



Original articles

# Dynamics and stability in retail competition

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## Abstract

Retail competition today can be described by three main features: (i) oligopolistic competition, (ii) multi-store settings, and (iii) the presence of large economies of scale. In these markets, firms usually apply a centralized decisions making process in order to take full advantage of economies of scales, e.g. retail distribution centers. In this paper, we model and analyze the stability and chaos of retail competition considering all these issues. In particular, a dynamic multi-market Cournot–Nash equilibrium with global economies and diseconomies of scale model is developed. We confirm the non-intuitive hypothesis that retail multi-store competition is more unstable than traditional small business that cover the same demand. The main sources of stability are the scale parameter, the number of markets, and the number of firms.

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## 1. Introduction

In an oligopolistic setting under a Cournot scheme [25], the strategy of each economic player depends on its own quantity decision, and on its rival's reaction. Puu was one of the first to explicitly show the complex dynamics of the oligopolistic setting under simple assumptions (isoelastic demand function and constant marginal cost) for two and three players [42–44]. This kind of analysis has grown significantly during the last decade in both, the mathematics and complex systems literature, as well as in the economically-oriented journals.

Indeed, since the Puu's approach, several games has been developed for the study of the market stability, focusing on different demand or price function [9,39], number of players [5,46], behavioral assumptions (naive [24,37,19], versus adaptive [13,18], bounded rationality [3,39,52] or heterogeneous expectations [1,2,8,36]). In terms of the cost function definition, several developments has been proposed as well as non-linear cost function [52,28,39,36,18], capacity constraints [48,47,18,34] and some spillover effects [15,14,17,16].

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Most works in this line of research have concentrated in single markets with linear production structures (i.e. assuming constant returns to scale). Nevertheless, oligopolistic competition today seems to present multi-market phenomena and, in some cases, they showcase important economies of scale, especially in the retail industry. Indeed, supermarket chains and retailers of food, gasoline, supplies and services all compete for market share through multi-store formats over geographically separated markets. This localized competition is presented in different levels: city, region, or country. In this context, companies segment their strategies, tailoring their selected outcome for different types of consumers and competitors, which vary by geographical location. On the other hand, on the supply side, multi-market retailers usually try to take full advantages of their size, in other words, their economies of scale. For instance, through the development of distributions centers that attend most of the stores in a specific territory. Thus, as the cost structure of multi-market retails depends on the total volume of the produced goods, the individual cost structure of each store is usually coupled with the whole business. It is important to point out that, this system of production, implies a centralized decisions making process, which becomes in practice an extremely difficult task. Summing up, retail competition today can be described by three main features: (i) oligopolistic competition, (ii) multi-store setting, and (iii) the presence of economies of scale.

Applications of the Cournot scheme into the multi-market problem have been proposed before by economists, for example, in the case of international trade. Some of these works modeled the presence of economies of scale, for the domestic and foreign markets, considering the size (quantity produced) and other properties of firms [20,21,33,26,32,11,35,38]. Thus, for instance in a work of Krugman [33], a multi-market Cournot model with economies of scale was used to explain the successful performance of Japan as an exporting country at the beginning of the 1980s.

In theoretical terms, the multi-market oligopoly framework was revisited and generalized in the seminal paper by Bulow, Geanakoplos and Klemperer [22]. One of their main remarks is that the presence of a multi-store firm in a market may affect the position of the firm in other markets due to the existence of demand and/or supply spillovers. In the same line, Bernheim and Whinston, [12], show that with scale economies, the multi-market contact may produce “spheres of influence” [29], that occurs when each of the multi-market competing firms may be more efficient in some subset of these markets and less efficient in others (symmetric advantage) or when one firm is more efficient in all markets (absolute advantage). Despite these multi-market analysis, this literature has focused mainly on the demand side of the problem, not the supply side. Specifically, they refer to multi-market contact, when demands curves recognize substitution and complementarity of different products.

In terms of the analysis of the dynamics of the multi-market Cournot problem, we found only a few papers [51,6,7,40], focusing on different products and scope.

In this context, this research deals with the analysis of stability and chaos of multi-market competition in the presence of economies and diseconomies of scale, extending in this way the analysis of the dynamics of the oligopolistic competition. Thus, we model the main characteristics of the retail competition today, analyzing the dynamics and stability of this particular business system, and we compare these results with the stability analysis of traditional small business that cover the same demand, the classic formulations of Theocharis, Fisher and Puu.

The main hypothesis of the paper is that non-linear cost structures in multi-market setting are important sources of instability in the game outcome. Particularly, we study the stability of a multi-market Cournot–Nash equilibrium with global economies of scale, that is, the scale level that is related to the total production of firms, in all markets, as opposed to local economies of scale presented at each store individually or linear production structures. In this setting, the internal organization of a firm may affect its performances over the markets and the global equilibrium [10]. For example, multi-market firms that buy their products in a centralized manner, storing them in a distribution center, to be redistributed afterwards to their retailers store in all markets usually operate this way to obtain economies of scale in the process of buying and distribution. In this paper, we assume this type of centralized structure where companies takes advantage of their size, under economies of scale, that allow them to decrease their cost structure [49].

This paper is organized as follows: in Section 2, classical models of the dynamics of the Cournot problem are described. In Section 3, a Multi-market-Cournot problem is presented, considering interrelated cost structures and economies of scale. In Section 4, the study of the stability of the system is addressed and generalized for different numbers of market, competitors and level of economies of scale. In Section 5, the complex dynamics of the multi-market retail model is analyzed using numerical simulations. The numerical results of the dynamics are compared with those of the single-market classical models, using path graphics and bifurcation diagrams. Finally, the main conclusions for this work are presented.

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