because the entrant cannot help but lose money by being in the market.¹⁷ The definition thus encompasses both below-cost and above-cost predatory pricing.

Prior to entry (in *PreEntry*), the incumbent is a monopoly and prices as such. The average observed price is 49.6, with 83 percent of the cases at exactly the monopoly price of 50.¹⁸ Entry lowers the average incumbent's price substantially to 34.9, which is in the exclusionary range of 37 and below.¹⁹

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 predatory pricing, and such pricing is a unicorn in our game. However, most incumbents (75 percent) respond to entry with above-cost predatory pricing: 26 percent of the prices are in the category above the incumbent's marginal cost and below the rival's marginal cost, while around half of the observations (49 percent) are above the rival's marginal cost and below the rival's break-even point. As a consequence, entrants usually make a loss. The average profit is -235 per period, and entrants only earn a positive profit in 13.4 percent of the cases when they are in competition with an incumbent. Presumably as a reaction, 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, so that the incumbent is again in a monopoly.

¹⁷In 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.

¹⁸The 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.

¹⁹The 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.

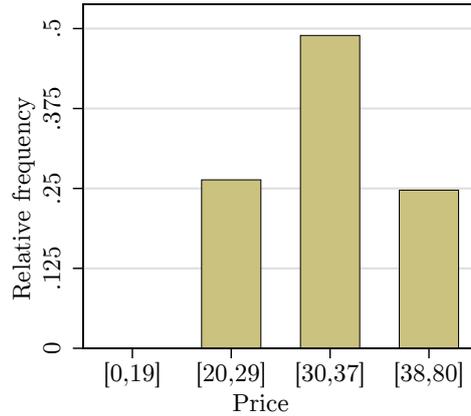


Figure 3: Incumbent prices in *Duopoly* of L'FAIRE.

Aside from the fact that entrants do not remain in the market, the most important effect of exclusionary pricing is that rivals do not dare to contest the incumbent in the first place. In one third of all rounds, rivals do not enter. Over the course of the seven rounds, there is a clear trend towards less entry. 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 successfully pushed the entrant out of the market, the game is in the *PostExit* structure. The incumbents switch back to monopoly pricing with an average of 50.7.²⁰

Result 1. *In L'FAIRE, incumbents generally engage in above-cost predatory 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 theoretical 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 possible post-entry price reductions, but they may not understand

²⁰There 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).

how much they need to earn to profitably enter the market. This is plausible as there are three different notions of costs to keep track of: 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 predatory pricing occurs under Laissez-faire. They also suggest that fear of such behavior may discourage entry. However, one cannot be sure about this last claim 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 a laissez-faire regime with the Brooke Group, Baumol and Edlin policies, respectively. The Edlin policy is particularly important, because it directly limits above-cost predatory 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, policy may influence the entry decision and therefore the frequency of the three market structures (*PreEntry*, *Duopoly*, *PostExit*). Second, policy may affect prices under each of the market structures. In the following, we will 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.

3.2.1 Prices Under Different Market Structures

***PreEntry*:** Theory predicts that in L'FAIRE, BROOKE, and BAUMOL, the incumbent will charge the monopoly price of 50 in *PreEntry*, because its price does not affect entry. In EDLIN the incumbent will charge 46 in order to deter entry.

Figure 4 bins the observed prices into three categories. The intervals are motivated by our theoretical analysis. The intermediate category [47, 53] contains the monopoly price as well as slightly higher and lower prices; this category is what

theory predicts we should expect under the first three treatments. Low prices in $[0, 46]$ are those that qualify as entry-detering under the Edlin rule, by which we mean that, for these prices, 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 generally 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.²¹ Thus, firms systematically respond to the Edlin rule and frequently choose entry-detering prices as expected.

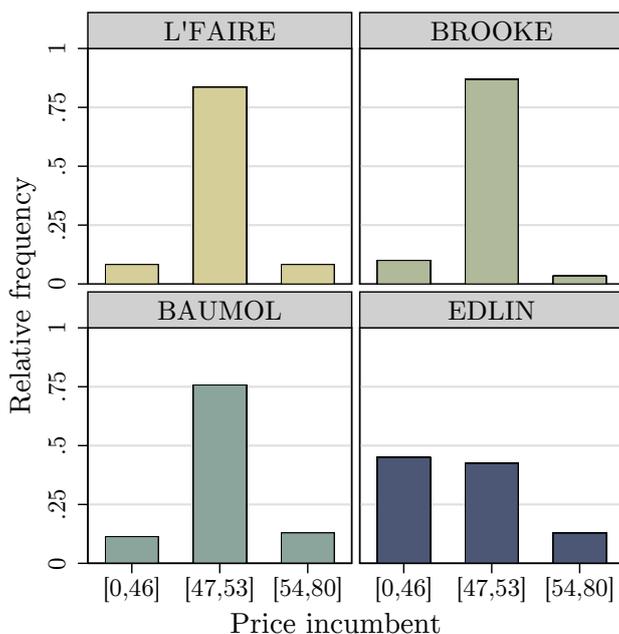


Figure 4: Distribution of incumbent prices in the structure *PreEntry*.

²¹The 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. All tests use the independent matching group averages as observations.

Duopoly: Advocates of strict predatory pricing rules want to reduce the frequency of predatory pricing, while Laissez-faire 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 predatory pricing (37 or lower) by incumbents in the periods where they compete with the rival. We find that 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 three treatments.²²

The lower frequency of predatory pricing in EDLIN is clearly due to the policy restrictions. When incumbents are not restricted by the rule, we observe a very high frequency of above-cost predatory prices (88.0 percent) even in EDLIN.²³

These observations are very much in line with what we would expect. In L'FAIRE and BROOKE, nothing prevents the incumbents from setting above-cost predatory prices, and it is optimal for them to do so. In BAUMOL, firms can set duopoly prices as they want, but they must worry about the adverse consequences for allowable post-exit prices. Finally, in EDLIN, incumbents are simply 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.²⁴ The differences between adjacent bars are not significant, but the comparison between EDLIN and the first two treatments is ($p < .004$). In addition, if we pool the observations from L'FAIRE and BROOKE and test against BAUMOL, the differences become significant at $p = .043$. Consequently, while BROOKE does not have an effect, the two other policies have the downside that they lead to higher prices than L'FAIRE when entry happens.

²² $p < .003$, Wilcoxon rank-sum test on average frequency in the matching group. All other bilateral comparisons are insignificant ($p > .128$).

²³Incumbents are not restricted when either no rule applies to them or the rule allows predatory prices.

²⁴In 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.

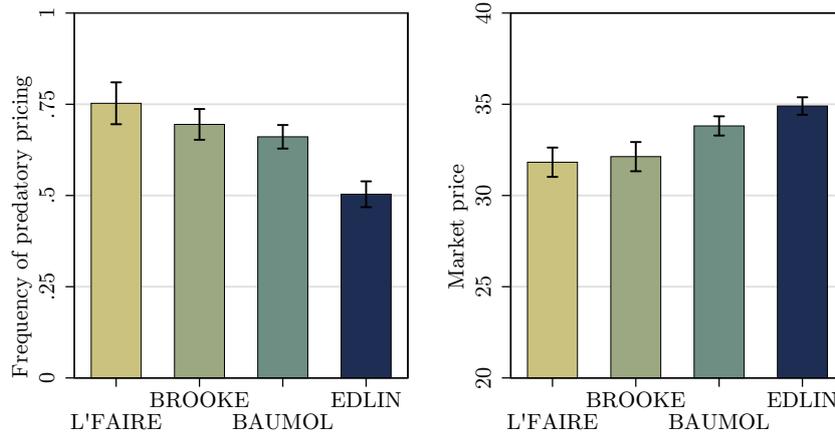


Figure 5: Prices in *Duopoly*. Left panel: frequency of predatory pricing by the incumbents across treatment. Right panel: market prices across treatment. Spikes indicate standard errors, calculated with clustering on matching group.

PostExit: In the structure *PostExit*, the firm remaining in the market has a monopoly and does not face the threat of market entry. Unless restricted, we would expect that such a firm sets the monopoly price. This is indeed the case: incumbents' average prices are very close to 50 with 78 percent or more at exactly 50 in L'FAIRE, BAUMOL, and EDLIN.²⁵ 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 38.7.²⁶

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 predatory pricing is frequent in L'FAIRE, BROOKE, and BAUMOL. EDLIN substantially reduces the frequency of above-cost predatory pricing. When both firms are in the market, L'FAIRE and BROOKE yield the most competitive pricing.*

²⁵In the cases where the incumbent exited, we observe prices close to the monopoly price of the entrant of 55.

²⁶The differences to all other treatments are highly significant.

By and large, the results are consistent with the theoretical 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 cases, above-cost predatory 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 will 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. Recall that theory predicts no entry under any rule in equilibrium. In addition, there is no entry in L'FAIRE, BROOKE, or BAUMOL in any subgame equilibrium, 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, we observe entry in all regimes. In period 2, we observe that 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, we find the highest fraction of entry decisions in EDLIN with 72.7 percent.²⁷

Incumbent Price and Entry: We will 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.

²⁷Differences across all treatments are significant at $p = .005$, differences between EDLIN and L'FAIRE or BAUMOL are significant at $p < .003$.

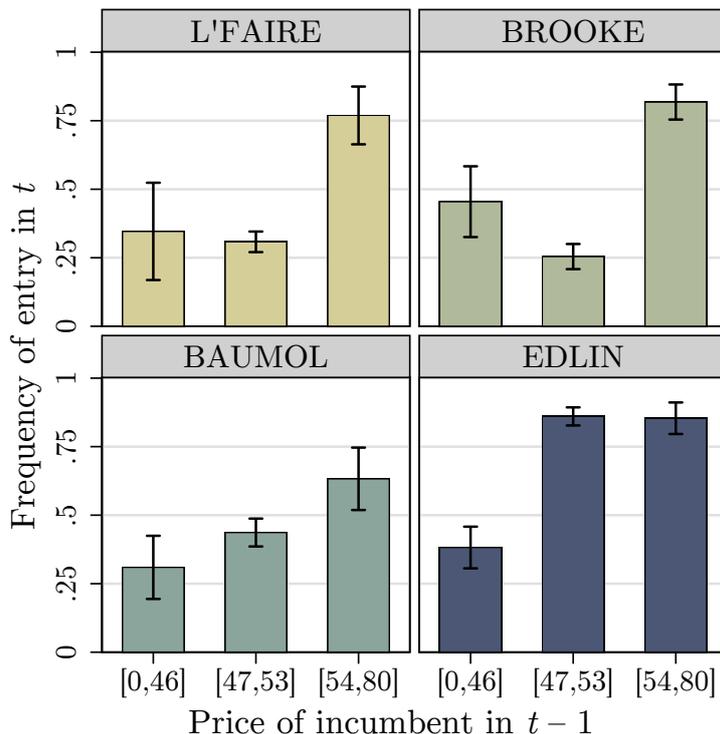


Figure 6: Frequency of entry for different incumbent prices in the previous period. For this figure, we use all periods in which the rival can enter. We use the same bins for the incumbent price in the previous period as in Figure 4. Spikes indicate standard errors (with clustering on matching group).

Figure 6 shows the fraction of rivals entering the market, 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, entry behavior differs across policies in the intermediate price range. 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 what happens to them after entry. 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 percent of the *entrants* undercut the incumbent in the first period after entry, but nevertheless 50.9 percent exit. This shows that 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
<i>PreEntry</i>	55.1	59.1	47.3	37.0
<i>Duopoly</i>	27.7	22.9	25.2	31.4
<i>PostExit</i>	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.

The main insights are as follows. 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.²⁸

²⁸It 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).

Result 3. *We observe frequent market entry in all treatments, particularly in EDLIN and, to a slightly lesser extent, in BAUMOL. Consistent with the theory of off-equilibrium path behavior, entry in EDLIN mainly happens in cases where the incumbent does not set entry-detering 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.

3.3 Dynamics

For the analysis so far, we considered all seven rounds of the game. Investigating the dynamics across the seven 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: Throughout the experiment, average prices in *PreEntry* for L'FAIRE, BROOKE, and BAUMOL are very close to the monopoly price, in particular, in the last round, when more than 85 percent of the incumbents set the monopoly price. Model (1) in Table 2 shows the results of OLS estimates for the incumbents' pre-entry prices in the first period (with clustered standard errors). Prices in EDLIN are significantly lower than in the omitted case (L'FAIRE) and in BAUMOL ($p = .006$).²⁹ The differences between EDLIN and the other treatments become stronger later in the experiment, as is shown in Model (2), where we estimate treatment-specific time trends. EDLIN shows a highly significant negative time trend, while the other three treatments do not. A closer look at the data shows that 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-detering prices in *PreEntry*. In the second half of the

²⁹The difference between EDLIN and BROOKE is insignificant, which is due to relatively similar prices in early rounds.

rounds, this percentage increases to 59.2 percent. This pattern suggests that it took some time for the subjects to learn how to react to the strategic incentives provided by the Edlin rule.

Model (3) in Table 2 explains market prices in *Duopoly*. Prices are significantly higher in BAUMOL and EDLIN than in L'FAIRE and BROOKE, and the overall time trend is significantly negative, suggesting that competition becomes fiercer in later rounds. In Model (4), we qualify this observation by estimating separate time trends: the point estimate is negative in all four treatments, but significant only in L'FAIRE.

Table 2: Incumbents' prices in *PreEntry* and market prices in *Duopoly*

	Price in $t = 1$ (<i>PreEntry</i>)		Market price in <i>Duopoly</i>	
	(1)	(2)	(3)	(4)
BROOKE	-1.405 (0.976)	-3.548 (2.888)	0.255 (1.093)	-0.616 (1.837)
BAUMOL	0.300 (0.921)	-1.669 (2.010)	2.080* (0.933)	1.274 (1.264)
EDLIN	-2.679* (1.044)	-1.340 (1.785)	3.216** (0.906)	1.865 (1.225)
Round	-0.123 (0.163)		-0.277* (0.124)	
Round \times L'FAIRE		-0.281 (0.198)		-0.527* (0.259)
Round \times BROOKE		0.254 (0.522)		-0.260 (0.333)
Round \times BAUMOL		0.211 (0.258)		-0.281 (0.215)
Round \times EDLIN		-0.616** (0.203)		-0.136 (0.211)
Constant	50.598 (1.011)	51.232 (1.335)	32.733 (0.825)	33.553 (0.937)
F -test	2.8	3.9	6.4	3.8
Prob $> F$	0.042	0.003	0.001	0.003
R^2	0.024	0.033	0.047	0.048
N	798	798	1720	1720

Notes: OLS estimates. Dependent variables in model (1) and (2): incumbent's price in period 1. Model (3) and model(4): market prices in *Duopoly*. Independent variables: treatment dummies, round, interactions, and a dummy for incumbent. Robust standard errors, clustered on matching group, in parentheses. * $p < 0.05$, ** $p < 0.01$.

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 with the game. The drop is particularly strong in L'FAIRE and BROOKE. In both cases, the fraction of games in which the rival enters drops from close to 100 percent in the first round to less than 50 percent in the second half of the experiment (rounds 5–7). 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 second half of the rounds.³⁰

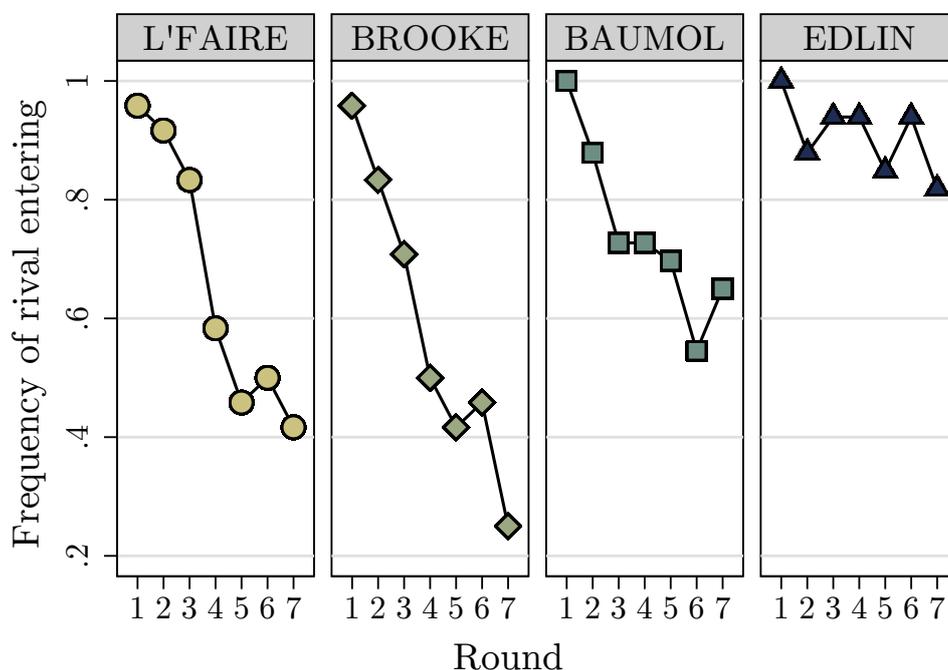


Figure 7: Frequency of rival entry across the seven rounds and by treatment.

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

³⁰The 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.

some protection for the entrant. Consequently, there is a smaller reduction in entry with increasing experience.

Result 4. *Over the course of the seven periods we observe no time trend in the prices when incumbents hold the monopoly, with the exception of PreEntry in EDLIN, in which subjects converge on average to the entry-detering prices only in the second half of the rounds. Price wars in Duopoly tend to become fiercer in later rounds. As subjects gain experience with the game, 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 across the seven rounds suggests that some of the strategic incentives set by the different policies require experience to become effective. In our welfare analysis below we therefore put more emphasis on 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 clearly 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. Moreover, the latter two policies encourage entry. We now summarize the welfare implications of these results.

3.4.1 Consumer Surplus and Welfare for Fixed Market Structures

Figure 8 shows how our previous price observations translate into results on consumer surplus, conditional on market structure. The bars show the average consumer surplus from rounds 5–7, where subjects have experience with the policies.³¹ In *PreEntry*, the consumer surplus is very close to the predicted monopoly consumer surplus of 450 in all but one treatment. The exception is EDLIN, in which

³¹The results of rounds 1–4 are qualitatively identical, with the only notable difference that the advantage of EDLIN in *PreEntry* is not yet as pronounced as in rounds 5–7.

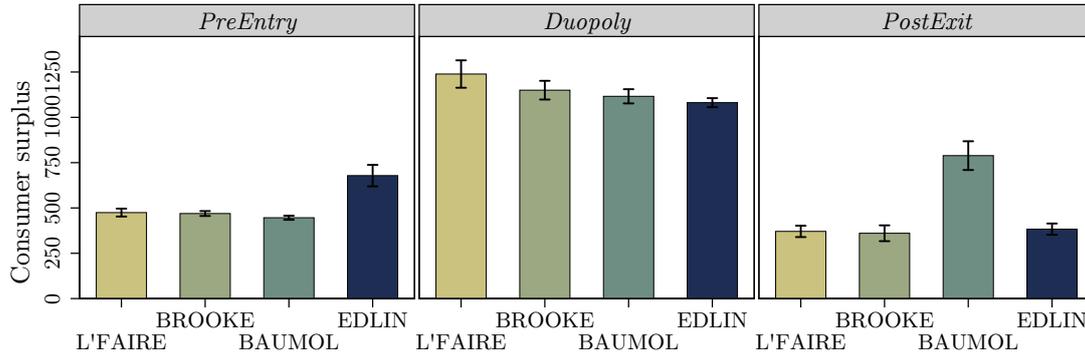


Figure 8: Consumer surplus in rounds 5–7. Bars show average consumer surplus, spikes indicate standard errors (with clustering on matching group).

the predicted price prior to entry is 46 resulting in a consumer surplus of 578. The observed consumer surplus is even higher with 678.³² In *Duopoly*, we observe the most competitive outcomes in L'FAIRE and BROOKE, but the overall treatment differences are not significant ($p = .155$, Kruskal-Wallis test). In *PostExit*, only BAUMOL results in a consumer surplus significantly and substantially higher than in the unregulated monopoly.

In terms of total welfare (consumer surplus plus producer surplus net of fixed operating costs) results in rounds 5–7 are very similar as for consumer surplus only: EDLIN is significantly more efficient than the other treatments in *PreEntry*, and the same is true for BAUMOL in *PostExit*. For *Duopoly*, on the other hand, EDLIN is significantly less efficient than the other treatments. Apart from the duplication of fixed costs, the reason for this difference is that, under the Edlin rule, it is more likely that the entrant serves the market than in the other treatments, which results in efficiency losses due to the higher marginal cost.

3.4.2 Overall Comparison

Finally, we analyze the overall welfare implications, taking into account that policies also affect market structure and not only prices conditional on market structure. Table 3 shows the average consumer surplus and welfare over the four periods of the game. The resulting numbers aggregate the policy effects on pricing and

³²The difference between EDLIN and each of the other three treatments is highly significant ($p < .002$, Wilcoxon rank-sum tests).

Table 3: Consumer surplus and welfare across treatment

	Consumer surplus		Welfare	
	Rounds 1–4	Rounds 5–7	Rounds 1–4	Rounds 5–7
L'FAIRE	702	597	1050	1123
BROOKE	697	533	1096	1101
BAUMOL	738	664	1117	1118
EDLIN	649	697	970	1049

Notes. Average consumer surplus and welfare across the four periods of the respective game, for Rounds 1–4 and Rounds 5–7 of the experiment.

market structure. The theoretical benchmarks with monopoly in all four periods and no entry result in a consumer surplus of 450 and a welfare of 1150. This is the prediction for all treatments but EDLIN, in which case there are three periods of entry-detering prices and monopoly prices in the fourth period, resulting in an average consumer surplus of 546 and a welfare of 1234. In rounds 1–4, there are no significant overall differences across treatments in consumer surplus ($p = .105$, Kruskal-Wallis test). In rounds 5–7, differences become significant ($p = .005$) with BAUMOL and, even more so, EDLIN generating more consumer surplus than the other two treatments. For welfare, however, 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.*

The low consumer surplus in L'FAIRE and BROOKE is essentially in line with what we would expect 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 relatively 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 relatively 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 theoretical predictions.

4 Discussion and Conclusion

Economists, lawyers, and policy makers debate whether post-entry price cuts discourage entry and whether we should care. This paper studies such 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 predatory pricing occurs on the equilibrium path. In this sense, predatory pricing is a unicorn from a theoretical perspective.

The observations of the experiment differ from our theoretical predictions. Neither L'FAIRE nor BROOKE – the current U.S. policy – 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 predation. Such pricing is no unicorn. It is prevalent.³³

³³Such a pattern fits the anecdotal evidence in Bolton et al. (2000) who 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.

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 predation, L'FAIRE and BROOKE, and BAUMOL all perform well with respect to total welfare and substantially better than EDLIN. From a consumer perspective, however, EDLIN is preferable.

There is scope for exploring the robustness of our analysis. Most directly, it would be instructive to vary some of our main assumptions. Apart from considering smaller cost differences and other policy parameters, it would seem particularly important to explore longer games under different assumptions for the length of protection by the Edlin and Baumol rules. Moreover, one could explore the efficacy of these policies in a situation of learning by doing such as Cabral and Riordan (1994) and Besanko et al. (2010, 2014), where it is possible for an inefficient entrant to eventually be efficient.

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