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Dynamics of market structure driven by the degree of consumer's rationality☆

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ABSTRACT

We study a simple model of market share dynamics with boundedly rational consumers and firms interacting with each other. As the number of consumers is large, we employ a statistical description to represent firms' distribution of consumer share, which is characterized by a single parameter representing how rationally the mass of consumers pursue higher utility. As the boundedly rational firm does not know the shape of demand function it faces, it revises production and price so as to raise its profit with the aid of a simple reinforcement learning rule. Simulation results show that (1) three phases of market structure, i.e. the uniform share phase, the oligopolistic phase, and the monopolistic phase, appear depending upon how rational consumers are, and (2) in an oligopolistic phase, the market share distribution of firms follows Zipf's law and the growth-rate distribution of firms follows Gibrat's law, and (3) an oligopolistic phase is the best state of market in terms of consumers' utility but brings the minimum profit to the firms because of severe competition based on the moderate rationality of consumers.

1. Introduction

The main purpose of this article is to investigate the time evolution of the market structure in order to understand how oligopoly and monopoly spontaneously emerge from competition among firms. To this end, the framework of mainstream (i.e. neoclassical) microeconomics is of limited use for the reasons described below. Mainstream microeconomics claims that market structures can be classified into four categories: perfect competition, monopolistic competition, oligopoly and monopoly, according to the number of firms and the existence of product differentiation [1]. One extreme case is perfect competition, which is defined as the state of affairs where there is an indefinitely large number of firms and no product differentiation.[1] The other extreme case is monopoly, which is defined as the state of affairs where there is only one firm. Thus, perfect competition is on an equal footing with oligopoly and monopoly. As the term 'competition' here is prescribed mainly by largeness of the number of firms, it has a quite different meaning from what is used in economic actuality. Rather than being a *state of affairs*, competition in the business world is closely related to the *acts* of price cutting, product differentiation and so forth. The difference is not simply a matter of definition but rather, more seriously, that of

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[1] Perfect competition will be described in some more detail in Section 2.3.2.

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the theoretical structure of mainstream microeconomics. As Hayek points out in Ref. [2], competition ought to be defined as a dynamic process through which a certain state of affairs is brought about, and not to be defined as a state of affairs per se. Price competition, for example, may result in some firms being defeated and exiting the market. In consequence, a state of affairs emerges that the total market share of surviving firms is increased. From this point of view, we can say that the dynamical property of competition is ruled out in mainstream microeconomics by the underlying premises for static analysis of a particular state of affairs, i.e. an equilibrium. In this study, we investigate the dynamic process of a 'competitive market' and one of the focuses is on describing competition as a dynamic process and studying what kind of state of affairs emerges, i.e. how market structure changes, through competition. Note that a 'competitive market' here is defined as a market where firms compete for better business performances such as market shares. Neoclassical microeconomics defines 'competition' as the states where there is a large number of firms. On the contrary, we define it as the acts or processes in which firms do something against rivals along the lines of Hayek. By our definition, the number of firms does not matter. We need only two or more firms for competition to exist. In what follows, we focus on a competitive market where there are many firms and consumers as an initial state of market dynamics.

Another difficulty of mainstream microeconomics, which is closely related to the above, is that its paradigm is rigidly static and lacks the dynamical point of view in the true sense of the word. It supposes one-shot decision making by economic agents. Even if intertemporal decision making is considered, it is always assumed in order to ensure the rationality of agents in an uncertain world, that agents know all the future information certainly, that agents know the probability distribution of all the future states, or that agents know the true economic model and form rational expectations consistent with it. In other words, agents know the future states of the economy in advance, at least on an average. In this sense, it is obvious that the time structure collapses, which mainstream microeconomics premises. It deals with a world essentially without time and not with how a market economy evolves with the passing of time. Studying the evolutionary process of a market economy does not make sense unless the premises of mainstream microeconomics are loosened and agents are accepted as boundedly rational. In this study, we investigate the time evolution of a competitive market, transforming from an initial state with many boundedly rational firms, into an oligopolistic or monopolistic state.

From a dynamical point of view, a decentralized competitive market can be regarded as a typical complex system which consists of a large number of boundedly rational and adaptive agents interacting with each other. These micro-level local interactions give rise to a certain macro-level spontaneous order, and then, the macro-order plays the role of binding conditions for micro-behavior. For example, persons who watch and imitate others' apparel beget a fad, and then get carried away by the fad itself. Complex dynamical behavior emerges as a consequence of recurrent causal chains between individual behavior and the macro-order. This complex two-way feedback between microstructure and macrostructure has been recognized for a very long time, at least since the time of Adam Smith. Nevertheless, until recently, not only economics but also other branches of science have lacked the means to model this feedback structure qualitatively in its full dynamical complexity. Researchers are now able to model, with the aid of high-performance computers, a wide variety of complex phenomena in a decentralized market economy, such as business cycles, endogenous trade network formation, market share fluctuations, and the open-ended coevolution of individual behavior and economic institutions. One branch of this research direction has come to be known as agent-based computational economics, i.e. computer-aided studies of the economy modeled as an evolving system of autonomous interacting agents (see, e.g. [3,4]).

In this study, we model a competitive market as a complex adaptive system consisting of mutually interacting, boundedly rational firms and consumers [5,6]. Special attention is paid to market share dynamics, in common with Ref. [7] where product differentiation exists and consumer's brand loyalty plays an important role for emerging oligopoly. In this article, however, it is assumed that a consumer decides from which firm to purchase goods so as to increase his utility, and we employ, as a first step, a statistical description because the number of consumers is large. Aggregate consumer behavior is described by the Boltzmann distribution which is characterized by the 'inverse temperature' indicating how rationally the consumer seeks to increase his utility. A firm, on the other hand, revises production decision and price so as to raise its profit with the aid of a reinforcement learning algorithm, i.e. by learning through experience. We mainly focus on the dynamical phases which emerge as the rationality of consumers changes, and characterize their statistical properties such as the probability distribution of firms' size and growth rates.

The remainder of the article is organized as follows. In Section 2, we present our model and demonstrate that it includes neoclassical competitive equilibria (Cournot equilibrium and perfectly competitive equilibrium) as special stationary states. In Section 3, we discuss simulation results. Firstly, an artificial monopoly case is examined in order to verify that the learning process is workable in the model. Secondly, time evolution of the competitive model is examined and it is demonstrated that all firms come to face approximately the same demand curves through a learning process. Thirdly, it is demonstrated that our model exhibits three phases, i.e. the uniform share phase, the oligopolistic phase, and the monopolistic phase depending upon a key parameter β_1 which represents the degree of consumer's rationality. Fourthly, market structure dynamics is characterized from various aspects, i.e. Herfindahl index, variances, probability distributions, and averaged utility and profit. Section 4 concludes the article.

2. Model

Our model consists of many consumers and many firms that are boundedly rational in the sense that they attempt to increase their utility and profit subject to information constraint and, hence, through a learning process. Consumers and