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&= X_i \beta_{ij} + Z_j \gamma_i + \nu_{ij} && \beta_{ij} \sim N\left(\bar{\beta}_j, \sigma_\beta^2 \right),\ \gamma_i \sim N\left(\bar{\gamma}, \sigma_\gamma^2 \right)
\end{aligned}
$$

Parametric identification: assume mixing distribution shape, estimate parameters

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But this just pushes problem back one level...

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How can we know if choice variation comes from η_i or ν_{ij} part of preferences?

Cross-sectional data: impossible to separate

Person A chooses different alternative than Person B

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$\Rightarrow$ Different tastes? Or different random shocks?

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Person A chooses different alternative than Person B

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Single observation per person provides no way to distinguish

Panel data solution: same person, multiple choice situations

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Persistent patterns across periods $\Rightarrow$ permanent tastes (δ_i, ϕ_i)

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Key assumption: tastes δ_i, ϕ_i stable across choice instances for each person

Identification logic:

Person consistently chooses similar alternatives across T situations

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$\Rightarrow$ Reveals their δ_i, ϕ_i (permanent taste parameters)

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$T \rightarrow \infty \Rightarrow$ can perfectly identify each person's δ_i, ϕ_i

Different types of variation can identify taste heterogeneity:

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AUTOMOBILE PRICES IN MARKET EQUILIBRIUM

BY STEVEN BERRY, JAMES LEVINSOHN, AND ARIEL PAKES[1]

This paper develops techniques for empirically analyzing demand and supply in differentiated products markets and then applies these techniques to analyze equilibrium in the U.S. automobile industry. Our primary goal is to present a framework which enables one to obtain estimates of demand and cost parameters for a class of oligopolistic differentiated products markets. These estimates can be obtained using only widely available product-level and aggregate consumer-level data, and they are consistent with a structural model of equilibrium in an oligopolistic industry. When we apply the techniques developed here to the U.S. automobile market, we obtain cost and demand parameters for (essentially) all models marketed over a twenty year period.

KEYWORDS: Demand and supply, differentiated products, discrete choice, aggregation, simultaneity, automobiles.

1. INTRODUCTION

THIS PAPER DEVELOPS TECHNIQUES for empirically analyzing demand and supply in differentiated products markets and then applies these techniques to analyze equilibrium in the U.S. automobile industry. Our primary goal is to present a framework that enables one to obtain estimates of demand and cost parameters for a class of oligopolistic differentiated products markets. Estimates from our framework can be obtained using only widely available product-level and aggregate consumer-level data, and they are consistent with a structural model of equilibrium in an oligopolistic industry. When we apply the techniques developed here to the U.S. automobile market, we obtain cost and demand parameters for (essentially) all models marketed over a twenty year period. On the cost side, we estimate cost as a function of product characteristics. On the demand side, we estimate own- and cross-price elasticities as well as elasticities of demand with respect to vehicle attributes (such as weight or fuel efficiency). These elasticities, together with the cost-side parameters, play central roles in the analysis of many policy and descriptive issues (see, e.g., Pakes, Berry, and Levinsohn (1993) and Berry and Pakes (1993)).

Our general approach posits a distribution of consumer preferences over products. These preferences are then explicitly aggregated into a market-level demand system that, in turn, is combined with an assumption on cost functions and on pricing behavior to generate equilibrium prices and quantities. The

[1] We would like to thank Don Andrews, Tim Bresnahan, Gary Chamberlain, Zvi Griliches, Jerry Hausman, G. Mustafa Mohatarem, Whitney Newey, Frank Wolak, and the Economic Analysis group at the General Motors Corporation, as well as referees and a Co-Editor of this journal, for helpful comments. While working on this paper, Berry was an Olin Fellow at the NBER and Levinsohn was a National Fellow at the Hoover Institution, Stanford University. Each thanks his respective host. We gratefully acknowledge funding from National Science Foundation Grants SES-8821722 (to Richard Ericson and Ariel Pakes) and SES-9122672. Readers wishing a more extensive discussion of several issues in this paper are referred to our NBER working paper of the same title.

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Key insight: Many ways of leveraging variation to separate δ_i, ϕ_i from ν_{ij}