Heuristic Thinking and Limited Attention in the Car Market

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Motivation

Substantial interest in how people process information

•Bounded rationality, heuristics (Simon, 1955; Gilovich, Griffin, and Kahneman, 2002)

Evidence of inattention, heuristics, and shrouded attributes *in markets*

•Brown, Hossain, Morgan, 2010; Chetty, Looney, Kroft, 2010; Englmaier-Schmoller 2009; Gabaix-Laibson, 2006; Finkelstein, 2009; Hossain-Morgan, 2006; Lee-Malmendier, 2010; Stango-Zinman, 2010

This paper:

•How does limited ability of agents to fully process info impact the used-car market?

- Large, important, competitive market for durable good
- Consider fully visible (and important) characteristic: odometer reading
- Model and document a specific bias: left-digit bias (Korvost and Damian, 2008; Poltrock and Schwartz, 1984; 99c-pricint lit. [Basu 1997])
 - E.g. 5,347 vs. 5,382 and 5,988 vs. 6,021
- Left-digit bias to odometer readings affect market prices for cars around thresholds such as 10k-mile marks.
- Find sizeable, persistent effects of the bias

A model of left-digit bias

INATTENTION FRAMEWORK (DELLAVIGNA, 2009)

Assume value of a product (V) as sum of visible component v and opaque component o.

Perceived value, $V^* = v + (1 - \theta)o$

θ is the inattention parameter.

- $\theta = 0$ is full attention
- $\theta = 1$ is complete inattention

LEFT-DIGIT BIAS OF QUALITY METRIC

 $m = 49,900 \Rightarrow m^* = 40,000 + (1 - \theta)9,000 + (1 - \theta)^2 900$

A model of left-digit bias

EXAMPLE

 $V^* = V(m^*) = K - \alpha m^*$ (assume negative slope to match the used car setting)



Market framework – Wholesale auto auctions

- Representative-agent framework for final customers that have left-digit bias
- Competitive retail used car market with large number of dealers.
- → A unique competitive equilibrium exists where wholesale auction prices reflect pattern of value of final customers.
- Can incorporate heterogeneity in consumer left-digit bias, in which case the market will reflect the inattention of the marginal customer.

Market framework – Wholesale auto auctions

1								
	2002	2003	2004	2005	2006	2007	2008	All Years
All Cars								
Cars brought to auction	4,201,337	3,946,544	4,013,990	3,922,811	3,857,324	3,956,676	3,103,236	27,001,918
Cars sold at auction	3,465,958	3,32 <mark>4,</mark> 874	3,276,768	3,226,587	3,132,033	3,238,287	2,531,154	22,195,661
Price Sold	\$9,861	\$9,396	\$9,862	\$10,421	\$10,789	\$11,141	\$10,832	\$10,301
Mileage	54,634	56,528	58,028	58,764	57,926	57,384	55,620	56,997
Model Year	1998.1	1999.0	1999.9	2000.8	2001.9	2002.9	2003.9	2000.8
Dealer Cars								
Cars brought to auction	2,010,481	2,060,560	2,318,420	2,406,979	2,384,672	2,313,739	1,604,615	15,099,466
Cars sold at auction	1,357,210	1,449,774	1,639,840	1,773,045	1,738,082	1,686,121	1,132,102	10,776,174
Price Sold	\$8,493	\$8,543	\$9,144	\$9,712	\$9,867	\$10,046	\$9,270	\$9,346
Mileage	65,269	65,473	65,327	65,710	66,242	67,582	68,128	66,197
Model Year	1996.8	1997.9	1999.0	2000.0	2000.9	2001.8	2002.6	1999.9
Fleet/Lease Cars								
Cars brought to auction	2,190,856	1,885,984	1,695,570	1,515,832	1,472,652	1,642,937	1,498,621	11,902,452
Cars sold at auction	2,108,748	1,875,100	1,636,928	1,453,542	1,393,951	1,552,166	1,399,052	11,419,487
Price Sold	\$10,742	\$10,055	\$10,582	\$11,287	\$11,938	\$12,329	\$12,096	\$11,203
Mileage	47,789	49,611	50,716	50,291	47,557	46,306	45,499	48,316
Model Year	1999.0	1999.9	2000.8	2001.9	2003.0	2004.2	2005.1	2001.7

Table 1. Summary Statistics

Wholesale used-car auction company

+: info on car types (make, model, body, prod. year), auction location, etc...



Results – Average price of cars sold at auction by mileage

Miles on Car (Rounded Down to Nearest 500)



Results – Volume of cars brought to auction by mileage

Volume patterns hinting at potential selection around the thresholds?

Results – Residual prices netting out make-model-body-model yearauction year fixed effects



Miles on Car (Rounded Down to Nearest 500)

Discontinuities (~\$150-\$200) correspond to estimates of β s from:

 $p_i = \alpha + f(m_i) + \sum_t \beta_t D_i [\operatorname{int}(m_i / 10,000t)] + \gamma X_i + \varepsilon_i$

Results – Volume of cars brought to auction by mileage – by type of seller



Fleet/lease

•Lower reserve prices, less selection concerns (e.g. >95% likely so sell)

Dealer

•Higher reserve price, selection concerns (e.g. ~60% likely to sell)

Results – Residual prices netting out make–model-body-model yearauction year fixed effects – by type of seller



Fleet/lease •Lower reserve prices, less selection concerns (e.g. >95% likely so sell)

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Results – Alternative explanations/mechanisms?

Selection on unobservables?

•Since it is a wholesale market, only worried about unobservables that are observed by auction participants

•Discontinuity is not being driven entirely by points right around the thresholds (where selection is the strongest)

•Selection on observables is in both directions (negative and positive).

Warranties?

•Not for all discontinuities!

•Regressions by individual makes and car types show discontinuities exist even when warranties not present

Odometer tampering?

•If people are savvy to this fraud, this will bias estimates downward

Results – Alternative explanations/mechanisms?

Differences across time?

•Year-by-year estimates are stable

Heterogeneity across cars?

•Separate regressions for most popular cars show heterogeneity, but discontinuities for all •Positively related to depreciation, as predicted by model.

Published price info?

•Fully smooth at Edmunds, some discontinuities, but not systematic and not at 10K marks, at KBB

Canadian Data •Discontinuities at 10,000 *Km*!

Who is inattentive? Wholesale buyers or final consumers?

- If end customers have bias, then observationally no difference between a market where the auction buyers are savvy about that or one where unaware but share bias.
- Auction buyers have incentives to overcome bias if their end customers do not display it.
- Tests and findings
 - More experienced (savvier) dealers buy disproportionately *before* thresholds
 - Do not perceive as overpriced, anticipate end consumer bias
 - Price drops begin *not* too close to a 10K threshold
 - Drive cars back to the lot...make sure still below mark!
 - Similar (volume) patterns at (end-consumer based) cars.com
 - \rightarrow Evidence of large part of the bias residing in end-consumers

Using price discontinuities to estimate θ

Simple linear case: $V(m^*) = K - \alpha m^*$



Similar results if higher-order polynomial in miles (NL estimates)

1,500.00 1,300.00 Average Discontinuity for 10,000-Mile Thresholds 1,100.00 900.00 700.00 500.00 Data Inear Fit of Data 300.00 100.00 0.08 0.14 0.1 0.12 0.16 0.18 0.02 0.06 0.04 -100.00 -300.00 -500.00 -Rate of Car Depreciation across Miles (Alpha)

Using heterogeneity in price discontinuities to estimate $\boldsymbol{\theta}$

For 250 most popular cars: Estimate $Gap = \delta + \theta^*(\alpha^*10,000) \rightarrow \text{est. of } \theta=0.3$

Summary and Implications

Clean evidence that heuristic thinking matters in an important durable goods market

- About \$160 price change for just a few miles
- Estimates of inattention parameter imply up to 30% of depreciation due to these drops
- Estimate ~\$2.5B worth of mispriced transactions, potential within consumer distributional issues
- Affect supply decisions
- \rightarrow Simple heuristic affects many facets of the market

Rational or irrational inattention?

• Positive relationship b/w discontinuities and depreciation rates is evidence of "irrational"

This type of heuristic processing of numeric information may be relevant in other settings

- Use of GPA and SAT in admissions or hiring
- Investor valuations of companies based on revenues or earnings
- Medical decisions based on laboratory tests, blood pressure, etc...



A model of left-digit bias

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