The Dynamics of Automobile Expenditures

by Adam Copeland[1]

1. Dept. of Commerce, BEA

The views expressed herein are my own and not necessarily those of the Bureau of Economic Analysis or the US Department of Commerce

Motivation

- A central question in durable goods analysis: how much do consumers time their purchase decisions?
- Auto-industry wisdom is that there exists a large degree of temporal substitution
  - pct change in aggregate sales looks like a jagged saw
- Little empirical work measuring temporal substitution vs. entry/exit.
- With motor vehicles, have a unique window on timing of purchases
  1. detailed monthly price and sales vehicle data
  2. coordinated model-year cycle for motor vehicle
  3. demographic data

Overview of the Paper

1. Analyze how consumers time their new vehicle purchase decisions
2. Focus on decisions within the model year
   - choice set constant, but prices vary (decline)
   - clear tradeoff of enjoying vehicle now vs. waiting for price decline
3. Consumers modeled as an optimal stopping problem
4. Structurally estimate parameters in the consumer's indirect utility function (estimate both a dynamic and static version)
5. Results:
   (a) Dynamic model fits the data much better
   (b) Consumers are price sensitive and willing to time purchases
   (c) Temporal substitution as large a force as entry/exit at aggregate level.

Literature review

1. Durable goods - infrequently purchased
   - (closest) Gowrisankaran and Rysman (2007) - DVD players
   - Carranza (2003, 2006), Song and Chintagunta (2003), Gordon (2006) and Nair (2005)
2. Non-durable goods - frequently purchased (grocery retail data)
   • impact of high/low pricing and other optimal pricing schemes, Slade (1998), Aguirregabiria (1999), Pesendorfer (2002), Erdem et al (2003), Hendel and Nevo (forthcoming).
3. Automobile pricing: incentives, dealer inventories, price cues (Zettelmeyer et al (2003,2006,2007).
4. Macroeconomic issues
   - aggregrate inventory behavior: Hall (2000) and Attanasio (2000)
   - GDP volatility: Ramey and Vine (2007)

Talk Outline

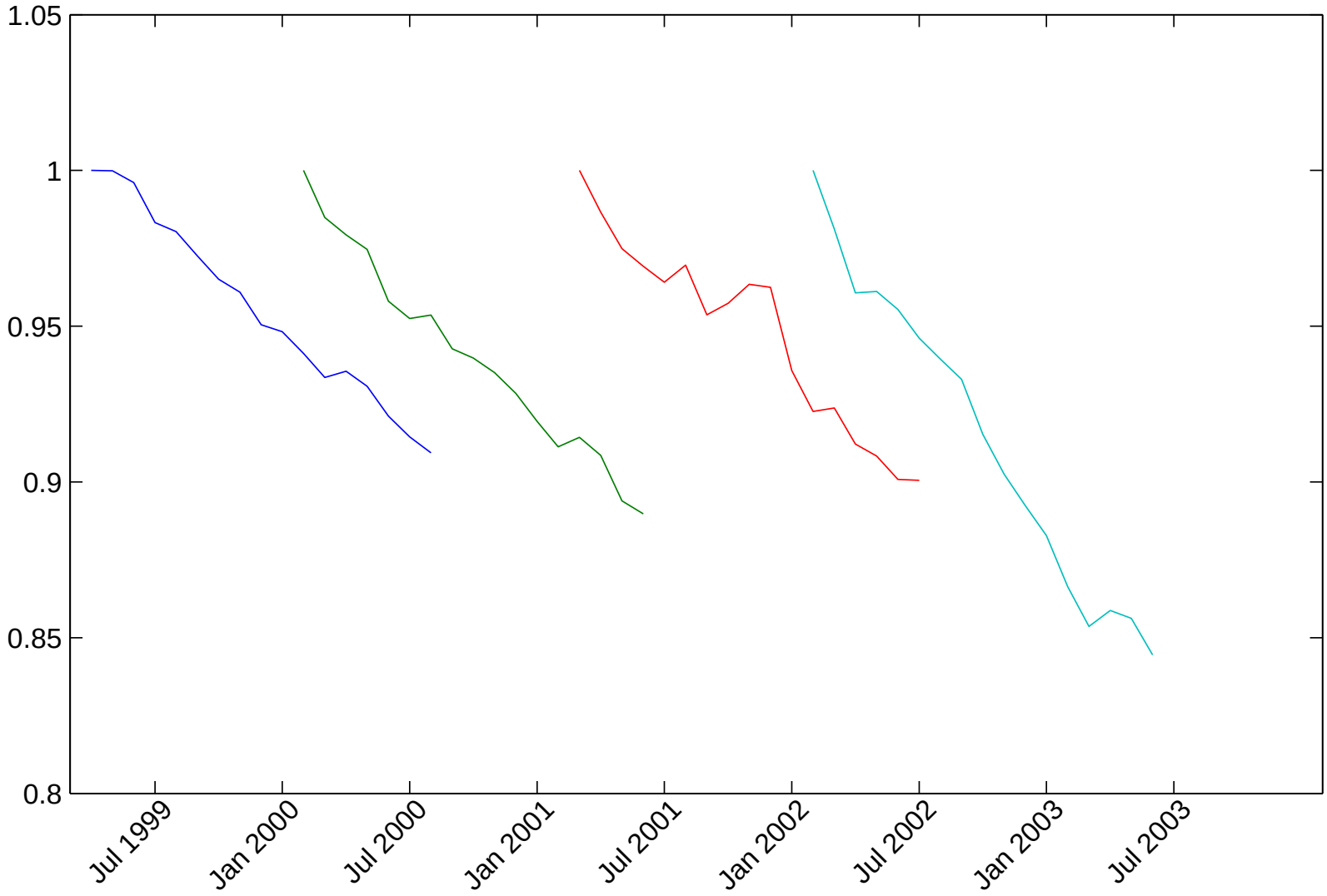
1. Data
2. Model: static (benchmark) and dynamic
3. Results

Data - Combined 2 data sets

1. First: Power Information Database (PIN), from JDPA
   - Collected from dealerships, 15-20% of all U.S. retail sales.
   - Monthly observations by model/model-year from 1999 to 2003
   - Observe price, cash rebate, and financial details
   - Observe model-year distribution of sales by model
2. Second: Wards Communications - US monthly sales by model.
3. Combine both data sets to get:
   - Monthly series of sales by model & model-year,
   - Monthly series of real market prices by model & model-year,

Data Facts

1. Prices fall over the model year at 9% annual rate
2. Mean income of new vehicle purchasers falls over model year
3. Model-level sales are hump-shaped
4. Aggregate sales volatile

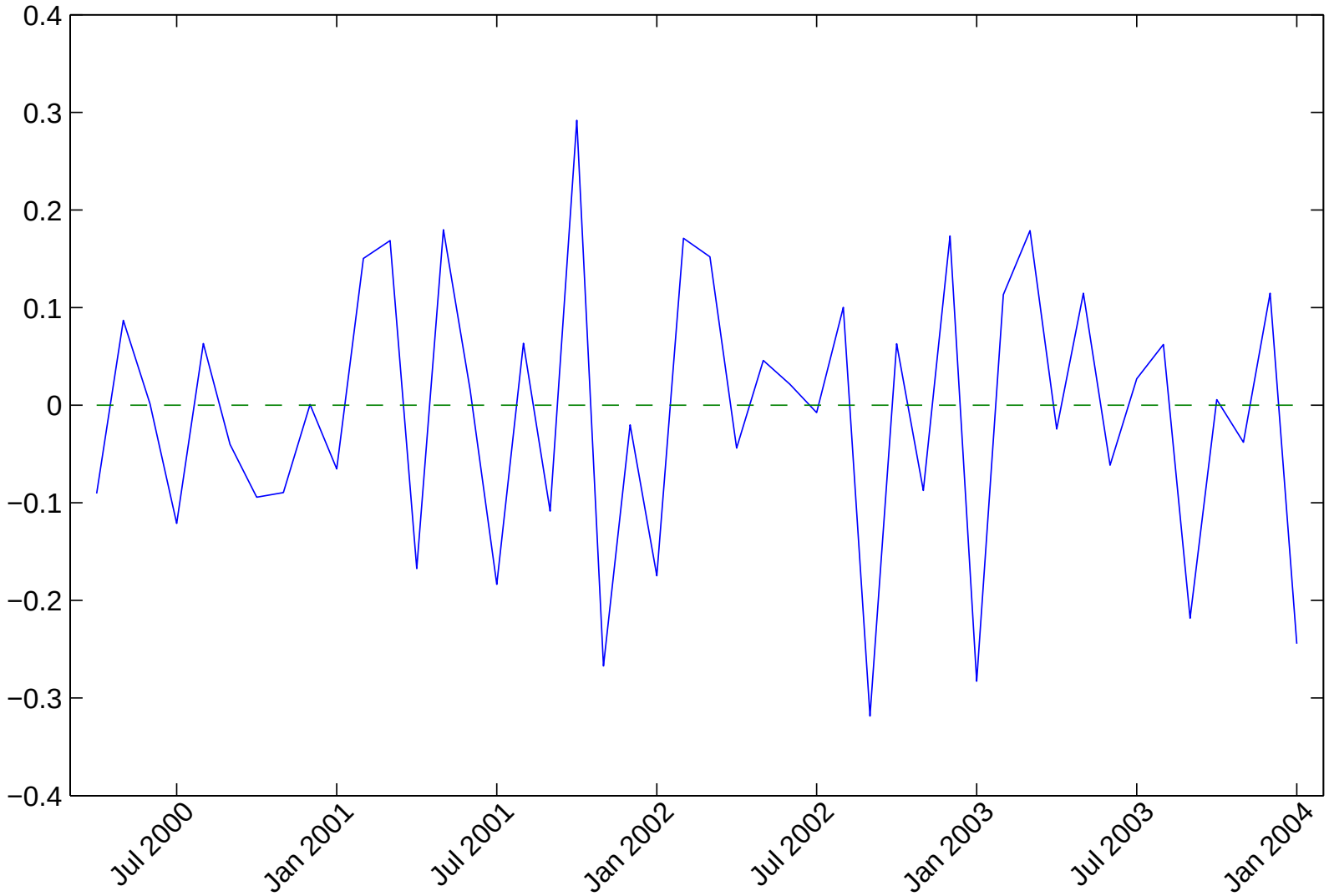


Laspeyres Price Indexes by Model Year

Data from Aizcorbe-Bridgman-Nalewaik 2007

	Income (thousands of dollars)
Quarter	Data
1	74.973
2	73.075
3	71.460
4	68.603

Average Income of New Vehicle Purchasers



Percent Change in Aggregate Sales

Reduced form analysis of prices and sales

- Is there positive correlation between p_{t-1} and s_t?
- First stage: detrend $\log(p), \log(s)$ by model
- Second stage: $\hat{s}_t = \Gamma_0 \hat{s}_{t-1} + \Gamma_1 \hat{p}_t + \Gamma_2 \hat{p}_{t-1} + \varepsilon_t$

variable	coefficient	estimate	std error
$\hat{s}_{t-1}$	Γ_0	0.482	0.008
$\hat{p}_t$	Γ_1	-0.631	0.134
$\hat{p}_{t-1}$	Γ_2	0.500	0.134

Table 1: Coefficient Estimates from Sales Residual Regression

Model: Optimal stopping problem within Model Year

- All consumers show up at the beginning of the model year.
- Every month, each decides whether to buy a new vehicle or wait.
- In last month of the model year, waiting mean not buying a new vehicle that model year.
- Remainder of income goes towards alternative consumption good.
- Aggregate across consumers to get predicted market shares
- Employ discrete-choice framework (BLP-style), includes
  - Consumer heterogeneity
  - Product differentiation
  - Constant choice set, changing prices
  - Perfect foresight on prices

Model Results

Used variation on the estimation strategy detailed in Gowrisankaran & Rsyman (2007).

- Parameters are precisely estimated
- Estimate heterogeneity in consumer tastes
- Negative trend in indirect utility over model year (consistent with residual value or fashion hypotheses)
- Temporal substitution is a large force

Quarter	Data	Model
1	\$74,973	\$74,960
2	\$73,075	\$73,156
3	\$71,460	\$71,301
4	\$68,603	\$68,654

Table 2: Average Income of New Vehicle Purchasers

Market Segment	Semi-Elasticities		
	Min	Mean	Max
Midsize	3.74	7.18	10.66
Pickup	4.49	7.96	11.95
SUV	3.65	7.15	15.69
Compact	2.76	6.65	10.41
Sporty	3.25	5.17	7.73
Fullsize	3.59	8.73	13.41
Upscale	3.64	5.71	11.18
Vans	4.02	8.42	13.39

Note: Semi-elasticities are the %Δ in market share given a \$1,000 price increase.

Table 3: Own Price Semi-Elasticities for the 2002 MY (absolute value)

Table 4: Change in unit sales given a $1,000 increase to Camry

Month	Mid-size	Pickup	SUV	Small	Sporty	Full-size	Up-scale
1	29.4	5.1	9.7	9.2	2.0	1.7	4.5
2	53.6	16.2	23.7	18.5	4.2	2.9	8.4
3	52.2	16.2	28.3	18.1	4.4	3.0	10.0
4	56.7	18.7	35.0	19.8	4.1	2.7	11.6
5	55.6	16.5	33.2	17.1	4.1	2.8	10.0
6	61.1	19.7	36.2	16.6	5.3	3.3	10.5
7	72.8	23.8	42.6	21.6	5.8	3.6	11.7
8	-2,757.8	23.3	39.8	21.1	6.1	3.6	12.0
9	65.7	18.0	34.2	20.0	4.9	3.0	10.4
10	62.8	18.0	34.4	20.6	4.3	2.7	9.6
11	65.5	18.1	38.4	21.1	4.1	2.7	9.3
12	72.0	21.6	43.0	22.3	4.3	2.0	10.0

Table 5: Response of Aggregate Sales To Price Change (Midsize)

Model	Aggregate Sales			Diff from Data	
Year	data	exp	unexp	exp	unexp
1	496.027	496.717	496.027	0.691	0
2	1,121.653	1,123.202	1,121.653	1.550	0
3	1,092.389	1,093.910	1,092.389	1.521	0
4	1,174.588	1,176.254	1,174.588	1.666	0
5	1,035.168	1,036.702	1,035.168	1.534	0
6	1,238.045	1,239.909	1,238.045	1.864	0
7	1,430.983	1,433.166	1,430.983	2.183	0
8	1,367.780	1,342.090	1,344.382	-25.690	-23.398
9	1,420.850	1,422.720	1,424.101	1.870	3.251
10	1,433.464	1,435.374	1,436.778	1.910	3.314
11	1,403.050	1,404.952	1,406.522	1.902	3.472
12	1,465.791	1,467.814	1,469.282	2.023	3.491

Table 6: Aggregate Sales Response to Δ Price for each Market Segment

Market Segment	Δ Monthly Sales (percent)					Δ Outside over Δ M 8 Sales
	M 8	M 9	M 10	M 11	M 12	
Midsize	-1.711	0.229	0.231	0.247	0.238	0.42
Pickup	-1.402	0.245	0.253	0.267	0.253	0.24
SUV	-1.430	0.259	0.264	0.281	0.268	0.22
Compact	-0.771	0.060	0.059	0.071	0.059	0.66
Sporty	-0.150	0.024	0.023	0.036	0.024	0.26
Fullsize	-0.198	0.039	0.040	0.053	0.040	0.10
Upscale	-0.265	0.050	0.050	0.063	0.051	0.16
Vans	-0.727	0.133	0.136	0.150	0.136	0.20
Average						0.28

Conclusion

- With motor vehicles, have a excellent opportunity to measure temporal substitution
- Find consumers are price sensitive and willing to substitute temporally (large role for price discriminate)
- Aggregate level, temporal substitution is much larger than cross-sectional
- Aggregate level, temporal substitution is as large as entry/exit of consumers