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

\( \theta \) is the inattention parameter.
- \( \theta = 0 \) is full attention
- \( \theta = 1 \) is complete inattention

LEFT-DIGIT BIAS OF QUALITY METRIC

\[ m = 49,900 \implies m^* = 40,000 + (1 - \theta)9,000 + (1 - \theta)^2900 \]
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

Table 1. Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>All Years</th>
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<tbody>
<tr>
<td>All Cars</td>
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<td></td>
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<td></td>
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<tr>
<td>Cars brought to auction</td>
<td>4,201,337</td>
<td>3,946,544</td>
<td>4,013,990</td>
<td>3,922,811</td>
<td>3,857,324</td>
<td>3,956,676</td>
<td>3,103,236</td>
<td>27,001,918</td>
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<tr>
<td>Cars sold at auction</td>
<td>3,465,958</td>
<td>3,324,874</td>
<td>3,276,768</td>
<td>3,226,587</td>
<td>3,132,033</td>
<td>3,238,287</td>
<td>2,531,154</td>
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<td>Price Sold</td>
<td>$9,861</td>
<td>$9,396</td>
<td>$9,862</td>
<td>$10,421</td>
<td>$10,789</td>
<td>$11,141</td>
<td>$10,832</td>
<td>$10,301</td>
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<td>Mileage</td>
<td>54,634</td>
<td>56,528</td>
<td>58,028</td>
<td>58,764</td>
<td>57,926</td>
<td>57,384</td>
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<td>56,997</td>
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<td>Dealer Cars</td>
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<tr>
<td>Cars brought to auction</td>
<td>2,010,481</td>
<td>2,060,560</td>
<td>2,318,420</td>
<td>2,406,979</td>
<td>2,384,672</td>
<td>2,313,739</td>
<td>1,604,615</td>
<td>15,099,466</td>
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<td>Cars sold at auction</td>
<td>1,357,210</td>
<td>1,449,774</td>
<td>1,639,840</td>
<td>1,773,045</td>
<td>1,738,082</td>
<td>1,686,121</td>
<td>1,132,102</td>
<td>10,776,174</td>
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<tr>
<td>Price Sold</td>
<td>$8,493</td>
<td>$8,543</td>
<td>$9,144</td>
<td>$9,712</td>
<td>$9,867</td>
<td>$10,046</td>
<td>$9,270</td>
<td>$9,346</td>
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<tr>
<td>Mileage</td>
<td>65,269</td>
<td>65,473</td>
<td>65,327</td>
<td>65,710</td>
<td>66,242</td>
<td>67,582</td>
<td>68,128</td>
<td>66,197</td>
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<td>Fleet/Lease Cars</td>
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<td>Cars brought to auction</td>
<td>2,190,856</td>
<td>1,885,984</td>
<td>1,695,570</td>
<td>1,518,832</td>
<td>1,472,652</td>
<td>1,642,937</td>
<td>1,498,621</td>
<td>11,902,452</td>
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<tr>
<td>Cars sold at auction</td>
<td>2,108,748</td>
<td>1,875,100</td>
<td>1,636,928</td>
<td>1,453,542</td>
<td>1,393,951</td>
<td>1,552,166</td>
<td>1,399,052</td>
<td>11,419,487</td>
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<tr>
<td>Price Sold</td>
<td>$10,742</td>
<td>$10,055</td>
<td>$10,582</td>
<td>$11,287</td>
<td>$11,938</td>
<td>$12,329</td>
<td>$12,096</td>
<td>$11,203</td>
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<tr>
<td>Mileage</td>
<td>47,789</td>
<td>49,611</td>
<td>50,716</td>
<td>50,291</td>
<td>47,557</td>
<td>46,306</td>
<td>45,499</td>
<td>48,316</td>
</tr>
</tbody>
</table>

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

![Graph showing the average sales price of cars sold at auction by mileage. The price decreases as the mileage increases.](image-url)
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 year-auction year fixed effects

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

$$p_i = \alpha + f(m_i) + \sum_t \beta_tD_i[\text{int}(m_i / 10,000t)] + \gamma X_i + \varepsilon_i$$
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 to sell)

Dealer
• Higher reserve price, selection concerns (e.g. ~60% likely to sell)
Results – Residual prices netting out make–model-body-model year-auction year fixed effects – by type of seller

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

Dealer
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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

→ Evidence of large part of the bias residing in end-consumers
Using price discontinuities to estimate $\theta$

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

Estimate of $\alpha = 0.047$ (fleet/lease), 0.060 (dealer)

Estimate of gap: $157$ (fleet/lease), $173$ (dealer)

$\Rightarrow$ Estimate of $\theta = 0.33$ (fleet/lease), 0.29 (dealer) (s.e. ~ 0.013)

Similar results if higher-order polynomial in miles (NL estimates)
Using heterogeneity in price discontinuities to estimate $\theta$

For 250 most popular cars: Estimate $\text{Gap} = \delta + \theta(\alpha \times 10,000) \rightarrow \text{est. of } \theta = 0.3$
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
→ 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…
THANKS!
A model of left-digit bias

“RECALL” SURVEY

- Showed each subject 2 used car – pic and some characteristics, and asked which one they preferred
- In next screen, asked to remember mileage (8 values overall)
- Most remember first digit, half remember second, few remember others, and most “wrong” guessed digits are 0