

# Adaptive learning models of consumer behavior

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## Abstract

In a model of dynamic duopoly, optimal price policies are characterized assuming consumers learn adaptively about the relative quality of the two products. A contrast is made between belief-based and reinforcement learning. Under reinforcement learning, consumers can become locked into the habit of purchasing inferior goods. Such lock-in permits the existence of multiple history-dependent asymmetric steady states in which one firm dominates. In contrast, belief-based learning rules must lead asymptotically to correct beliefs about the relative quality of the two brands and so in this case there is a unique steady state. © 2007 Elsevier B.V. All rights reserved.

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## 1. Introduction

Adaptive learning models attempt to describe the behavior of agents faced with repeated decision problems by assuming they use simple learning rules. These models are used in a number of apparently disparate environments. Economic theorists have analyzed them in abstract settings.<sup>1</sup> They have been fitted to actual choice data both in economic experiments and the quite different

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<sup>1</sup> Theoretical papers in this field include Arthur (1993), Rustichini (1999), Börgers and Sarin (2000), Sarin and Vahid (1999) and Börgers et al. (2004). A survey of the use of adaptive learning models in games can be found in Fudenberg and Levine (1998).

context of the empirical analysis of consumer behavior.<sup>2</sup> Despite differences in aims and terminology, some models of dynamic choice found in empirical marketing analysis are essentially the same as those used in economic theory. This research in marketing supports the experimental evidence that even simple adaptive learning models can help to explain human behavior. In the context of econometric work on experimental data, there has been an active debate as to whether the more sophisticated belief-based models or very simple reinforcement learning models offer the better fit. Up to now, this has been of interest because it throws light upon human reasoning processes. However, if the same question is considered in the context of consumer choice, there may be significant practical implications to consider as well.

This paper investigates the hypothesis that whether consumer behavior is best described by belief-based or reinforcement learning may have a significant impact on market organization. In particular, we examine a model of dynamic duopoly where consumers learn about the relative quality of the two different brands. The product is an experience good and so information is partial: consumers only learn the payoff to the good they actually consume. First, we investigate a reinforcement type learning model where more familiar products have a greater probability of being selected. Consequently, consumers can become locked into inferior choices. Such lock-in permits the existence of multiple history-dependent steady states. When multiple steady states exist, even if the two firms are identical in terms of costs and product quality, the symmetric outcome is unstable: one firm must dominate. This outcome under reinforcement learning is then contrasted with the outcome under belief-based learning. This form of learning leads to correct beliefs about relative quality even under partial information. Firms can influence consumer opinion only in the short run: if consumers' initial estimate of a firm's quality is high (low), it has an incentive to charge above (below) the myopic price in order to slow (speed up) learning. Given the convergence of beliefs to the unique correct outcome, the firms must converge to a unique steady state where prices are the same as under complete information. This paper, therefore, shows that the small differences in the learning rules, between belief-based and reinforcement learning, can have dramatic effects on market outcomes.

The situation to be modelled can be thought of as a consumer going on a regular basis to a supermarket to buy a grocery item and choosing between two competing brands. This type of decision has several aspects which I would like to emphasize. First, the prices for the competing brands are usually clearly marked on the shelves. Thus, the learning the consumer has to undertake is not about prices or their distribution. However, the goods in question are typically experience goods. One has to take them home and consume them before their quality is known. Second, quality in this context is very often subjective and imprecise, for example, whether a food product tastes good. Third, because each successive purchase decision is relatively unimportant to an individual consumer, a model of boundedly rational behavior may explain actual choices well. Such boundedly rational agents may have an impression of quality that is ambiguous and difficult to measure against past experience. As a consequence, it may be very difficult to be confident about *relative* quality. For example, I think I like the brand I bought today, but is it clearly better than the one I bought last month? Indeed, in this paper it is assumed that the consumption experience is noisy and memory is imperfect.

The formal model of price competition analyzed here is derived from that of Chintagunta and Rao (1996), who similarly consider a dynamic duopoly with adaptive consumers. Their

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<sup>2</sup> Empirical work includes Erev and Roth (1998), Camerer and Ho (1999), Erev and Barron (2005) and Blume et al. (2002). Examples of work in marketing are Chintagunta and Rao (1996), Seetharaman and Chintagunta (1998) and Ho and Chong (1999).

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