



## PQ strategies in monopolistic competition: Some insights from the lab



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### ABSTRACT

We present results from 50-rounds experimental markets in which firms decide repeatedly both on price and quantity of a perishable good. The experiment is designed to study the price–quantity setting behavior of subjects acting as firms in monopolistic competition. In the implemented treatments subjects are asked to make both production and pricing decisions given different information sets. We investigate how subjects decide on prices and quantities in response to signals from the firms' internal conditions, i.e., individual profits, excess demand, and excess supply, and the market environment, i.e., aggregate price level. We find persistent heterogeneity in individual behavior, with about 46% of market followers, 28% profit-adjusters and 26% demand adjusters. Nevertheless, prices and quantities tend to converge to the monopolistically competitive equilibrium and we find that subjects' behavior is well described by learning heuristics.

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## 1. Introduction

Traditionally two main frameworks to describe firms' competition can be distinguished. Cournot competition refers to the case when firms decide the quantity of the good they produce and then prices adjust such that the markets clear. On the contrary, a framework in which the selling price represents the strategic variable for the firm and quantities clear the markets is referred to as Bertrand competition. Both Cournot and Bertrand competition have been widely studied theoretically and by means of economic experiments.

However, economic frameworks characterized by only pure strategies do not describe all possible market scenarios. In fact in practice prices are usually determined by firms and not through some market clearing mechanism and it may happen that firms are not always able to satisfy the market demand at a given price. Moreover, the production process might take some time, hence firms need to decide on production in advance and they cannot react immediately to possible changes in the demand. Moreover, it is reasonable to think that firms, when strategically interacting with competitors, are indeed facing a simultaneous price–quantity decision problem. Starting from Shubik (1955) a wide strand of economic literature on price–quantity competition has been developed. Price–quantity competition models within an oligopolistic setup can be distinguished into three main classes. The first refers to those frameworks in which firms face price competition under a capacity limitation constraint (see e.g. Levitan and Shubik, 1972; Osborne and Pitchik, 1986; Maskin, 1986). The second category is described by a framework in which firms set price

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and quantity through sequential choices. Some examples can be found in [Kreps and Scheinkman \(1983\)](#) and [Friedman \(1988\)](#). Finally, the third category, known as PQ games (Price–Quantity games), develops a setup in which a firm has to decide simultaneously on prices and quantities. In particular, firms face price competition in an economic framework with perishable goods and production in advance (see e.g. [Levitan and Shubik, 1978](#); [Gertner, 1986](#)).

The present paper develops an economic experiment within a monopolistically competitive market along the PQ games approach. Price–quantity competition has also been analyzed in economic experiments. [Brandts and Guillen \(2007\)](#) conduct an experiment in which groups of two or three subjects form a market of a homogeneous, perishable good. The market demand and the marginal cost of production are constant. Both with two and three firms, the typical patterns that occur are collusion after a few periods, constant fights, and collusive price after a fighting phase (possibly due to bankruptcy). The average price shows an increasing pattern in both treatments. [Cracau and Franz \(2012\)](#) compare the subjects' actions with the unique mixed-strategy Nash equilibrium in a duopoly with a homogeneous good, linear demand and constant marginal costs. They find evidence that subjects do not play according to the mixed-strategy Nash equilibrium: prices depend on the outcome of the previous round (whether the subject had the lowest price or not), subjects produce less than the market demand at the price they charge and they make positive profits on average. The average price is more or less constant during the experiment. Both papers analyze price–quantity competition in oligopolistic markets. [Davis and Korenok \(2011\)](#) implement a monopolistically competitive experimental market in order to examine the capacity of price and information frictions to explain real responses to nominal price shocks. In their experiment, subjects were acting as firms setting prices in monopolistic competition with a known demand function.

Monopolistic price–quantity competition as described in [Dixit and Stiglitz \(1977\)](#) and [Blanchard and Kiyotaki \(1987\)](#) also plays an important role in modern macroeconomics e.g. in the New Keynesian framework (see e.g. [Woodford, 2003](#)), but also in agent-based macro models (e.g. [Delli Gatti et al., 2011](#)). Agent-based macro models make assumptions about the firms' individual price–quantity decision rules in a monopolistic competition setting. An important goal of our paper is to use a macro experiments to obtain empirical evidence about price–quantity decision rules. Two main questions that we want to address are the following:

- Does aggregate market and individual firm behavior in the experiment converge to the monopolistically competitive outcome in a more complicated market environment, i.e., without knowledge of the demand function and with production set in advance?
- What are the price–quantity setting strategies used by the subjects in response to signals from the firms internal conditions, i.e., individual profits, excess demand, excess supply, and the market environment, i.e., aggregate price level, as well as in the impact of different information sets on the market outcome?

The two research questions outlined above are functional to the final goal of our experiment that consists in deriving price–quantity strategies by means of experimental data on subjects acting as firms in a monopolistically competitive market.

Macro experiments to study simultaneously individual decision rules, their interactions and the emerging aggregate outcome are becoming increasingly important, see e.g. the survey in [Duffy \(2008\)](#). Our strategy to fit simple first-order heuristics to individual price–quantity decisions and explain aggregate market behavior as the emerging outcome is similar to the work on learning-to-forecast experiments (see [Hommes, 2011](#) for an overview).

The remainder of the paper is organized as follows. [Section 2](#) reviews the theoretical benchmarks, describes the experimental setting and presents the results of the experimental markets. [Section 3](#) analyzes individual price–quantity setting behavior. [Section 4](#) evaluates the impact of individual strategies on aggregate outcomes. [Section 5](#) concludes.

## 2. The price–quantity setting experiment

In the following section we will describe the theoretical framework underlying the experiment (in [Section 2.1](#)), the experimental design (in [Section 2.2](#)) and the experimental results (in [Section 2.3](#)).

### 2.1. Monopolistically competitive market

The market structure underlying our experiment is a variant of the standard monopolistically competitive market structure described by [Dixit and Stiglitz \(1977\)](#) and [Blanchard and Kiyotaki \(1987\)](#) among others. We consider a market with  $n$  firms, where each firm  $i$  offers a differentiated product at a price  $p_i$  with common constant marginal costs  $c$ . The demand for good  $i$  is linear and given by

$$q_i = \alpha - \beta p_i + \theta \bar{p}, \quad (2.1)$$

where  $\bar{p}$  is the average market price,  $\alpha > 0$  and  $\beta > \theta/n > 0$ .<sup>1</sup> We simplify standard models of monopolistic competition by specifying a linear demand function.<sup>2</sup> Several experimental studies on market with differentiated products use linear

<sup>1</sup> The restriction on the parameters ensures that demand depends negatively on the firms' own price and positively on the average market price, as in standard treatment of monopolistically competitive markets (see e.g. [Blanchard and Kiyotaki, 1987](#)).

<sup>2</sup> Consumers' demand is linear when they have quadratic utility over the differentiated products, see e.g. [Vives \(1999\)](#).

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