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Price-setting and attainment of equilibrium: Posted offers versus an administered price ☆

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ABSTRACT

The operation of the posted offer market with advance production environment (Mestelman and Welland, 1988), appropriately parameterized, differs from that of the market entry game (Selten and Güth, 1982), appropriately presented, only in terms of price-setting. We establish the effect of this difference in price-setting on attainment of the competitive equilibrium allocation while controlling for effects relating to the presentation of the market entry game and to the stationarity or non-stationarity of environment. Free posting of prices promotes convergence to the competitive equilibrium allocation, while the typical market entry game data can be characterized as displaying cycling prices.
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How do markets equilibrate? What is responsible when they do not? We generate insight on these questions by setting up a comparison of the market entry game (Selten and Güth, 1982) and a posted offer with advance production environment (Mestelman and Welland, 1988), hereafter denoted as the POAP. We demonstrate that the POAP can be thought of as a non-isomorphic relaxation of the market entry game, where the market entry game appears conversely as a market with advance production environment restricted to have an administered pricing rule—specifically a uniform price that allows ex post market clearing—instead of freely and individually posted offers. This insight then allows the construction of experiments which isolate the marginal effects of different design features, by means of a sequence of incrementally varying designs. Empirically, we find different out-of-equilibrium dynamics associated with the administered ex post market clearing price rule versus posted offers, and more evidence of convergence to the competitive equilibrium outcome given use of posted offers. Stationarity of environment also aids equilibration.

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The above results are demonstrated by data from our study. We generate these data by implementing a sequence of treatments, beginning with the market entry game in its original format. In our experiments, as in the prior empirical literature, the market entry game generates volatile outcomes that are generally inconsistent with complete adoption of pure strategy play, although perhaps tempting to describe as "equilibrium plus noise". From there we alter the exogenous control variable from "capacity" (i.e. a parameter of the demand schedule) to marginal cost. We then build on that by altering the presentation of the game (in previous literature, presented as an algebraic payoff function) to make explicit the (previously implicit) numerical demand schedule and the accompanying administered price rule, i.e. ex post market clearing, both inherent in the market entry game. Each of the experimental treatments listed so far introduces a single change in design only, isolating the marginal effect of each change. Each change in format and/or control variable as just described also preserves isomorphism with the original implementation of the market game.

However, we then break with isomorphism by introducing a further treatment, which introduces a second stage in which each subject nominates his or her own price subsequent to entry. Individual posting of prices thus replaces the uniform ex post market clearing price rule embedded in the immediately prior transformation of the market entry game; our sequence of treatments thus terminates at a particular version of the POAP.

While the market entry game and the POAP are not isomorphic, it is however the case that given pricing "via the demand curve"[1] in the second stage of the POAP (when prices are posted) the payoff function in the first (advance production) stage of the POAP is exactly equivalent to the payoff function in the market entry game. In consequence there are subgame perfect pure strategy equilibria in the POAP that have the same observable outcomes, in quantities and prices, as the pure strategy equilibria in the market entry game, in number of entrants and prices implicit to its administered price rule. (In Appendix A, we demonstrate the preceding and also delineate additional equilibria in the POAP which are not possible in the market entry game; those additional equilibria are not exhibited by our data.)

Does restricting the pricing possibilities, thereby reducing the number of pure strategy equilibria relative to the POAP, allow the market entry game to more quickly attain the competitive equilibrium allocation common to both? Quite the opposite: we find that the POAP converges more rapidly to the competitive equilibrium allocation than does the market entry game. Additionally, outcomes in the market entry game appear not to be evidence of mixed strategy use by the subjects, but rather an out-of-equilibrium phenomenon, *en route* to an equilibrium in pure strategies (consistent on this point with results from Duffy and Hopkins, 2005). We are also able to advance understanding of the market entry game by identifying something that it would seem *is* going on instead of mixing: cycling.

1. The game, the market, and their predictions

Introduced by Selten and Güth (1982), the market entry game is an n-player simultaneous game where players decide between two strategies: enter the market (IN) or stay out (OUT). Empirically, the game has been studied with linear payoffs. We consider a specification that nests earlier work, where player i's payoff is

$$\pi_i = \begin{cases} v, & \text{if player } i \text{ chooses OUT,} \\ v + r(c-m) - h, & \text{if player } i \text{ chooses IN.} \end{cases} \tag{1}$$

In this specification, m is the number of entrants, the parameters v, r, and c, are positive integers, and h is a non-negative integer that satisfies $0 < h \leq r(c-1)$. Following the literature, v may be interpreted as an outside option or entry subsidy, c as the capacity of the market to support entrants, and r as a parameter determining the scale of the surplus captured from entry, i.e. $r(c-m)$. The parameter h may be interpreted as a cost incurred to enter the market.

Alternatively, one might present the payoffs in Equation (1) as the consequence of entry or not when demand is $P(m) = r(c-m)$ with an *ex post* market clearing price, P, enforced based on a realized m; entry or not each attract the same subsidy, v; and marginal cost of production is h.

For our discussion of Nash equilibria, we define $\hat{c} \equiv c - h/r$. One might think of $\hat{c}$ as market capacity adjusted for the presence of an entry cost. If $h = 0$, then clearly $\hat{c} = c$.

There are many Nash equilibria for the market entry game (Gary-Bobo, 1990). There is a continuum of equilibria for which $\hat{c}-1$ players enter, $n-\hat{c}$ stay out, and one player enters with any probability. A pure strategy equilibrium occurs on either end of this continuum, where the profiles of pure strategies are consistent with either $m^* = \hat{c}$ or $m = \hat{c}-1$ players choosing to enter (and $n-\hat{c}$ or $n-\hat{c}+1$ players choosing to stay out, respectively).[2]

For $\hat{c} > 1$, there is a symmetric mixed strategy equilibrium for which player i enters with probability

$$p(\hat{c}) = \frac{\hat{c}-1}{n-1} \text{ for } i = \{1, \dots, n\}. \tag{2}$$

Additionally, there are asymmetric mixed strategy equilibria in which $j < \hat{c}-1$ players enter with certainty, $k < n-\hat{c}$ players stay out with certainty, and the remaining $n-j-k$ players enter with probability $(\hat{c}-1-j)/(n-1-j-k)$.

[1] Pricing "via the demand curve" means that each seller nominates a price that is equal to the price coordinate of the point on the demand curve where the quantity coordinate is given by the units produced (i.e., number of sellers who have decided to produce one unit) in that round.

[2] For ease of exposition, we denote only the number of entrants consistent with the competitive equilibrium allocation as m^*.

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