Sunk Cost Fallacy in Driving the World’s Costliest Cars

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Joint with
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National University of Singapore
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Key Research question

Driver A
Mercedes-Benz CLS Class
Purchase month: February 2009
Price = $300,000
US$242,000

Driver B
Mercedes-Benz CLS Class
Purchase month: February 2010
Price = $322,500
US$260,000

Question: If both owners enjoy driving equally, would Driver B drive more as a result of higher sunk cost?
Sunk cost fallacy

✓ Behavioral tendency of an economic agent to consume/produce at a greater than optimal level

✓ Consumption: Desire not to appear wasteful

✓ Project investment: Do not wish to recognize losses

✓ To recover the sunk investment one has made (or close a mental account that carries the sunk cost of the product or project)
Sunk cost fallacy – Over-consumption

- Experiment by Arkes and Blumer (1985)

- Setting:
  - Control: Bought a season theater ticket at full price
  - Treatment: Bought a season theater ticket with unexpected discount
  - Arkes and Blumer: Any difference in the attendance behaviour of the two (the number of shows attended)?

- Result:
  - Buyers in the control condition attended more shows than those in the treatment condition (*4.1 versus 3.3 out of 5 shows*)

- Once the season ticket has been acquired, the actual price of the ticket paid should not affect decision to go to the show.

- Unless, there is a tendency to recover the initial investment – sunk cost fallacy
Sunk cost fallacy – Escalation of commitment

- Field studies by Staw and Hoang (1995) and Camerer and Weber (1999)
- Setting:
  - National Basketball Association (NBA): Teams choose players in annual “draft”: higher rank = lower picks
  - Lower draft players are expected to perform better and guaranteed higher salaries compared to the higher draft players
  - Staw-Hoang and Camerer-Weber: Did teams deploy lower draft picks relatively (more minutes of play) because of the high salary commitment (after adjusting for performance)?
- Result:
  - A minimal decrement in draft order increases playing time by 14 minutes in Year 2 to 2 minutes in Year 5 (Camerer and Weber, 1999).
  - Performance should be the key driver of how many minutes a player plays and not the draft pick order.
  - Escalation of commitment is another manifestation of sunk cost fallacy.
Positioning of research

<table>
<thead>
<tr>
<th>Low stakes</th>
<th>High stakes</th>
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<tbody>
<tr>
<td><strong>Consumption</strong></td>
<td><strong>This study</strong></td>
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<td>Arkes and Blumer (1985) Small monetary involvement</td>
<td>High stakes consumption, free of agency problem</td>
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<td><strong>Project Investment</strong></td>
<td><strong>Staw and Hoang (1995) and Camerer and Weber (1999)</strong></td>
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<td>Agency problem</td>
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Singapore car market

- Singapore car market is heavily regulated to influence demand for cars

- High tariffs make the cars in Singapore the world’s costliest
  - ARF (Additional Registration Fee)
  - COE (Certificate of Entitlement)
Components of car price

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<tr>
<td>Car price on-the-road =</td>
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<tr>
<td>Open market value (OMV)</td>
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<tr>
<td>+ Retail mark-up</td>
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<tr>
<td>+ Customs duty</td>
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<tr>
<td>+ GST</td>
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<tr>
<td>+ Registration fee</td>
</tr>
<tr>
<td>+ Certificate of entitlement (COE) premium</td>
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<td>+ Additional registration fee (ARF)</td>
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</table>
A popular model in our sample – Jun 2009

| Car price on-the-road | $129,000 |
+-----------------------+----------|
| OMV: $34,952          |          |
+-----------------------+----------|
| Retail mark-up: $37,141|          |
+-----------------------+----------|
| Customs duty: $6,990  |          |
+-----------------------+----------|
| GST: $2,936           |          |
+-----------------------+----------|
| Registration fee: $140|          |
+-----------------------+----------|
| COE Premium: $11,889  |          |
+-----------------------+----------|
| ARF: $34,952          |          |

Ex-policy Price (P)

Policy components
Three sources of sunk cost

- Ex-policy price
- ARF
- COE Premium
Source of sunk costs: Ex-policy price

- Value of ex-policy price declines as soon as the car is out on the road
- Sunk cost is therefore the difference between the amount paid and the amount available if re-sold the very next day
Sunk cost of ex-policy price

Car age in years

Ex-policy price

$\Delta P$

ARF

COE

Premium

$s_0 P$
Source of sunk costs: ARF

- Owners can purchase a new car by paying ARF at a preferential rate (PARF) if they dispose the car within 10 years.

- If disposed within the first 5 years, a new car can be purchased by paying 25% of ARF (current policy).

- From the 6th year onward, the preferential rate increases by 5% per year (current policy).

- Therefore, 25% of ARF is sunk cost.
Sunk cost of ARF

\[ s_1 \text{ARF} = 0.25 \text{ARF} \]
Source of sunk costs: COE premium

- COE is valid for 10 years

- If vehicle is disposed within 2 years of purchase, only 80% is refundable

- After 2 years the COE premium is depreciated on a monthly basis until the end of the 10th year.

- Therefore, 20% of COE premium is sunk cost
Sunk costs of COE Premium

\[ s_2 \text{COE} = 0.20 \text{COE} \]
Panel dataset of car usage

- Proprietary field data from a car dealer in Singapore
  - Jan 2001 – Dec 2011
  - 33,457 observations on 6,474 cars
  - Engine capacity – 15 different sizes
  - LTA registration date
  - Servicing date
  - Cumulative mileage

- Other information (from Land Transport Authority, Dept of Statistics)
  - OMV
  - ARF rates
  - COE quota and premium - monthly
  - CPI Fuel - monthly
  - Car population per km - monthly
Noticeable phenomenon: Usage declines with time and price

Vertical axis: average usage per month in km, horizontal axis: age of car in months
(the most popular model in the sample)
Hypothesis 1: Novelty effect (H1.)

- Driver’s may drive more right after purchase of the car
- Novelty effect can be assumed to have non-negative contribution to utility of driving
- The effect diminishes over time
Hypothesis 2: Increasing gasoline cost (H2.)

Gasoline Cost
2001-2011
Hypothesis 3: Increasing congestion due to more cars on the road (H3.)
Hypothesis 4: Reduction in sunk cost (H4.)

- Decreasing prices resulted in decreasing sunk cost
- Average ARF and COE Quota Premium also declined
Hypothesis 4: Reduction in sunk cost (H4.)

- Decreasing prices resulted in decreasing sunk cost
- Average ARF and COE Quota Premium also declined
Hypothesis 5: Reduction in price – selection effect (H5.)

Average price of two most popular models in our sample:

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<th>Year of Purchase</th>
<th>Model A</th>
<th>Model C</th>
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<td>2003</td>
<td>$174,578</td>
<td>$212,140</td>
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<tr>
<td>2007</td>
<td>$145,347</td>
<td>$171,920</td>
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Model of driving behavior

- **Assumptions**: 
  - Individual buys a car
  - Plans to use for 120 months
  - Scrap value at the end of the 120\textsuperscript{th} month – 50% of ARF
Model of driving behavior

Standard model

- Usage in period $t$ is $q_t$
- Driver’s utility in period $t$,

$$U(q_t) = V(q_t) - G(q_t, t) - C(q_t, t) - D(t)$$

Usage value  Gasoline cost  Congestion cost  Depreciation cost
Model of driving behavior

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- Driver’s utility in period $t$,

$$U(q_t) = V(q_t) - G(q_t, t) - C(q_t, t) - D(t)$$

- Usage value
- Gasoline cost
- Congestion cost
- Depreciation cost

$$
\theta_0 + \left(\theta_1 + e^{-\theta_2 t}\right) q_t - \theta_3 q_t^2 \\
\beta_1 g_t q_t \\
\beta_2 c_t q_t \\
D(t)
$$

Notes: $\theta_0, \theta_1, \theta_2, \beta_1, \beta_2, \gamma, \delta_0, \delta_1, \delta_2 > 0$, $P$ is ex – policy price
Model of driving behavior

\[ U(q_t) = V(q_t) - G(q_t, t) - C(q_t, t) - D(t) \]

Usage value

\[ \theta_0 + (\theta_1 + e^{-\theta_2 t})q_t - \theta_3 q_t^2 \]

Novelty effect

Gasoline cost

\[ \beta_1 g_t q_t \]

Congestion cost

\[ \beta_2 c_t q_t \]
Optimal usage – standard model

Optimal usage in \( t = 1, 2, \ldots, T \),

\[
q_t^* = \frac{1}{2\theta_3} \{\theta_1 + e^{-\theta_2 t} - \beta_1 g_t - \beta_2 c_t\}
\]
Incorporating sunk-cost fallacy

✓ Driver’s utility in period $t$,

$$U(q_t) = V(q_t) - G(q_t, t) - C(q_t, t) - D(t) - \max \left\{ 0, \lambda S \left[ 1 - \frac{Q_t}{\hat{Q}} \right] \right\}$$

✓ Consumer amortizes sunk cost $S$ by the actual cumulative usage $Q_t = \sum_{\tau=1}^{t} q_{\tau}$ relative to some target cumulative usage $\hat{Q}$

✓ This nests the standard model ($\lambda = 0$)

✓ Sunk cost gets smaller over time as usage accumulates
Optimal usage with sunk costs

- Optimal usage in \( t = 1, 2, ... T \),

\[
q_t^* = \frac{1}{2\theta_3} \left\{ \theta_1 + e^{-\theta_2 t} - \beta_1 g_t - \beta_2 c_t + [T - t + 1] \frac{\lambda S}{Q} \right\}
\]

- H1.
- H2.
- H3.
- H4. (confounded by H5.)
Assumptions:
- Constant gasoline prices over time
- Constant level of congestion over time
- Zero novelty effect
Selection effect and identification of sunk-cost fallacy

- It is possible that heavy users are willing to pay higher price, thus higher sunk cost.
- Since sunk-cost is assumed to be a function of price, sunk-cost effect is not identified using the optimal usage function.
- However, it may be plausible to assume that selection effect has no time-varying effect.
  - In other words, heavy users may pay higher price, but their change in usage over time may have little to do with paying higher price.
- On the other hand, our model suggests that sunk-cost effect diminishes over time (Arkes and Blumer find similar diminishing effect).
- Change in usage equation can be used to estimate the sunk-cost parameter $\lambda$. 
Total sunk cost is the sum of the sunk costs associated with the three components of car price

- Ex-policy price \( P \)
- ARF
- COE Premium

\[
S = s_0 P + s_1 ARF + s_2 COE
\]

\( s_0, s_1, s_2 \in (0,1) \)
Estimating sunk-cost fallacy

- Estimation equation:
  \[
  \Delta q_{it}^* = \Delta e^{-\theta_2 t} - \beta_1 \Delta g_t - \beta_2 \Delta c_t - \frac{\lambda [0.25 \times ARF_i + 0.2 \times COE_i + s_0 P_i]}{Q_i} + \epsilon_{it}'
  \]

- \( \lambda > 0 \) would indicate presence of sunk-cost fallacy
Target usage

- Target usage $\hat{Q}$ is unobserved
- $\hat{Q}$ is assumed to be log-normally distributed with mean equaling sample average
- Maximum simulated likelihood method is applied to estimate the parameters of interest
The following specifications are estimated:

**Specification a:** Conventional model (without sunk cost)

**Specification b:** Main specification (previous slide)

**Specification c:** Allowing marginal benefit to be dependent on price

**Specification d:** Alternative definition of sunk cost

**Specification e:** Main specification – smaller cars only

**Specification f:** Main specification – larger cars only

**Specification g:** Main specification – heterogeneous distribution of target usage for smaller and larger cars
Robustness check specifications

✓ Marginal benefit dependent on price (specification c):

\[
\text{Usage value} = \exp(\mu.\text{Total Price}). (\theta_0 + \theta_1q_t + e^{-\theta_2t}q_t - \theta_3q_t^2)
\]

✓ Alternative definition of sunk cost (specification d):

\[
\text{Sunk cost, } S = \alpha.\text{Total Price}, \alpha \in (0,1)
\]

✓ Separate estimation for small and large cars (specifications e, f)
  • Target usage drawn from distributions with corresponding sample average as mean

✓ Heterogeneous target usage (specification g):
  • Target usage drawn from two distributions with means corresponding to small and large cars
## Estimates: With and Without Sunk Cost

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<td>0.73*** (0.269)</td>
<td>0.51*** (0.043)</td>
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Estimates: Controlling for Self-selection

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Estimates: Allowing for Different Means of Target Usage for Different Engine Sizes

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Results

✓ Significant improvement in log-likelihood with specifications including sunk-cost
✓ Sunk-cost effect is significant in all specifications
✓ Elasticity wrt sunk-cost is similar (statistically not different) in all specifications
✓ Novelty effect is generally positive and significant
✓ Effect of gasoline cost is not significant (plausible since the sample is of premium cars)
✓ Congestion cost is generally positive and significant
✓ COE premium increased by $22,491 from February 2009 to February 2010

✓ **Specification b:** Estimated increase in sunk cost $4,500 and increase in average monthly usage is 147 km (8.8% increase)

✓ **Specification d:** Estimated increase in average monthly usage due to increase in sunk cost is 164 km (9.9%)
Policy/Managerial implications

✓ Policy:
  - Making cars expensive has countervailing effect
  - Better to directly price congestion

✓ Managerial:
  - Countervailing argument against ‘razor/razorblade strategy’
  - Underpricing the razor would reduce consumption of razor blade?
Back to the question that we posed in the beginning....

Driver A

Mercedes-Benz CLS Class
Purchase month: February 2009
Estimated price=$300,000
US$242,000

Driver B

Mercedes-Benz CLS Class
Purchase month: February 2010
Estimated price=$322,500
US$260,000

• Owner of the second car pays $22,500 more for the same model, due to increase in the COE premium.

• Structural estimation suggests that Driver B will drive 147-164 km per month more than Driver A.
Conclusion

- Developed a behavioral model of car usage that incorporated mental accounting for sunk cost, where the standard model is a special case.

- Tested the model on a proprietary data set of 6,474 cars in Singapore, the world’s most expensive car market

- Found compelling evidence of sunk cost fallacy in car usage in Singapore