



# Allowing for two production periods in the Cournot duopoly: Experimental evidence

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## Abstract

In this study behavior in a Cournot duopoly with two production periods (the market clears only after the second period) is compared to behavior in a standard one-period Cournot duopoly. Theory predicts the endogenous emergence of a Stackelberg outcome in the two-period market. The results of the experiments, however, reveal that in both markets (roughly) symmetric outcomes emerge and that, after a short adaptation phase, average industry output in the two-period markets is the same as in the standard one-period markets.

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## 1. Introduction

In the standard Cournot duopoly both firms are assumed to decide only once and simultaneously about their outputs before the market clears. [Saloner \(1987\)](#) analyzes an extended market game allowing for two production periods before the market clears. In this model, the initial outputs chosen in the first production period become publicly known before firms decide about their additional non-negative outputs in the second production period. Only after the second production period is the market price determined according to the total

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amount of output produced in both periods. Moreover, production costs are assumed to be the same in both periods. Saloner shows that in case of constant marginal costs and linear demand<sup>1</sup> any outcome on the outer envelope of the best-response functions between and including the firms' Stackelberg points<sup>2</sup> can be achieved in a subgame perfect Nash equilibrium of the two-period model. However, Ellingsen (1995) shows that only the Stackelberg points survive the elimination of weakly dominated strategies. Thus, the interesting feature of this model is that it predicts an asymmetric outcome even when firms are a-priori symmetric. As a consequence total quantity and welfare are higher than in a standard one-period Cournot market.

Another model in which duopolists are given more flexibility in the timing of moves is Hamilton and Slutsky's (1990) extended game with action commitment in which two firms may choose their action in one out of two periods. A firm may move early by committing itself to a quantity, or it may wait until the second period and observe the other firm's first-period action. Again, there are two endogenous Stackelberg equilibria with either firm as the Stackelberg leader.<sup>3</sup> While there also exists a simultaneous-move Cournot equilibrium in pure strategies, this equilibrium is in weakly dominated strategies.

This paper reports the results of an experiment designed to investigate Saloner's two-period model with quantity competition and identical firms. In the experiment, fixed pairs of subjects are repeatedly matched to play the game. The results in the two-period market are compared with results in standard one-period Cournot markets. Given the two models' predictions, I shall focus on three research questions: (1) Do we observe the endogenous emergence of Stackelberg outcomes in the two-period markets? (2) Will the two-period markets (as in theory) yield higher total outputs at smaller prices than standard Cournot markets, thus increasing total welfare?<sup>4</sup> (3) What is the actual behavior in the two periods of Saloner's model?

There are several reasons why in an experimental setting of the two-period model it is doubtful that one observes the endogenous emergence of a Stackelberg outcome. First, Ellingsen's result is based on iterated elimination of weakly dominated strategies. Earlier experiments, however, have demonstrated that subjects do not iteratively eliminate dominated strategies but stop after one or very few rounds of reasoning.<sup>5</sup> Second, there is a coordination problem as there are two Stackelberg outcomes with either firm evolving as the Stackelberg leader. In a symmetric setup, it is not clear how subjects can overcome this coordination problem.<sup>6</sup> Third, both subgame perfect equilibria imply large payoff dif-

<sup>1</sup> Saloner actually allows for a much more general demand function. See Section 2 and especially footnote 15.

<sup>2</sup> This is set  $E$  indicated in Fig. 1.

<sup>3</sup> See Matsumura (1999), for a more general version of this model with more than two firms and with more than two production periods.

<sup>4</sup> In Huck et al. (2001) in which Stackelberg markets with exogenous role assignment are compared with Cournot markets, it is found that although "pure" Stackelberg outcomes are rarely observed, total output in the former markets are consistently higher than in the latter.

<sup>5</sup> A stunning failure of subjects to go through longer chains of reasonings is reported in a recent paper by Kübler and Weizsäcker (2004) on informational cascades. For further evidence on subjects' depth of reasoning see, for example, the seminal work by Nagel (1995) or the more recent paper by Costa-Gomes et al. (2001).

<sup>6</sup> van Damme and Hurkens (1999) analyze Hamilton and Slutsky's extended game with action commitment in the presence of cost differences. Their model also has two pure strategy Stackelberg equilibria. However, in order

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