Quantifying the Benefits of New Products: The Case of the Minivan

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This paper proposes a technique for obtaining more precise estimates of demand and supply curves when one is constrained to market-level data. The technique allows one to augment market share data with information relating consumer demographics to the characteristics of the products they purchase. This extra information plays the same role as consumer-level data, allowing estimated substitution patterns and (thus) welfare to directly reflect demographic-driven differences in tastes for observed characteristics. I apply the technique to the automobile market, estimating the economic effects of the introduction of the minivan. I show that models estimated without micro data yield much larger welfare numbers than the model using them, primarily because the micro data appear to free the model from a heavy dependence on the idiosyncratic logit “taste” error. I complete the welfare picture by measuring the extent of first-mover advantage and profit cannibalization both initially by the innovator and later by the imitators. My results support a story in which large improvements in consumers’ standard of living arise from competition as firms cannibalize each other’s profits by seeking new goods that give them some temporary market power.

I. Introduction

Consumers benefit from a greater breadth of choice in both the kind and quality of products over time. Firms are the driving force behind

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these improvements, usually seeking the transitory market power associated with being the first mover. This source of economic growth can be seen in products ranging from automobiles and consumer electronics to health care.[1]

In this paper I estimate the change in consumer welfare from the introduction of the minivan. I also infer the changes in producer surplus, measuring the extent of first-mover advantage and the profit cannibalization that took place both initially by the innovator and later by the imitators. My results suggest that the introduction generated large welfare gains for consumers and surplus for the innovator at the expense of the other producers.

I follow the random coefficients discrete choice approach taken in Berry et al. (1995), which allows substitution patterns to reflect consumer-level heterogeneity in tastes for observed product characteristics.[2] Modeling this heterogeneity is important when estimating demand elasticities, although the estimates tend to be imprecise when constrained to market-level data. Goldberg (1995) and Berry et al. (1998) utilize consumer-level data to improve these estimates.

I offer an alternative approach when consumer-level data are not available: augment the market-level data on sales and characteristics with information that relates the *average* demographics of consumers to the characteristics of the products they purchase. The extra information plays the same role as consumer-level data, allowing estimated substitution patterns and (thus) welfare to directly reflect demographic-driven differences in tastes for observed characteristics. For example, observing average family size conditional on the purchase of a minivan and asking the model to reproduce this same average helps to more precisely identify the taste term relating families and minivans. Similarly, matching probabilities of purchase conditioned on different income levels helps to identify income effects. Since this approach requires only a modification of the Berry et al. (1995) objective function, it adds no real computational burden to their method.

This approach can be useful for any market in which information on purchaser aggregates is available. In the minivan case, I add information

[1] Welfare consequences of introductions of new products have recently received increased attention from economists (in particular, see Bresnahan and Gordon [1997]). Papers focusing on buyer benefits from new products cover a range of goods, including automobiles (Feenstra 1988; Berry, Levinsohn, and Pakes 1993; Fershtman and Gandal 1998), computers (Bresnahan 1986; Greenstein 1994), health care technology (Trajtenberg 1989), breakfast cereals (Hausman 1997*a*), telecommunications services (Hausman 1997*b*), and cellular phones (Hausman 1999). New products have also been the focus of economists' attempts at revising the consumer price index (CPI), in part because of findings by Armknecht (1984) that changes in the index are mostly due to price inflation that accounts for new products and quality changes in existing products.

[2] Characteristics-based models were introduced by Gorman-Lancaster and developed econometrically in McFadden (1981).

on purchasers of new vehicles from the Consumer Expenditure Survey (CEX). I estimate four different demand-side specifications and find that the models without the micro data yield welfare estimates that are much larger than the model with them. I also find that *only* the welfare estimates implied by the micro data are free from a heavy dependence on the idiosyncratic logit "taste" error.

The paper is organized as follows. Section II provides a brief history of the introduction of the minivan. Section III reviews recent advances in discrete choice estimation. Section IV outlines the utility specification and Section V discusses the supply side. The different sources of data are covered in Section VI, and the estimation procedure is outlined in Section VII. Sections VIII and IX report results and conclusions.

II. The Minivan Innovation

In the early 1970s Ford proposed the "Mini/Max," an alternative to the family station wagons and full-size vans of the day. This functional box-like vehicle provided much of its interior space through its height instead of its length or width, and it came equipped with front wheel drive, which permitted the floor of the passenger compartment to be lowered, adding more interior space, making entry easier, and allowing passengers more movement inside the vehicle. The "Mini/Max" idea received little support from Ford management, who raised concerns about cannibalizing their strong station wagon sales.[3]

Introduced in 1984 by the financially troubled Chrysler Corporation, the Dodge Caravan (its minivan) was an immediate success, with sales of 170,000 in its debut year. General Motors (GM) and Ford quickly responded, introducing their own versions of minivans in 1985 (GM Astro/Safari) and 1986 (Ford Aerostar). However, they were unprepared for the Caravan's success and were forced to build their minivans on truck platforms with rear wheel drive, resulting in minivans that handled more like downsized full-size vans than passenger cars.

Chrysler continued to dominate this market niche over time, in part by adding popular features such as a larger engine and a second sliding door. Fourteen years after the introduction, with six firms marketing a total of 13 different minivans, Chrysler captured 44 percent of this market, in which 1.16 million minivans were sold. Over the same time period, Ford and GM watched as both their own and Chrysler's minivans cannibalized station wagon sales; after peaking at 950,000 in 1984, wagon sales fell to 300,000 over the next seven years.

[3] Much of the discussion in this section comes from Yates (1996) and from industry publications.

III. Estimating Discrete Choice Demands

A. *Overview*

Discrete choice models start with conditional indirect utility, $u_{ij}(\boldsymbol{\theta})$, given as a function of observed and unobserved product j and consumer i characteristics and model parameters $\boldsymbol{\theta}$, and often written as

$$u_{ij}(\boldsymbol{\theta}) = \delta_j(\boldsymbol{\theta}) + \mu_{ij}(\boldsymbol{\theta}) + \epsilon_{ij}.$$

The first component, $\delta_j(\boldsymbol{\theta})$, is a product-specific term common to all consumers. The $\mu_{ij}(\boldsymbol{\theta})$ term captures heterogeneity in consumer tastes for observed product characteristics. The term ϵ_{ij} is a "love of variety" taste term that is assumed to be independent and identically distributed across both products and consumers. Consumer i is assumed to choose the product j that yields maximal utility, and market shares obtain from aggregating over consumers.

The utility component common to all consumers, δ_j, is usually given as

$$\delta_j = -\alpha p_j + \mathbf{X}_j\boldsymbol{\beta} + \xi_j,$$

where α is the marginal utility of income; $\mathbf{X}_j$ and $\boldsymbol{\beta}$ are, respectively, vectors of observed product characteristics and the taste parameters associated with those characteristics; and ξ_j represents utility derived from characteristics observed by consumers and producers but not observed by the econometrician. If these omitted characteristics are positively correlated with price, estimates of the price sensitivity term α will be biased toward zero (see, e.g., Trajtenberg 1989). Instrumental variable methods are the usual solution, although their application is frustrated by the fact that both the p_j and ξ_j enter the market share equation in a nonlinear way. Berry (1994) provides an important advance, developing a method that makes instrumental variables applicable to a large class of these models.

Berry et al. (1995) show that allowing substitution patterns to reflect heterogeneity in consumer tastes for observed product characteristics (i.e., $\mu_{ij}(\boldsymbol{\theta}) \neq 0$) is important when estimating demand elasticities.[4] The usual approach is to assume that these tastes come from some distribution (e.g., multivariate normal). Precise estimates of this distribution's parameters obtain when good information on how consumers substitute

[4] When taste heterogeneity for observed product characteristics is ruled out, the only consumer heterogeneity arises from the independent and identically distributed ϵ_{ij}'s. In terms of substitution patterns, the implication is that all consumers share the same expected ranking over the products (that given by the δ_j's). Thus any consumer facing a price increase in her first choice that induces substitution is always most likely to substitute to vehicles that are, on average, most popular, regardless of the characteristics of her first choice.

is observed. Market-level data may not provide much variation along these dimensions.[5] Goldberg (1995) and Berry et al. (1998) use consumer-level data to overcome this problem.

B. *Identifying Taste Heterogeneity Using Aggregate Data*

When consumer-level data are not available, an alternative is to add to the market-level data information that relates the *average* demographics of consumers to the characteristics of the products they purchase. The extra information plays the same role as consumer-level data, allowing estimated substitution patterns to reflect demographic-driven differences in tastes for product characteristics.

The approach adds the relevant omitted demographics and their associated parameters to the model. For a given set of parameter values and household demographics, the model yields predictions of individual household behavior. The implied market-level averages obtain when the model and the distribution of household-level demographics in the market are used (by averaging over households). I include the difference between the observed market-level averages and the model predictions for them as new moments in the objective function. These moments improve precision by providing a penalty for parameter values with model predictions that are different from the data.

In this paper I match the model predictions to some averages describing new vehicle purchasers obtained from the CEX. In particular, I match the model's probability of new vehicle purchase for different income groups to the observed conditional purchase probabilities from the CEX. I also match model predictions for average household characteristics (such as family size) for purchasers of different vehicles to those in the CEX data. Substitution patterns and (thus) welfare numbers may then better reflect income effects or differences in tastes for minivans and station wagons that derive from differences in family size.

[5] The identification obtains in part from observing variation in choice sets. Consider a market with three cars that differ only in the amount of their interior space, with two cars having lots of interior space relative to the third and each car obtaining a market share of one-third. Suppose that in a second market (in the following year or in a different geographic region), one of the vehicles with lots of interior space is no longer available. If the remaining vehicle with lots of interior space obtains two-thirds of the market, then its consumers appear to substitute on the basis of interior space, suggesting that they have a strong taste for this characteristic. Furthermore, they disagree with the consumers purchasing the car with limited interior space, suggesting that heterogeneity in tastes for interior space exists. However, if the two remaining vehicles split the market share, there is no evidence of heterogeneity in taste (consumers appear to randomly sort between the two available alternatives).

IV. The Utility Specification

I tailor the utility specification to approximate substitution patterns among family vehicles. The utility function has consumer i choosing the good j that maximizes

$$u_{ij} = \alpha_i \ln (y_i - p_j) + \mathbf{X}_j \boldsymbol{\beta} + \sum_k \gamma_k \nu_{ik} x_{jk} + \xi_j + \epsilon_{ij},$$

where $\mathbf{X}_j$, $\boldsymbol{\beta}$, ξ_j, and ϵ_{ij} are as described in Section III, and $x_{jk} \in \mathbf{X}_j$. Utility from the composite commodity good is given by $\alpha_i \ln (y_i - p_j)$. I allow the marginal utility of income to vary according to income groups:

$$\alpha_i = \begin{cases} \alpha_0 & \text{if } y_i \leq \bar{y}_1 \\ \alpha_1 & \text{if } \bar{y}_1 \leq y_i < \bar{y}_2 \\ \alpha_2 & \text{if } y_i \geq \bar{y}_2, \end{cases}$$

where $\bar{y}_1$ and $\bar{y}_2$ divide the U.S. population into three equally sized groups ordered by income. The kth characteristic of vehicle j is given by x_{jk}, for $k = 1, \ldots, K$. Each consumer i has K idiosyncratic tastes for the K observed characteristics, $\nu_i = (\nu_{i1}, \ldots, \nu_{iK})$. The consumer-specific ν_{ik} are interacted with γ_k, a parameter measuring the heterogeneity in tastes for the observed characteristics in the population. This yields γ_{ik}, consumer i's personal taste for characteristic k, $\gamma_{ik} = \gamma_k \nu_{ik}$.

I allow the γ_{ik}'s associated with minivans, station wagons, full-size passenger vans, and sport-utility vehicles to depend on demographics. Specifically, if fs_i is the family size of household i and, for example, mi and sw subscripts denote minivan and station wagon, consumer i's tastes are

$$\gamma_{i,mi} = \gamma_{mi} \ln (fs_i) \nu_{i,fv},$$

$$\gamma_{i,sw} = \gamma_{sw} \ln (fs_i) \nu_{i,fv},$$

where $\nu_{i,fv}$ is a common idiosyncratic taste i has for family vehicles (independent of demographics) and $\ln (fs_i) \nu_{i,fv}$ is the full demographic-dependent taste term. The parameter γ_{mi} (γ_{sw}) is a taste shifter that allows families of different sizes to value minivans (station wagons) differently. With this parameterization, the covariance between taste for minivans and taste for station wagons is increasing in γ_{mi} and γ_{sw}. Thus patterns of substitution between family vehicles can emerge for two reasons: larger families prefer these vehicles, or the vehicles share other similar observed characteristics.

After integration over ϵ_{ij}, which is assumed to have a type 1 extreme value distribution, the probability household i purchases good j is given by

$$\Pr(j|\mathbf{X},\ i) = \frac{\exp[\alpha_i \ln(y_i - p_j) + \mathbf{X}_j\boldsymbol{\beta} + \sum_k \gamma_k \nu_{ik} x_{jk} + \xi_j]}{\sum_l \exp[\alpha_i \ln(y_i - p_l) + \mathbf{X}_l\boldsymbol{\beta} + \sum_k \gamma_k \nu_{ik} x_{lk} + \xi_l]}.$$

Aggregate demand s_j obtains from integration over i, which indexes demographics and the vector of unobserved tastes. For demographics I use the empirical distribution function from the CEX to approximate the demographics of U.S. households. I use K independent $\chi^2(3)$ distributions truncated at 95 percent to approximate the distribution of unobserved consumer tastes for two reasons: these distributions are bounded above and below, and they imply that taste heterogeneity in the population is skewed in the direction of positive taste.

V. The Supply Side

I use the supply-side approach from Berry et al. (1995) to approximate competition in the new vehicle market. There are F multiproduct firms competing in a Bertrand-Nash fashion; given their products and the prices and attributes of competing products, firms choose prices to maximize profits. Each firm f produces some subset J_f of the J total products. Firms have a marginal cost function that is log-linear in a vector of k' cost characteristics. Similarly to the demand side, the cost characteristics are separated into an observed and an unobserved component. The vector $\mathbf{W}_j$ represents the observed component and ω_j the unobserved component. Given these assumptions, the (log) marginal cost function can be written

$$\ln(mc_j) = \mathbf{W}_j\boldsymbol{\tau} + \omega_j, \tag{1}$$

where $\boldsymbol{\tau}$ is the vector of cost parameters, and an estimate of mc_j obtains from the demand-side model and the equilibrium notion in a manner I now describe.

Each firm has a profit function

$$\Pi_f = M \sum_{j \in J_f} (p_j - mc_j) s_j(\mathbf{p}, \mathbf{X};\ \boldsymbol{\theta}),$$

where M is the number of households in the United States, $s_j(\cdot)$ is good

j's predicted market share, and $q_j(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta}) = Ms_j(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta})$.[6] The J first-order conditions for static price competition are given by

$$s_j(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta}) + \sum_{r \in J_f} (p_r - mc_r) \frac{\partial s_r(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta})}{\partial p_j} = 0, \tag{2}$$

for $j = 1, \ldots, J$. This system of equations can be inverted to solve for the marginal costs that enter (1), or

$$\mathbf{mc} = \mathbf{p} - \Delta(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta})^{-1} s(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta}), \tag{3}$$

where $\Delta(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta})$ is the appropriately defined matrix of own- and cross-price share derivatives that has as elements $\partial s_r(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta})/\partial p_j$, and $\mathbf{mc}$, $\mathbf{p}$, and $s(\mathbf{p}, \mathbf{X}; \boldsymbol{\theta})$ are, respectively, the vectors of marginal costs, prices, and market shares.

I also use (2) to solve for new equilibrium price vectors under different counterfactuals. A new equilibrium price vector $\mathbf{p}_{cf}$ that obtains under a counterfactual choice set (e.g., one without minivans) solves (2) for the choice set. The new price vector $\mathbf{p}_{cf}$ is used to compute the change in variable profits under the counterfactual for each firm f, or $\Pi_f(\mathbf{p}_{cf}, \mathbf{mc}; \boldsymbol{\theta}) - \Pi_f(p_0, \mathbf{mc}; \boldsymbol{\theta})$, where p_0 is the initial set of prices. Then $\sum_f [\Pi_f(\mathbf{p}_{cf}, \mathbf{mc}; \boldsymbol{\theta}) - \Pi_f(p_0, \mathbf{mc}; \boldsymbol{\theta})]$ gives the total change in producer profits.

VI. Data

I use two data sets. One contains market-level information on new vehicles and the second contains information on purchasers of new vehicles.

The new vehicle data set includes all 2,407 nameplates marketed in the United States from the years 1981 to 1993 with sales over 1,000 vehicles. It is a combination of information from *Automotive News Market Data Book* and *Ward's Automotive Yearbook:* most information on passenger cars came from the former, and the latter provided information on station wagons, minivans, sport-utility vehicles, and full-size passenger vans.[7] Vehicle characteristics include a measure of acceleration (horsepower/curb weight), vehicle dimensions, drive type, fuel efficiency, and a measure of luxury (air conditioning standard). Quantity sold and list price are linked to the characteristics of the base model to produce a

[6] This profit function ignores the 25 percent tariff levied against Japanese minivans during the 1980s. While it is possible to incorporate this tariff into the model, I do not add this complication because Japanese minivans make up a very small part of total minivan sales.

[7] My thanks to Berry et al. for providing me with the data on passenger cars and to Rob Feenstra for data on prices and quantities sold for many of the early 1980s full-size vans and sport-utilities.

vehicle-year observation. Econometrically, nameplate-year observations that lie in adjacent years and do not change horsepower, wheelbase, width, or length by more than 10 percent are treated as the same model. Given this definition, there are 916 independent observations.

Consumer information comes from the CEX, a rotating panel that records U.S. household purchasing patterns. I use the years 1987–92, which include almost 30,000 observations on U.S. households, to approximate the empirical distribution function of demographics in the United States.

I also use the CEX automobile supplement, which allows me to link demographics of purchasers of new vehicles to the vehicles they purchase. I observe 2,660 new vehicle purchases in the supplement over this six-year period. I use these purchases to estimate the probabilities of new vehicle purchases for different income groups.[8] The survey also allows me to identify the subset of purchasers for vehicles of principal interest to my questions, including purchasers of minivans, station wagons, sport-utility vehicles, and full-size vans. The sample sizes are limited: I observe 120, 63, 131, and 23 observations, respectively. However, this does provide me with reasonably precise estimates of average family size and age of head of household for purchasers of each of these vehicle types.[9]

VII. Estimation

My estimation strategy closely resembles the generalized method of moments (GMM) approach taken by Berry et al. (1995), except that I supplement their moments with a new set of micro moments.

A. *The Micro Moments*

The idea for using these additional moments derives from Imbens and Lancaster (1994). They suggest that aggregate data may contain useful information on the average of micro variables. In my case, the CEX automobile supplement provides information on aggregates of pur-

[8] While there are about 200 different kinds of vehicles marketed annually, only 400 new vehicle purchases are reported annually, frustrating efforts to use the micro data directly. See Goldberg (1995) for a more complete discussion of these data.

[9] I also use some annual information from other sources. The number of households (M) in the United States comes from the *Statistical Abstract of the United States,* as well as prices for a gallon of unleaded gas in the 1990s. Gasoline prices in the 1980s are taken from the U.S. Department of Commerce's *Business Statistics.* Figures on gross national product are drawn from the *Economic Report of the President.* Finally, the lognormal parameters of the distribution of income in the United States were estimated using data from the annual March Current Population Surveys (used for the random coefficients approach with just aggregate data).

chasers of new cars. The GMM estimation routine essentially chooses the parameter estimates to match (in part) the average model predictions to the observed averages from the CEX outcomes.

I use three sets of additional moments. The first matches average probability of new vehicle purchase conditional on income level. These moments are given by

$$E[\{i \text{ purchases new vehicle}\}|\{y_i < \bar{y}_1\}],$$

$$E[\{i \text{ purchases new vehicle}\}|\{\bar{y}_1 \leq y_i < \bar{y}_2\}],$$

$$E[\{i \text{ purchases new vehicle}\}|\{y_i \geq \bar{y}_2\}],$$

where $\{i$ purchases new vehicle$\}$ is the event that consumer i purchases a new vehicle, and $\{y_i < \bar{y}_1\}$, $\{\bar{y}_1 \leq y_i < \bar{y}_2\}$, and $\{y_i \geq \bar{y}_2\}$ are, respectively, the events that consumer i is in the low-, middle-, and high-income group. I also match the model predicted averages to those observed in the CEX for the moments:

$$E[fs_i|\{i \text{ purchases a minivan}\}],$$

$$E[fs_i|\{i \text{ purchases a station wagon}\}],$$

$$E[fs_i|\{i \text{ purchases a sport-utility}\}],$$

$$E[fs_i|\{i \text{ purchases a full-size van}\}],$$

the average family size of purchasers of minivans, station wagons, sport-utilities, and full-size vans, respectively. Finally, I include four moments that match the probability the head of the household is between ages 30 and 60 for each of these four family vehicle groups.

B. *The Berry et al. Moments*

One might describe the Berry et al. approach as using two different sets of moments. The first set of moments matches the model's share predictions, $s_j(\boldsymbol{\delta}(\boldsymbol{\theta}), \boldsymbol{\theta})$, to those in the data, s_j, or

$$s_j(\boldsymbol{\delta}(\boldsymbol{\theta}), \boldsymbol{\theta}) - s_j = 0, \quad j = 0, 1, \ldots, J.$$

This moment matching is equivalent to solving for the vector $\boldsymbol{\delta}(\boldsymbol{\theta})$ of product dummy variables that matches the predicted to the observed market shares, which Berry (1994) shows exists and is unique under mild regularity conditions on the distribution of consumer tastes.

The second set of moments relates to the market-level disturbances $(\xi_j(\boldsymbol{\theta}), \omega_j(\boldsymbol{\theta}))$. Except for price, the unobserved demand and supply disturbances for any vehicle j are assumed to be uncorrelated with observed demand- and cost-side variables of all vehicles in that year, or

$$E[\xi_j(\boldsymbol{\theta}_0)|(\mathbf{X},\ \mathbf{W})] = E[\omega_j(\boldsymbol{\theta}_0)|(\mathbf{X},\ \mathbf{W})] = 0.$$

I follow Berry et al.'s approximation to the optimal instruments. Product l's characteristics are valid instruments for themselves. For prices, two sets of instruments are available. The first set are cost-side variables that are excluded from the demand equation. The second set derive from the equilibrium first-order conditions from (2), where firm f's choice of its product l's price is determined by its proximity in characteristics space to competing products and to its own-firm products. In any year, a first-order approximation to the optimal instruments is given by the sum of the characteristic k across other own-firm products, or $\sum_{j\neq l, j\in J_f} x_{jk}$, and the sum of the characteristic across competing firms, or $\sum_{j\notin J_f} x_{jk}$.[10]

C. *The Objective Function*

The two sets of moments that enter the GMM objective function are $\mathbf{G}_1(\boldsymbol{\theta})$, the Berry et al.–like moments, and $\mathbf{G}_2(\boldsymbol{\theta})$, the moments associated with the CEX data. The population moment conditions are assumed to uniquely equal zero at the truth $\boldsymbol{\theta}_0$, or

$$E[\mathbf{G}(\boldsymbol{\theta}_0)] = E\begin{bmatrix}\mathbf{G}_1(\boldsymbol{\theta}_0)\\ \mathbf{G}_2(\boldsymbol{\theta}_0)\end{bmatrix} = 0.$$

I follow Hansen (1982), who shows that the optimal (two-step) GMM estimator takes the form

$$\hat{\boldsymbol{\theta}} = \arg\min_{\boldsymbol{\theta}\in\Theta} \mathbf{G}^*(\boldsymbol{\theta})'\mathbf{G}^*(\boldsymbol{\theta}),$$

where $\mathbf{G}^*(\boldsymbol{\theta}) = \mathbf{a}(\tilde{\boldsymbol{\theta}})\hat{\mathbf{G}}(\boldsymbol{\theta})$, $\hat{\mathbf{G}}(\cdot)$ is the sample analogue to $\mathbf{G}(\cdot)$, and $\mathbf{a}(\tilde{\boldsymbol{\theta}})$ is a consistent estimate of the "square root" of the inverse of the asymptotic variance-covariance matrix of the moments (obtained using $\tilde{\boldsymbol{\theta}}$, a preliminary consistent estimate of $\boldsymbol{\theta}_0$).

The two sources of variance in $\mathbf{V} = E[\mathbf{G}^*(\boldsymbol{\theta}_0)\mathbf{G}^*(\boldsymbol{\theta}_0)']$ come from two independent sampling processes, so $\mathbf{V}$ is block-diagonal. Let $\boldsymbol{\Gamma} = E[\partial\mathbf{G}^*(\boldsymbol{\theta}_0)/\partial\boldsymbol{\theta}]$, the gradient of the moments with respect to the parameters evaluated at the true parameter values. The asymptotic variance of $\sqrt{n}(\hat{\boldsymbol{\theta}} - \boldsymbol{\theta}_0)$ is then given by

$$(\boldsymbol{\Gamma}'\boldsymbol{\Gamma})^{-1}\boldsymbol{\Gamma}'\mathbf{V}\boldsymbol{\Gamma}(\boldsymbol{\Gamma}'\boldsymbol{\Gamma})^{-1}.$$

[10] Bresnahan, Stern, and Trajtenberg (1997) provide a nice discussion of the intuition behind using these instruments.

TABLE 1
AVERAGE (Sales-Weighted) CHARACTERISTICS FOR SELECTED VEHICLE TYPES, 1981–93

	ALL VEHICLES			STATION WAGONS			
	Mean (1)	Standard Deviation (2)	MINIVANS (3)	p <\$7,754 (4)	p≥\$7,754 (5)	SPORT-UTILITIES (6)	FULL-SIZE VANS (7)
Horsepower/weight	.39	.07	.36	.35	.37	.40	.30
Length × width × height	.71	.13	.87	.60	.78	.83	1.13
Air conditioning standard	.27	.44	.78	.00	.16	.56	.37
Miles/dollar	24.11	6.55	22.84	26.50	22.24	20.20	17.56
Front wheel drive	.64	.48	.63	.83	.60	.00	.00
List price (1982–84 CPI \$)	9,867	4,559	10,060	6,864	10,421	10,949	10,321

NOTE.—List price is the base model price. The lowest list price quartile of station wagons is separated out from the top 75 percent.

Reported standard errors estimate $\mathbf{\Gamma}$ and $\mathbf{V}$ using the consistent estimates $\mathbf{\Gamma}(\hat{\boldsymbol{\theta}})$ and $\mathbf{V}(\hat{\boldsymbol{\theta}})$.[11]

VIII. Results

A. *Descriptive Statistics*

The average characteristics of new vehicles sold in the United States are reported in table 1, including averages for the different *family vehicles* (minivans, station wagons, sport-utility vehicles, and full-size vans).[12] Except for the small, inexpensive station wagons, family vehicles were priced competitively with one another and differed from other vehicles primarily in their size. Most minivans and station wagons came equipped with front wheel drive, with Chrysler almost exclusively accounting for the 63 percent of front wheel drive minivan sales. Minivans also had the distinction of coming with more "luxury": 78 percent had air conditioning (the luxury proxy) as part of the standard list price package.

Table 2 summarizes income, family size, and age of head of household for purchasers of different new vehicles and for the United States population as a whole. Purchasers of new vehicles had an average income of \$36,113, about \$13,000 higher than the average income of U.S. house-

[11] Moment restrictions for models that are similar in nameplate and characteristics over time are aggregated into one sample observation. Thus the standard errors of the parameter estimates permit product-specific errors for similar models to exhibit arbitrary correlation across years.

[12] Petrin (2001) contains a more complete set of results, including a number of robustness checks and an appendix that describes computational details.

TABLE 2
AVERAGE CONSUMER CHARACTERISTICS FOR THE UNITED STATES AND SELECTED SUBPOPULATIONS, 1987–92

	United States		Purchasers of				
	Mean	Standard Deviation	New Vehicles	Minivans	Station Wagons	Sport-Utilities	Full-Size Vans
Income	23,728	21,255	36,113	39,476	40,196	41,569	31,164
Family size	2.58	1.53	2.87	3.86	3.17	2.97	3.47
Midage	.55	.49	.64	.78	.73	.74	.65

SOURCE.—Consumer Expenditure Survey.
NOTE.—Income is measured in 1982–84 CPI-adjusted dollars. Family size is the number of household members. Midage is a binary variable for the age of the head of household between 30 and 60 inclusive.

holds (1982–84, CPI adjusted). Minivans, station wagons, sport-utilities, and full-size vans were most often purchased by larger families and by households whose head is between the ages of 30 and 60. In particular, for family vehicles, minivans had the highest average family size (3.86) and the highest fraction of heads of households between the ages of 30 and 60 (78 percent).

Table 3 presents summary sales figures for the family vehicle market segment for 1981–93. Sales of minivans climbed over the 1980s, moving from a market share of 1.5 percent in 1984 to almost 10 percent in 1993. The waning appeal of station wagons was closely correlated with the success of minivans. They captured approximately 10 percent of the new car market in each year 1981, 1982, and 1983, but in the minivan's introductory year, their sales started to fall. Sales continued to fall every year until 1991. This negative correlation in sales is consistent with a

TABLE 3
FAMILY VEHICLE SALES AS A PERCENTAGE OF TOTAL VEHICLE SALES: U.S. AUTOMOBILE MARKET, 1981–93

Year	Minivans (1)	Station Wagons (2)	Sport-Utilities (3)	Full-Size Vans (4)	Minivans and Station Wagons (5)	U.S. Auto Sales (Millions) (6)
1981	.00	10.51	.58	.82	10.51	7.58
1982	.00	10.27	.79	1.17	10.27	7.05
1983	.00	10.32	3.51	1.04	10.32	8.48
1984	1.58	8.90	5.51	1.20	10.48	10.66
1985	2.32	7.33	6.11	1.05	9.65	11.87
1986	3.63	6.70	5.73	.85	10.43	12.21
1987	4.86	6.47	6.44	.73	11.33	11.21
1988	5.97	5.14	7.18	.69	11.11	11.76
1989	6.45	4.13	7.47	.61	10.58	11.06
1990	7.95	3.59	7.78	.27	11.54	10.51
1991	8.29	3.05	7.80	.29	11.34	9.75
1992	8.77	3.07	9.33	.39	11.84	10.12
1993	9.93	3.02	11.66	.29	12.95	10.71

TABLE 4
Parameter Estimates for the Demand-Side Equation

Variable	OLS Logit (1)	Instrumental Variable Logit (2)	Random Coefficients (3)	Random Coefficients and Microdata (4)
	A. Price Coefficients (α's)			
α_1	.07	.13	4.92	7.52
	(.01)**	(.01)**	(9.78)	(1.24)**
α_2			11.89	31.13
			(21.41)	(4.07)**
α_3			37.92	34.49
			(18.64)**	(2.56)**
	B. Base Coefficients (β's)			
Constant	−10.03	−10.04	−12.74	−15.67
	(.32)**	(.34)**	(5.65)**	(4.39)**
Horsepower/weight	1.48	3.78	3.40	−2.83
	(.34)**	(.44)**	(39.79)	(8.16)
Size	3.17	3.25	4.60	4.80
	(.26)**	(.27)**	(24.64)	(3.57)*
Air conditioning standard	−.20	.21	−1.97	3.88
	(.06)**	(.08)**	(2.23)	(2.21)*
Miles/dollar	.18	.05	−.54	−15.79
	(.06)**	(.07)	(3.40)	(.87)**
Front wheel drive	.32	.15	−5.24	−12.32
	(.05)**	(.06)**	(3.09)	(2.36)**
Minivan	.09	−.10	−4.34	−5.65
	(.14)	(.15)	(13.16)	(.68)**
Station wagon	−1.12	−1.12	−20.52	−1.31
	(.06)**	(.07)**	(36.17)	(.36)**
Sport-utility	−.41	−.61	−3.10	−4.38
	(.09)**	(.10)**	(10.76)	(.41)**
Full-size van	−1.73	−1.89	−28.54	−5.26
	(.16)**	(.17)**	(235.51)	(1.30)**
% change GNP	.03	.03	.08	.24
	(.01)**	(.01)**	(.02)**	(.02)**

Note.—Standard errors are in parentheses. A quadratic time trend is included in all specifications.
* Z-statistic >1.
** Z-statistic >2.

positive covariance in taste for these vehicles. A related finding is in column 5, where the sum of sales of station wagons and minivans is reported. While the market share for station wagons fell and the share of minivans climbed, the sum of the shares remained fairly constant over the sample period.

B. *Parameter Estimates*

Tables 4 and 5 report the results for the four different demand-side models: ordinary least squares (OLS), instrumental variables, random coefficients with instrumental variable correction, and random coeffi-

TABLE 5
RANDOM COEFFICIENT PARAMETER ESTIMATES

Variable	Random Coefficients (γ's): Uses No Microdata (1)	Random Coefficients (γ's): Uses CEX Microdata (2)
Constant	1.46	3.23
	(.87)*	(.72)**
Horsepower/weight	.10	4.43
	(14.15)	(1.60)**
Size	.14	.46
	(8.60)	(1.07)
Air conditioning standard	.95	.01
	(.55)*	(.78)
Miles/dollar	.04	2.58
	(1.22)	(.14)**
Front wheel drive	1.61	4.42
	(.78)**	(.79)**
γ_{mi}	.97	.57
	(2.62)	(.10)**
γ_{sw}	3.43	.28
	(5.39)	(.09)**
γ_{su}	.59	.31
	(2.84)	(.09)**
γ_{pv}	4.24	.42
	(32.23)	(.21)**

NOTE.—The OLS and instrumental variable models assume that these random coefficients are zero. Standard errors are in parentheses. A quadratic time trend is included in all specifications. The subscript *mi* stands for minivan, *sw* for station wagon, *su* for sport-utility, and *pv* for full-size passenger van.
* Z-statistic >1.
** Z-statistic >2.

cients with instrumental variable correction and the CEX data. Estimated sensitivity to price almost doubles when one moves from OLS to instrumental variables (similarly to Berry et al.'s finding), suggesting that instrumenting will be important in any final specification. The OLS and instrumental variables restrict the random coefficients in table 5 to be zero. As many of these estimates are significantly different from zero, they lead Wald tests to reject OLS and instrumental variables in favor of the more flexible frameworks.

Column 3 of table 4 and column 1 of table 5 contain the complete set of random coefficient demand estimates obtained using just the market-level data. Only six of 24 demand-side parameter estimates have *Z*-statistics that are greater than one, and none of the eight coefficients that relate to the family vehicles has a *Z*-statistic that is greater than one.

The final columns in both tables present results for the random coefficients model estimated using the micro moments. Twenty-one of the 24 parameter estimates now have *Z*-statistics greater than one. The parameters most closely related to the additional information show the biggest increase in precision, since all 11 coefficients related to family vehicles and income effects have *Z*-statistics greater than three. Thus the micro moments combined with the 13 years of market-level data provide sufficient information to precisely estimate many of the model's parameters, especially those most relevant for the welfare questions.

Results from the regression of the (log of) estimated marginal costs on the vehicle characteristics are presented in table 6. All the car characteristics enter with significant coefficients that have the expected sign. It costs more to build more acceleration, bigger vehicles (measured by weight), better fuel efficiency, and more luxury into a new vehicle. I now turn to the implications of these demand and supply estimates.

C. Changes in Consumer Welfare: 1984

I use compensating variation to measure changes in consumer welfare from the introduction of the minivan. This cost-of-living index is the change in a consumer's income that equates utility in a particular economic environment to some chosen benchmark utility (see Hicks 1946). For the benchmark I use the standard of living attained with minivans available as a choice. In the counterfactual environment, there are no minivans, and other vehicle prices solve the set of equilibrium first-order conditions from (2) (without minivans). Compensating variation is the dollar amount a consumer would need to be just indifferent between the equilibrium with minivans and the one without them. Thus, for minivan purchasers, it is the dollar amount a (former) minivan consumer needs to be compensated at the new equilibrium prices to achieve the "minivan standard of living."

Table 7 summarizes the implied equilibrium price changes (with the micro data) that occur with the minivan's entry in 1984. They suggest that the Dodge Caravan had many substitutes that were top-selling vehicles in the large-sedan and wagon segments of the market. In particular, station wagons experienced the largest percentage price decreases upon entry, and the large family sedans show the largest dollar decreases ($100–$150). For non–minivan purchasers, compensation is determined entirely by changes (mostly decreases) in vehicle prices associated with the entry of minivans. Overall, in 1984 the estimated gains to non–minivan purchasers from increased price competition account for almost 43 percent of total consumer benefits.

Table 8 presents summary statistics for the distribution of compensating variation for minivan purchasers under each of the four demand-side models. I begin with the OLS and instrumental variable logit models, which have no random coefficients and use no micro data. Estimated average compensation is $13,652 and $7,414, respectively. Since the sum of compensation and the price paid equals the willingness to pay, OLS and instrumental variables imply that 1984 minivan consumers would have willingly spent (on average) $22,374 and $16,136, respectively, to

TABLE 6
PARAMETER ESTIMATES FOR THE COST SIDE
Dependent Variable: Estimated (Log of) Marginal Cost

Variable (τ's)	Parameter Estimate	Standard Error
Constant	1.50	.08
ln(horse power/weight)	.84	.03
ln(weight)	1.28	.04
ln(MPG)	.23	.04
Air conditioning standard	.24	.01
Front wheel drive	.01	.01
Trend	−.01	.01
Japan	.12	.01
Japan × trend	−.01	.01
Europe	.47	.03
Europe × trend	−.01	.01
$\ln(q)$	−.05	.01

TABLE 7
EQUILIBRIUM PRICES WITH AND WITHOUT THE MINIVAN, 1984:
1982–84 CPI-ADJUSTED DOLLARS

	PRICE			
	With Minivan	Without Minivan	ΔPRICE	% ΔPRICE
	A. Largest Price Decreases on Entry			
GM Oldsmobile Toronado (large sedan)	15,502	15,643	−141	.90
GM Buick Riviera (large sedan)	15,379	15,519	−139	.89
GM Buick Electra (large sedan)	12,843	12,978	−135	1.04
GM Chevrolet Celebrity (station wagon)	8,304	8,431	−127	1.51
Ford Cadillac Eldorado (large sedan)	19,578	19,704	−126	.64
Ford Cadillac Seville (large sedan)	21,625	21,749	−125	.57
GM Pontiac 6000 (station wagon)	9,273	9,397	−123	1.31
GM Oldsmobile Ciera (station wagon)	9,591	9,714	−123	1.27
GM Buick Century (station wagon)	8,935	9,056	−121	1.34
GM Oldsmobile Firenza (station wagon)	7,595	7,699	−104	1.35
	B. Largest Price Increases on Entry			
Chrysler LeBaron (station wagon)	9,869	9,572	297	3.10
Volkswagen Quattro (station wagon)	13,263	13,079	184	1.41
Chrysler (Dodge) Aries K (station wagon)	7,829	7,659	170	2.22
AMC Eagle (station wagon)	10,178	10,069	109	1.08

NOTE.—Equilibrium prices without minivans are estimated using the model with microdata and Bertrand-Nash first-order conditions. Bertrand-Nash pricing with random coefficients does not a priori determine signs of firm-specific price changes.

TABLE 8
Average Compensating Variation Conditional on Minivan Purchase, 1984: 1982–84 CPI-Adjusted Dollars

	OLS Logit	Instrumental Variable Logit	Random Coefficients	Random Coefficients and Microdata
Compensating variation:				
Median	9,573	5,130	1,217	783
Mean	13,652	7,414	3,171	1,247
Welfare change from difference in:				
Observed characteristics ($\delta_j + \mu_{ij}$)	−81,469	−44,249	−820	851
Logit Error (ϵ_{ij})	95,121	51,663	3,991	396
Income of minivan purchasers:				
Estimate from model	23,728	23,728	99,018	36,091
Difference from actual (CEX)	−15,748	−15,748	59,542	−3,385

Note.—Compensating variation is evaluated at equilibrium prices without minivans. Decomposition of compensation is the average difference in the value of observed and unobserved characteristics between first and second choices. For logit models, the purchase decision is independent of income, so mean purchaser income is mean U.S. household income.

obtain a minivan. Such estimates of willingness to pay seem inconsistent with profit-maximizing behavior by Chrysler and unlikely given the wide selection of vehicles available at significantly lower prices.

The table also decomposes compensating variation into two components.[13] One component is related to the observed characteristics entering the utility function. The second component is related to the idiosyncratic logit taste term. The OLS and instrumental variable welfare estimates suffer from a heavy dependence on this term. Minivan consumers require an average of \$95,121 (\$51,663) compensation for loss of the characteristics captured by the idiosyncratic minivan taste relative to the second-choice vehicle. The OLS and instrumental variable results also imply that minivan consumers *strongly dislike* the observed characteristics of this vehicle relative to their second choice.

Compensating variation falls to \$3,171 when heterogeneity in taste is allowed (and instruments continue to be used). The decomposition improves in the sense that the magnitude of the idiosyncratic term falls significantly. However, the welfare change is still dominated by this component, and consumers of minivans still dislike the utility provided by its observed characteristics. The model estimates also imply that only

[13] Because of income effects, this decomposition is approximate for the random coefficients models.

the wealthiest (and least price sensitive) households purchase new vehicles, as average purchaser income from the model exceeds that observed in the CEX by almost $60,000.

Once the random coefficients model is augmented with data on consumer observables, the average compensating variation falls to $1,247. At $851, compensation arising from the loss of the minivan's observed characteristics (relative to the second-choice vehicle) is now positive. The welfare change implied by the idiosyncratic logit term is $396, much smaller than the three alternative approaches. Finally, with the micro moments, the implied average income conditional on a new minivan purchase is $36,091, about $3,000 less than the CEX estimate of $39,476.

Figure 1 plots the distributions of compensating variation for the instrumental variable logit model, the random coefficients approach without micro data, and the full model. Here the consumers with "extreme tastes" are very apparent. Estimates from the instrumental variable logit model (the top histogram) imply that 10 percent of minivan purchasers would have needed at least $20,000 in compensation. With the random coefficients (the second histogram), the tail is much less pronounced, although there are still many consumers who would have needed thousands of dollars in compensation to relinquish their minivan. Adding the information from the micro moments (the third histogram) appears to significantly reduce the "extreme-tastes" tail. The cumulative weight of these results leads me to prefer the full model with micro moments when estimating changes in welfare.

D. *Markups, Producer Surplus, and Profit Dissipation*

Before focusing exclusively on the results using micro data, I compare estimated markups across the demand-side models. Table 9 summarizes these markups. In the case of the OLS and instrumental variable logit, implied markups averaged $13,904 and $7,551.[14] Observed prices less estimated markups yield estimates of marginal costs. They are negative for 73 percent and 22 percent of vehicles, respectively, reflecting the low estimated demand elasticities under OLS and instrumental variables.[15] They illustrate how demand-side bias can transmit itself to the supply side when marginal costs are estimated in this manner.

Markups from the random coefficients model restricted to market-level data (cols. 3 and 4) and the full model (cols. 5 and 6) are all positive. The average markup with random coefficients but no micro

[14] Note also that the ratio of the estimated markups from the OLS and instrumental variable logit frameworks, $13,904/$7,551, is almost exactly equal to the ratio of the price sensitivity coefficients, a result that obtains from the logit framework.

[15] Many of the estimated own-price elasticities are less than one, making them inconsistent with static profit-maximizing behavior in an oligopolistic market.

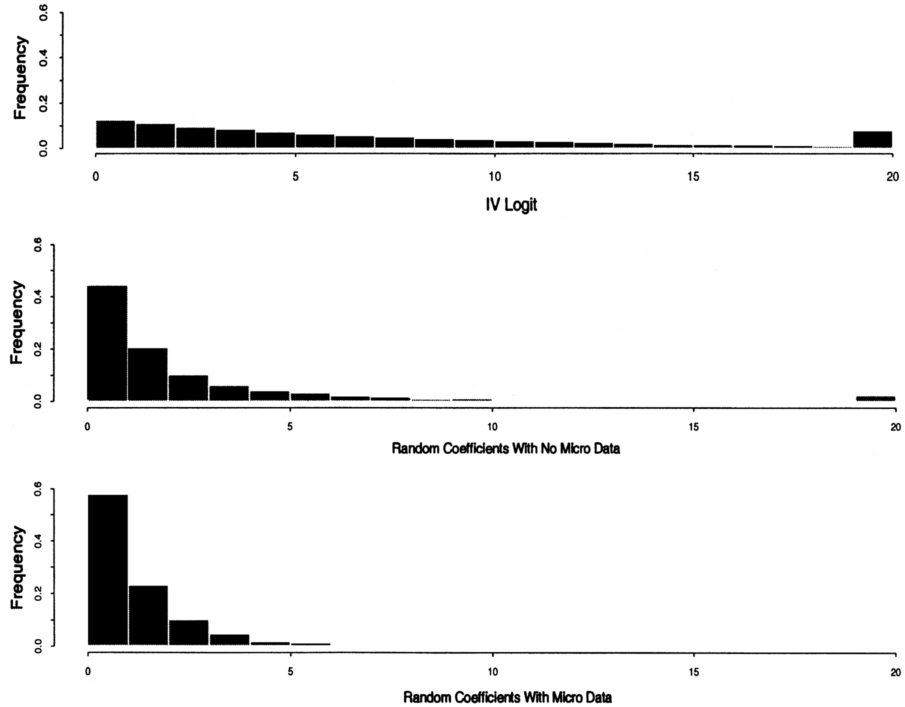

FIG. 1.—Compensating variation for 1984 minivan purchasers: thousands of 1982–84 CPI-adjusted dollars

TABLE 9
IMPLIED MARKUPS DERIVED FROM DEMAND-SIDE ESTIMATES AND BERTRAND-NASH PRICING ASSUMPTION, 1981–93 (2,407 Models)

Statistic	OLS Logit (1)	Instrumental Variable Logit (2)	Random Coefficients (3)	(4)	Random Coefficients and Microdata (5)	(6)
Median	\$13,834	\$7,513	\$2,593	36.7%	\$1,439	15.0%
Mean	\$13,904	\$7,551	\$4,017	40.7%	\$1,753	16.7%
10%	\$13,647	\$7,413	\$1,628	27.8%	\$819	11.2%
90%	\$14,297	\$7,765	\$8,357	62.6%	\$2,856	24.8%
Standard deviation	\$257	\$140	\$4,089	14.0%	\$1,229	6.2%
Estimated marginal costs that are negative	73.7%	22.6%	0%		0%	

NOTE.—Percentage markups are estimated markups divided by observed prices. They are not reported for instrumental variable and OLS logits because the estimated marginal cost is negative for many vehicles. Dollars are 1982–84 CPI adjusted.

data is about twice that of the average markup when micro data are added to the framework (40 percent vs. 17 percent). Both are well within the range of previously reported estimates.[16]

I now focus exclusively on results using the micro data. Table 10 reports sales-weighted average prices and percentage markups (estimated markups divided by observed prices) for selected vehicle groups from 1983–87. Minivans enjoyed consistently larger markups than station wagons, sport-utility vehicles, and other new vehicles, in part derived from their location in a less crowded region of product space. Station wagon markups were 2–3 percent lower, on average, than minivan markups and consistently fell below the market average. Overall, markups fell over this time period as the number of vehicle choices increased from 157 in 1983 to 198 in 1987.

Changes in Chrysler's, Ford's and GM's estimated total variable profits due to the introduction of the minivan are reported in table 11. These numbers obtain by computing implied profits with no minivans and comparing them to estimated profits with minivans (see Sec. V). They

[16] Two estimates of markups from the same time period come from Berry et al. (1995) and Goldberg (1995). Berry et al. use market-level data for 1971–90 on the U.S. passenger car market (i.e., no minivans, sport-utilities, or vans). Their random coefficients model yields ranges of markups depending on the cost- and demand-side specification from as small as 15–25 percent to as large as 30–40 percent. Goldberg uses a nested logit framework with the same market-level data as Berry et al. (using only 1983–87) and combines these data with consumer-level information from the CEX. She finds an average markup of 38 percent, with a range from 14 percent to 61 percent. She also reports implied estimates for markups ranging from 15 percent to 50 percent using separate information from the Annual Survey of Manufacturers and *Consumer Reports.*

TABLE 10
Average (Sales-Weighted) Markup/Price and Price, 1983–87

Year	Minivans		Station Wagons		Sport-Utility Vehicles		All Other Vehicles	
1983	...	...	18.27%	\$8,230	17.28%	\$9,715	18.85%	\$9,059
1984	19.19%	\$8,722	17.83%	\$8,400	17.07%	\$9,952	17.72%	\$9,085
1985	19.43%	\$8,655	16.81%	\$8,412	16.51%	\$9,904	17.12%	\$9,101
1986	17.33%	\$8,898	15.82%	\$9,164	15.41%	\$10,115	16.43%	\$9,480
1987	16.31%	\$9,527	13.86%	\$9,620	14.06%	\$11,123	14.79%	\$10,053

Note.—Percentage markups are estimated markups divided by observed prices. Dollars are 1982–84 CPI adjusted.

suggest that Chrysler benefited significantly from introducing the minivan, as variable profits increased by \$202 million (14 percent) in the first year relative to what profits would have been without the introduction. Sales and estimated markups continued to grow over the next few years. By the end of 1987, Chrysler's minivans had generated almost \$1.5 billion in estimated profits, exceeding the reported \$700 million spent on the cost of development.[17]

Ford and GM quickly responded to Chrysler with their own versions of minivans. However, these minivans were built on downsized full-size van platforms and thus were more like their predecessors than Chrysler's front wheel drive family van. In the end, both Ford and GM were hurt by Chrysler's innovation, with the results suggesting a fall in variable profits between 1 percent and 2 percent annually (for high-volume GM, this amounted to hundreds of millions of dollars).

Profit dissipation is reported in table 12, which compares Chrysler's implied profits with Ford and GM minivans removed from the market to the estimated profits that obtain with all minivans in the market. Over four years, GM and Ford cannibalized an estimated \$126 million of Chrysler's profits, which amounts to profits equivalent to a loss in sales of 76,000 minivans. While these losses are not trivial, Chrysler's minivan appears to have differentiated itself enough to maintain some market power.

E. *Total Welfare Change: 1984–88*

Table 13 summarizes changes in consumer and producer welfare across the industry for the years 1984–88. Consumers benefited significantly, gaining a new product for which some households, especially those with

[17] This \$700 million figure was reported in the March 21, 1983, issue of *Time*. Other figures include an estimate from the November 14, 1983, issue of *Fortune*, which reported a \$400 million cost of retooling at the first minivan plant (a lower bound on total development costs). Chrysler's total planned investment in new products was reported to be \$1.5 billion in 1983 (*Ward's Automotive*, 1983). Of course, some of the initial design of the minivan had been completed by Ford in the 1970s.

TABLE 11
CHANGE IN INDUSTRY AND BIG THREE TOTAL VARIABLE PROFITS WITH THE ADVENT OF MINIVANS

Year	Industry	Chrysler		Ford		GM	
1984	−.21%	\$202.5	14.38%	−\$31.8	−1.16%	−\$155.8	−1.50%
1985	−.13%	\$259.1	13.99%	−\$37.4	−1.29%	−\$171.0	−1.63%
1986	.14%	\$201.1	12.42%	\$54.7	1.84%	−\$119.9	−1.09%
1987	.17%	\$346.1	23.27%	−\$22.8	−.66%	−\$174.5	−2.14%
1988	.65%	\$504.1	32.50%	−\$24.7	−.70%	−\$235.4	−2.90%

NOTE.—Dollar figures are given in millions. The numbers are computed using the model to estimate profits both with minivans in the market and with minivans removed from the market (see Sec. V).

large families, had a strong taste. Additionally, non–minivan consumers benefit from the price competition, obtaining \$157 million of the \$367 million in consumer gains for 1984. It also appears that the industry (ex post) would have been willing to pay Chrysler not to produce the minivan, since total producer surplus for the industry fell slightly in 1984 and 1985. Finally, the total welfare gain over the first five years was about \$2.9 billion, of which \$2.8 billion came from consumer surplus. Thus estimated benefits from this new product introduction were far larger than both the costs to society of producing the vehicle and the private returns the innovator obtained.

IX. Conclusions

In this paper I report two main findings. One is a technique I find useful for estimating demand curves. The second quantifies how the introduction of the minivan changed consumer and producer welfare in the United States.

I suggest a technique for obtaining more precise estimates of demand curves when consumer-level data are not available. My recommendation is to supplement market-level data with information relating demographic averages of consumers to the products they purchase. The extra

TABLE 12
CHRYSLER'S PROFIT DISSIPATION WITH ENTRY OF FORD AND GM MINIVANS

Year	Change in Total Variable Profits	
1985	−\$6.06	−.16%
1986	−\$22.72	−1.99%
1987	−\$42.35	−2.25%
1988	−\$55.68	−2.63%

NOTE.—These profit changes are computed using the model (see the text).

TABLE 13
CHANGE IN U.S. WELFARE FROM THE MINIVAN INNOVATION, 1984–88 ($ Millions)

Year	Compensating Variation	Change in Producer Profits	Welfare Change
1984	367.29	−36.68	330.61
1985	625.04	−25.07	599.97
1986	439.93	27.30	467.23
1987	596.59	29.75	626.34
1988	775.70	110.24	885.94
Total	2,804.55	105.54	2,910.09

NOTE.—Computations were done using 1982–84 CPI-adjusted dollars.

information plays the same role as consumer-level data, allowing estimated substitution patterns and (thus) welfare to directly reflect demographic-driven differences in tastes for observed characteristics. The technique should be useful for a broad range of markets in which data on price and product characteristics may not be sufficient to precisely identify the relevant substitution patterns. In the minivan case, I find that the microdata are important for demand and welfare measurement, primarily because they appear to free the model from a heavy dependence on the idiosyncratic logit error.

My results suggest that overall gains from the introduction of the minivan were large and that consumer benefits far outweighed the costs of development and the profits obtained by the innovator. Consumer benefits were distributed across households in a nonrandom way, and almost half of these benefits came from increased price competition and accrued to non–minivan purchasers. On the producer side, the results were mixed. Chrysler obtained large benefits from the introduction of the minivan, easily recouping its initial development costs. These sales came at the expense of the rest of the industry, which was unprepared for the minivan innovation and unable to respond quickly with the introduction of a comparable product.

These results support a story in which large improvements in consumers' standard of living arise from competition between firms. These firms ignore the externalities they impose on one another, cannibalizing each other's profits by introducing new and different goods. The new goods that successfully differentiate themselves from existing products can yield large profits for the innovator and substantial gains for consumers.

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