Pure numbers effects, market power, and tacit collusion in posted offer markets☆

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ARTICLE INFO

ABSTRACT

This paper studies the effects of seller concentration and static market power on tacit collusion in extensively repeated laboratory posted-offer markets. Contrary to the implications of some earlier research, we find that tacit collusion does not become pervasive with extensive repetition. In a 'strong no-power' design persistently competitive outcomes are observed in markets with three or four sellers. Even duopolies are frequently competitive in this design. Unilateral market power raises prices, as predicted. However, static Nash predictions fail to organize outcomes across power treatments, because tacit collusion moves *inversely* with concentration. Excess capacity appears to explain observed tacit collusion levels.

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1. Introduction

The impressive capacity of static Nash equilibrium (often competitive) predictions to organize market outcomes represents one of the most prominent successes of using laboratory methods to study market processes (see, e.g., Smith, 1982, or Plott, 1989). Markets organized under 'posted offer' trading rules, where sellers post-prices to buyers on a take-it-or-leave-it basis, are no exception. Posted offer markets are of prominent interest in industrial organization because they parallel important aspects of retail exchange and because they can be analyzed as games of Bertrand–Edgeworth competition. In such markets, competitive outcomes have been robustly observed even in thin markets with as few as three sellers (e.g., Ketcham et al., 1984). Further, the introduction of unilateral market power, in the form of capacity restrictions that assure sellers some sales at supra-competitive prices, has a price-increasing effect as static Nash equilibria predict (e.g., Davis and Holt, 1994; Davis et al., 2002).

Nevertheless, the organizing power of static Nash predictions in posted offer markets is imperfect. In some contexts, tacit collusion has been observed with frequency. A number of studies conclude that tacit collusion becomes problematic when the number of sellers is reduced to two (e.g., Fouraker and Siegel, 1963; Isaac and Reynolds, 2002). Of particular note is Dufwenberg and Gneezy (2000) who observe large supra-competitive deviations in duopolies of very short duration (10 trading periods), even when participants are re-matched into new markets each trading period. Potentially more generally

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problematic are results by Alger (1987) that suggest that extensive repetition may make tacit collusion pervasive in even less concentrated markets. Alger (1987) reports results of a series of two, three and four seller posted-offer markets that included as many as 140 periods each and finds that prices often increase after initially falling.

These behavioral results regarding the effects of intense concentration and repetition have some intuitive appeal. Extensive repetition allows sellers increased opportunities to develop a 'language of coordination' via their pricing activities. Further, to the extent that a two seller structure is not inherently anticompetitive, as results by Dufwenberg and Gneezy suggest, fewer sellers presumably make this task even easier.

Tacit collusion in the form of prices in excess of static Nash predictions have also been observed in some 'market power' experiments (e.g., Davis and Holt, 1994; Davis et al., 2009; Orzen, 2008). However, the same sort of intuitive results regarding the effects of increased concentration and repetition observed in no-power designs do not clearly emerge from the literature examining power designs. In an experiment of relatively short duration, Davis and Holt reduce the number of sellers from five to three in a way that leaves static market power unchanged, and find that tacit collusion increases only slightly. In more extensively repeated contexts Orzen (2008) reports a tendency for tacit collusion in duopolies but not in thicker (quadropoly) markets, while Davis et al. (2009) find more evidence of tacit collusion in thicker (triopoly) markets than in duopolies.[1]

In order to improve our understanding of when and how robustly Nash predictions may be expected to organize posted offer market outcomes, a good understanding of both the causes and pervasiveness of tacit collusion is important. This paper reports an experiment conducted to inform this question. Specifically, we use a 'near continuous' variant of the posted-offer trading institution to study the interrelationships between concentration, repetition and static market power in generating tacit collusion.[2] By way of presummary, we find that, contrary to the implications of Alger (1987), tacit collusion is not a pervasive feature of posted-offer markets. In a 'strong' no-power design, transactions prices in triopolies and quadropolies are uniformly quite competitive and remain so even with very extensive repetition. Further, in the 'strong no-power' design we find only sporadic evidence that increasing concentration to a duopoly generates higher prices as was observed, for example, in the re-mixed markets by Dufwenberg and Gneezy (2000).

We further find that unilateral market power sizably increases prices. However, static Nash predictions do not organize outcomes well across the power treatments because tacit collusion arises frequently and moves *inversely* with concentration levels. In a follow-up experiment we explore the inverse relationship between tacit collusion and concentration and find support for the conjecture that tacit collusion in posted offer markets is driven by a 'follow rate' which reflects the number (or, if only a subset is needed, the percentage) of 'other' sellers who must follow a signaler's price lead in order for the signaler to profit from supra-competitive prices in subsequent periods.

The remainder of this paper is organized as follows. Section 2 develops the experiment design and predictions. Section 3 presents the experimental procedures. Results appear in Section 4. Section 5 considers some additional possible causes of tacit collusion in our markets, and reports a follow-up experiment. The paper concludes with a short discussion in Section 6.

2. Experiment design

2.1. The near-continuous posted-offer institution

The posted-offer trading institution has a long history in experimental economics (see, e.g., Ketcham et al., 1984). Trading occurs in a sequence of 'periods'. At the outset of each period, sellers, endowed with unit costs, simultaneously make price and maximum offer quantity decisions. Production is 'to demand' in the sense that sellers incur unit costs only for offered units that subsequently sell. Once all price-posting decisions are complete, a public display of prices appears, and a (simulated) buyer makes purchases, starting with the lowest priced units. In the case of a price tie, the buyer divides purchases as evenly as possible among the sellers posting the same price. The buyer routine continues making purchases until demand has been exhausted, no further units are available, or until unit values no longer exceed the lowest available price. The period concludes by showing each seller his or her own period sales and earnings.

In most respects, the posted offer implementation used here follows standard procedures. Our markets are distinctive, however, in that they are extensively repeated. Each 'treatment sequence' in our experiment consists of 220 trading periods. This large number of trading periods was made possible by truncating to seven seconds the maximum length of decision

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[1] Despite several common features Orzen (2008) and Davis et al. (2009) differ in a number of important respects, including opposite predicted comparative static effects of concentration changes. Orzen examines a price setting game where a division of buyers into 'price sensitive' and 'convenience shopping' segments generates a predicted direct relation between the number of sellers and the price cost markup. Orzen finds that theoretical predictions organize behavior well in a 'static' condition where sellers are re-matched across periods (e.g., prices are higher in quadropolies than in duopolies). However, when participants remained in fixed groups duopoly prices increase, reversing the comparative static predictions observed in the re-matched group treatment. Davis et al. (2009) studies a more standard design where a reduction in the number of sellers increases the central moments of the static NE mixing prediction. In markets with re-matching Davis et al. (2009) observe this predicted comparative static effect. However in fixed group markets, triopoly prices trended up toward those in the duopolies.

[2] In a related paper Davis et al. (2008) hold the market structure fixed and examine the capacities of signaling activity and the underlying propensity of sellers to behave cooperatively to explain tacit collusion. Given a structure that is susceptible to tacit collusion (similar to the *3wp* treatment examined below), they find little evidence that signaling activity (at least the volume of signals sent) affects observed prices, but that 'type' importantly affects outcomes. As will be evident below, several of the structural alterations studied here appear to dominate the effects of 'type' on outcomes.