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Maximum likelihood estimation of search costs

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Abstract

In a recent paper Hong and Shum [2006. Using price distributions to estimate search costs. Rand Journal of Economics 37, 257–275] present a structural method to estimate search cost distributions. We extend their approach to the case of oligopoly and present a new maximum likelihood method to estimate search costs. We apply our method to a data set of online prices for different computer memory chips. The estimates suggest that the consumer population can be roughly split into two groups which either have quite high or quite low search costs. Search frictions confer a significant amount of market power to the firms: Despite more than 20 firms operating in each of the markets, we estimate price-cost margins to be around 25%. The paper also illustrates how the structural method can be employed to simulate the effects of the introduction of a sales tax.

JEL classification: C14; D43; D83; L13

Keywords: Consumer search; Oligopoly; Price dispersion; Structural estimation; Maximum likelihood

1. Introduction

There is substantial evidence that the prices of seemingly homogeneous consumer goods are quite dispersed (see e.g. Stigler, 1961; Dahlby and West, 1986; Pratt et al., 1979; Sorensen, 2000; Brown and Goolsbee, 2002; Lach, 2002; Baye et al., 2004). During the last 25 years, economists have dedicated a significant theoretical effort to explain this empirical

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regularity as an equilibrium phenomenon. One of the findings is that price dispersion can be sustained in equilibrium when some consumers observe several prices while other consumers observe only one price. Such unequal distribution of price information across consumers often arises in the market as a result of costly search (see e.g. Varian, 1980; Burdett and Judd, 1983; Rob, 1985; Stahl, 1989).

In spite of the considerable theoretical effort, somewhat surprisingly, very little empirical work has focused on identifying and measuring search costs in real-world markets. From an applied point of view, this is certainly an omission because predictions and policy recommendations from the various theoretical models are often sensitive to the magnitude of search costs.[1]

In a recent paper, Hong and Shum (2006) present structural methods to retrieve information on search costs in markets for homogeneous goods. They show that firm and consumer equilibrium behavior imposes enough structure on the data to allow for the estimation of search costs using only observed prices. Hortaçsu and Syverson (2004) show that when price and quantity data are available, these methods can be extended to richer settings where price variation is not only caused by search frictions but also by quality differences across products.[2]

The non-sequential search model studied by Hong and Shum (2006) generalizes Burdett and Judd's (1983) seminal paper by introducing search cost heterogeneity. They consider a market operated by a continuum of firms which compete by setting prices. Consumers, who have heterogeneous search costs, engage in search to discover prices. Once a consumer has observed the desired number of prices, he/she buys from the cheapest firm in his/her sample. In equilibrium, only a fraction of consumers compare the prices of various firms which leads to price dispersion. Hong and Shum formulate the estimation of the unknown search cost distribution as a two-step procedure. They first estimate the parameters of the equilibrium price distribution by *maximum empirical likelihood* (MEL). To do this, they derive a (potentially infinitely large) number of moment conditions from the equations that describe the equilibrium. The estimates of the parameters of the cumulative distribution function (cdf) of prices give the height of the search cost distribution evaluated at a series of cutoff points. In the second step, these cutoff points are estimated directly from the empirical cdf of prices. While innovative, this method is limited by the ability to solve a computationally demanding high-dimensional optimization problem. Indeed, in practice, only a few parameters of the price distribution can be estimated which can result in the introduction of biases into the estimates.[3]

In this paper we present an alternative strategy to estimate an oligopoly version of the non-sequential search model of Burdett and Judd (1983) by using *maximum likelihood* (ML). We first estimate the parameters of the price distribution by ML. To do this,

[1]See e.g. Janssen and Moraga-González (2004) for the influence of the magnitude of search costs on equilibrium search intensity and market competitiveness.

[2]There is a well-established literature in labor economics that structurally estimates models of job search. Key contributions in this literature are Eckstein and Wolpin (1990) and Van den Berg and Ridder (1998). This literature, recently surveyed in Eckstein and Van den Berg (2007), has studied, among other issues, wage dispersion, duration of unemployment, minimum wage policies, returns to schooling and earnings inequality. The empirical work using models where search efforts are endogenous is however relatively small. For a first attempt to estimate search cost distributions in labor markets see Gautier et al. (2007).

[3]For example, in the empirical examples presented in Hong and Shum (2006) low search cost consumers are ignored because the number of searches a consumer can make is (artificially, by the econometrician) limited.