Sunk Cost Fallacy in Driving the World's Costliest Cars

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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

	Low stakes	High stakes
Consumption	**Arkes and Blumer (1985)** **Small monetary involvement**	**This study** **High stakes consumption, free of agency problem**
Project Investment		**Staw and Hoang (1995) and Camerer and Weber (1999)** **Agency problem**

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

Car price on-the-road =

Open market value (OMV)

+

Retail mark-up

+

Customs duty

+

GST

+

Registration fee

+

Certificate of entitlement (COE) premium

+

Additional registration fee (ARF)

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
s
Registration fee: $140

Ex-policy Price (P)

+
COE Premium: $11,889
+
ARF: $34,952

Policy components

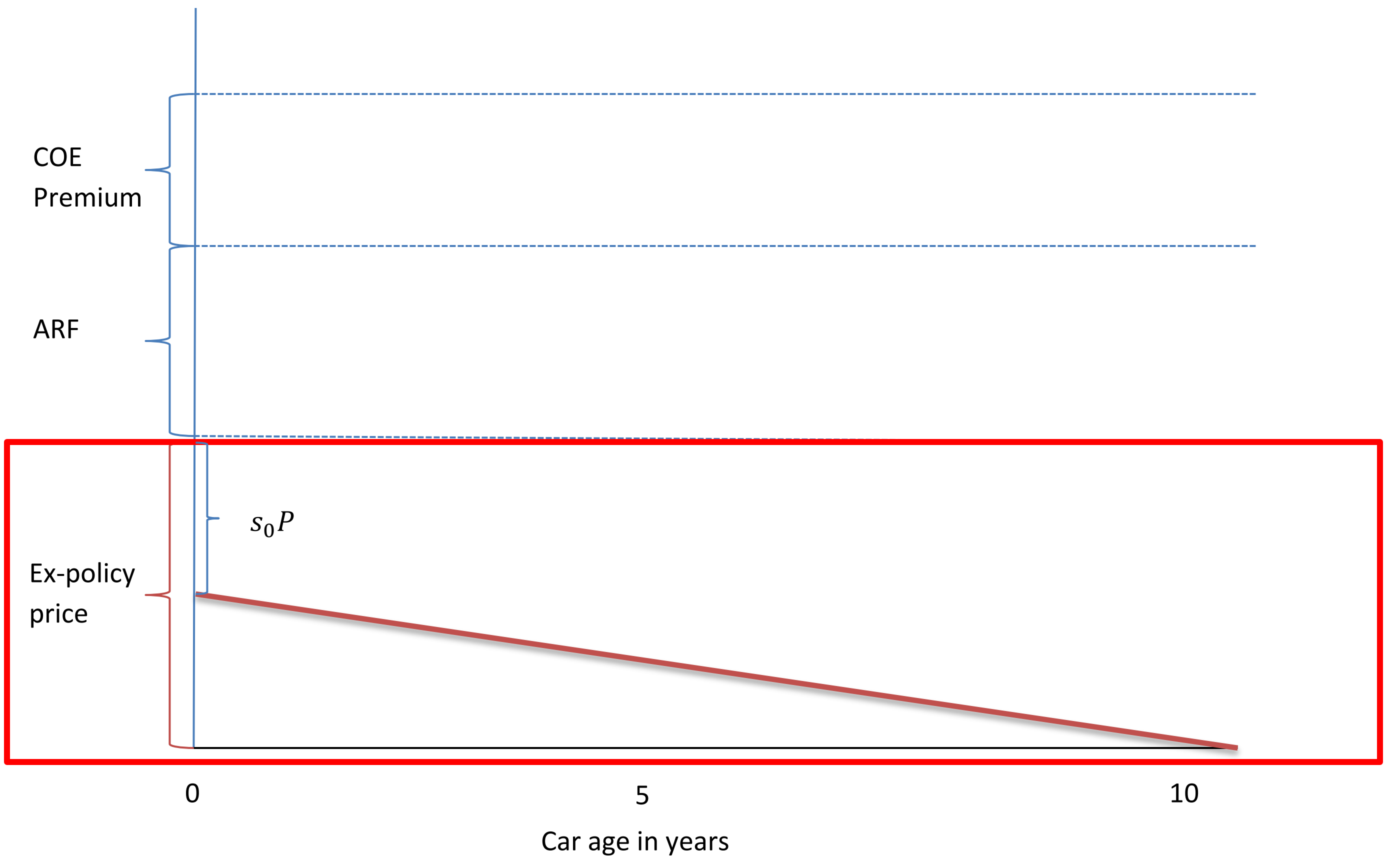
Three sources of sunk cost

- 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

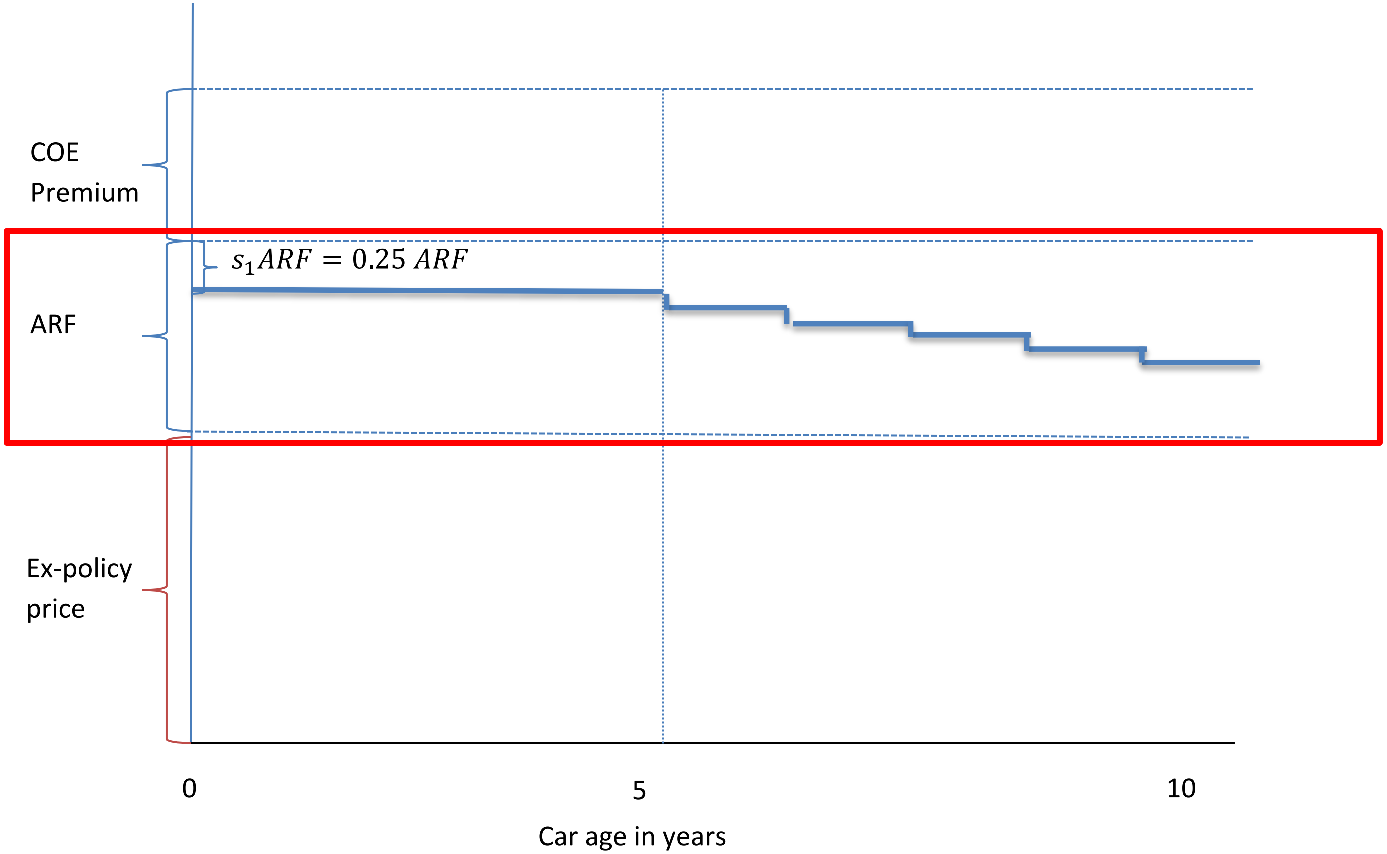
Sunk cost of ex-policy price



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 6^{th} year onward, the preferential rate increases by 5% per year (current policy)
- Therefore, 25% of ARF is sunk cost

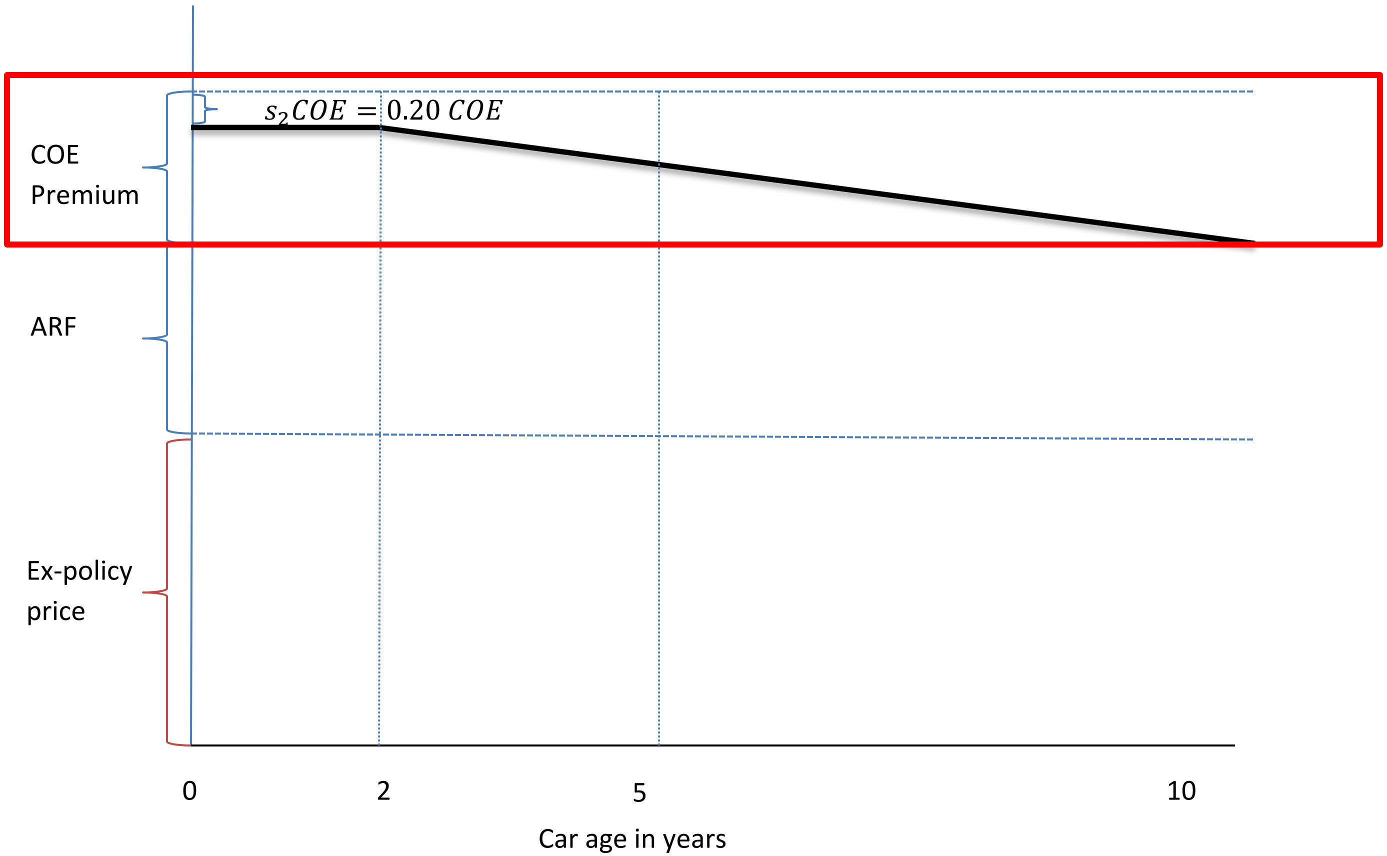
Sunk cost of ARF



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 10^{th} year.
- Therefore, 20% of COE premium is sunk cost

Sunk costs of COE Premium

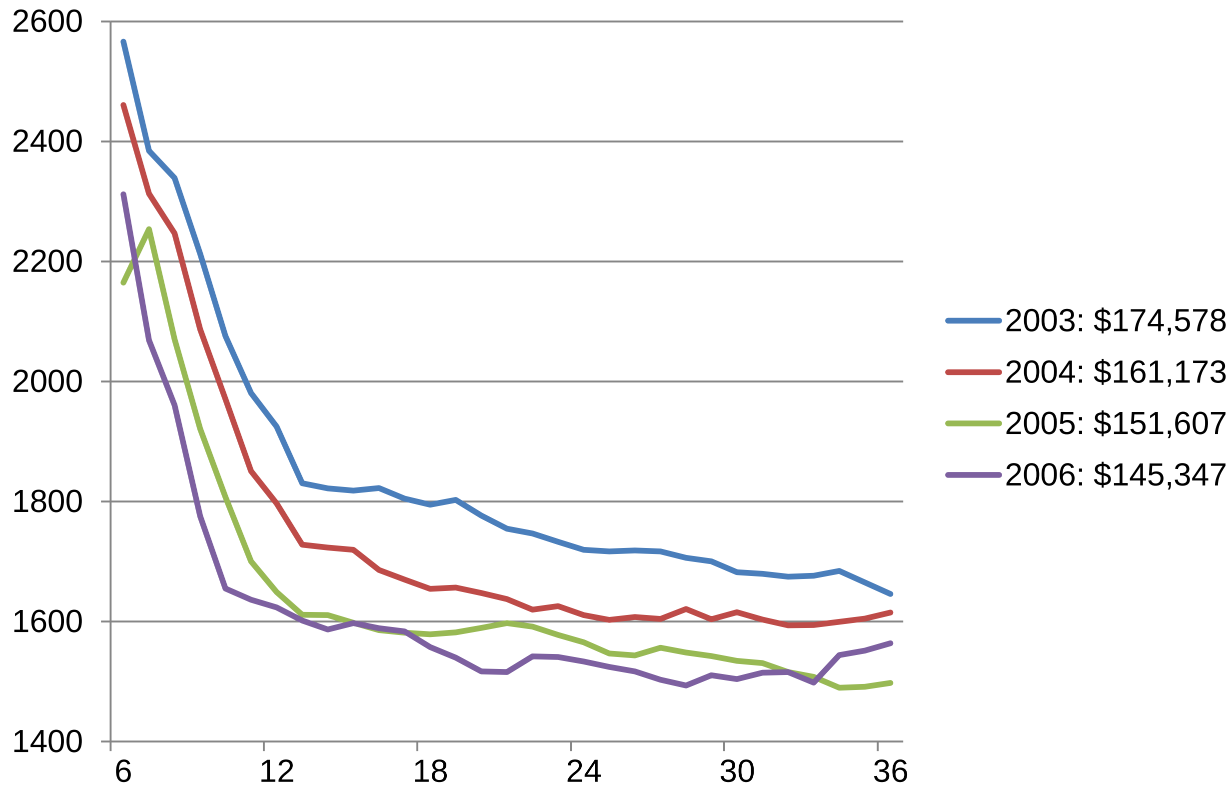


Panel dataset of car usage

- 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

Key empirical regularity

Noticeable phenomenon: Usage declines with time and price

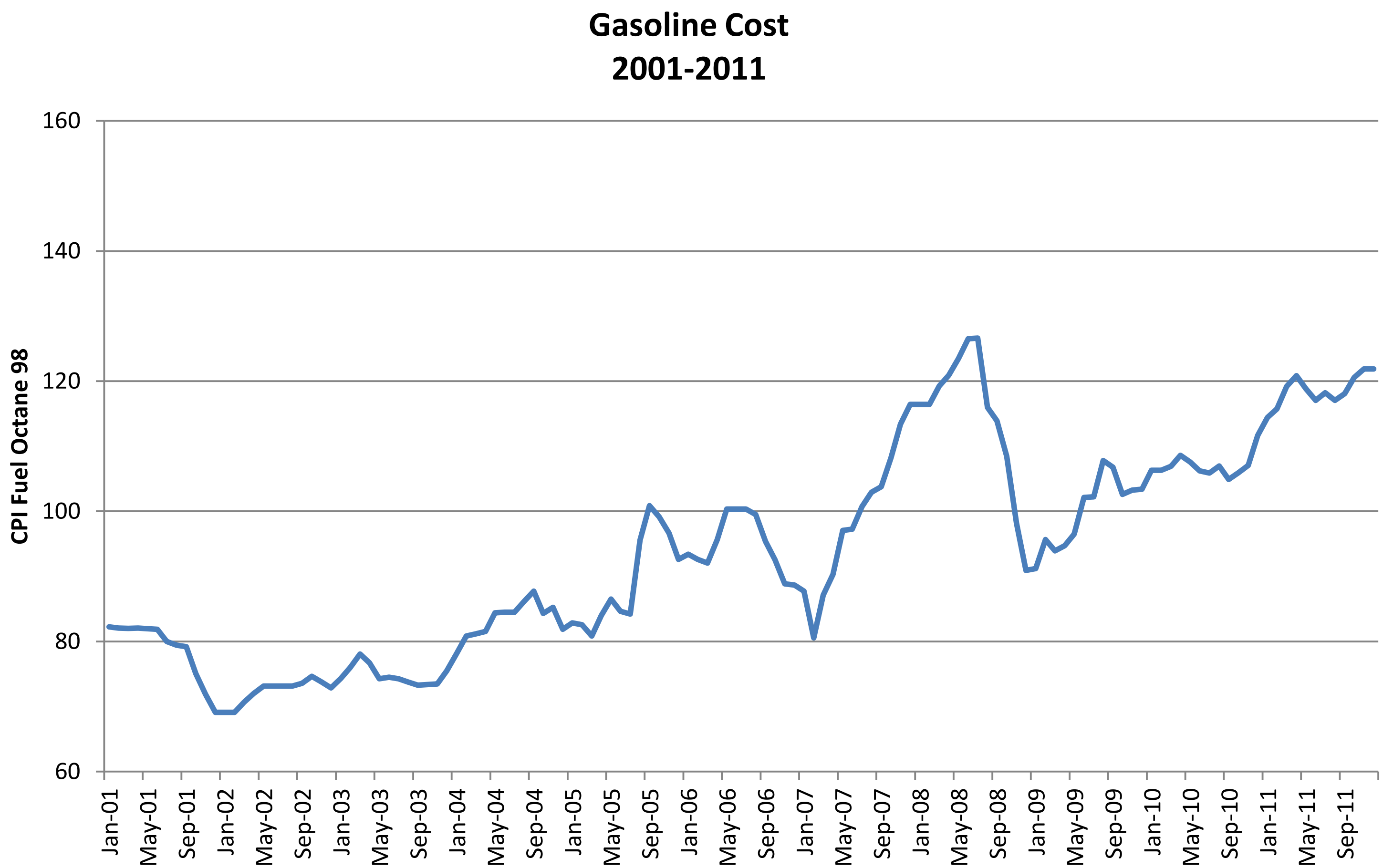


Vertical axis: average usage per month in km, horizontal axis: age of car in months
(the most popular model in the sample)

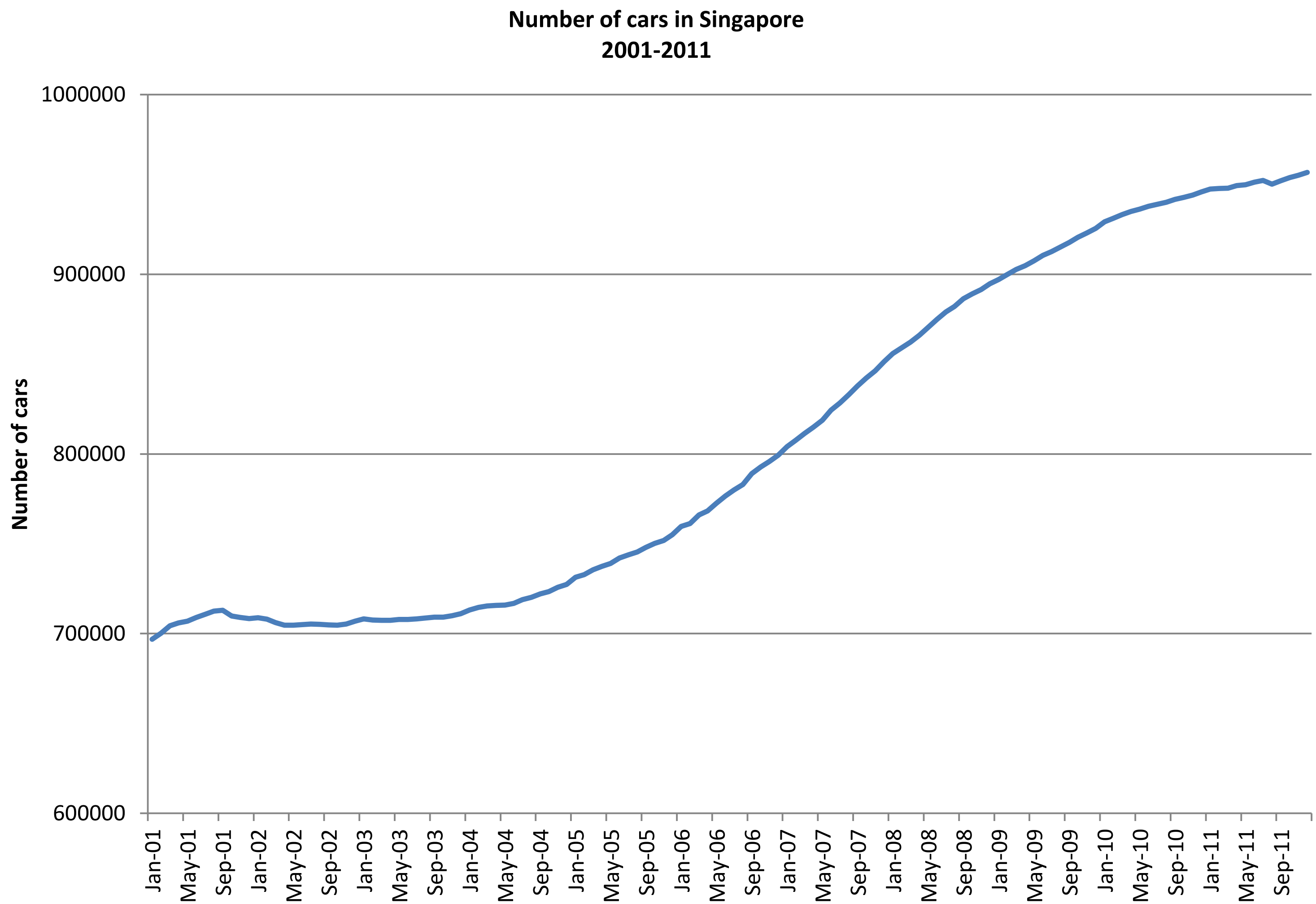
Hypothesis 1: Novelty effect (H1.)

- 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.)



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

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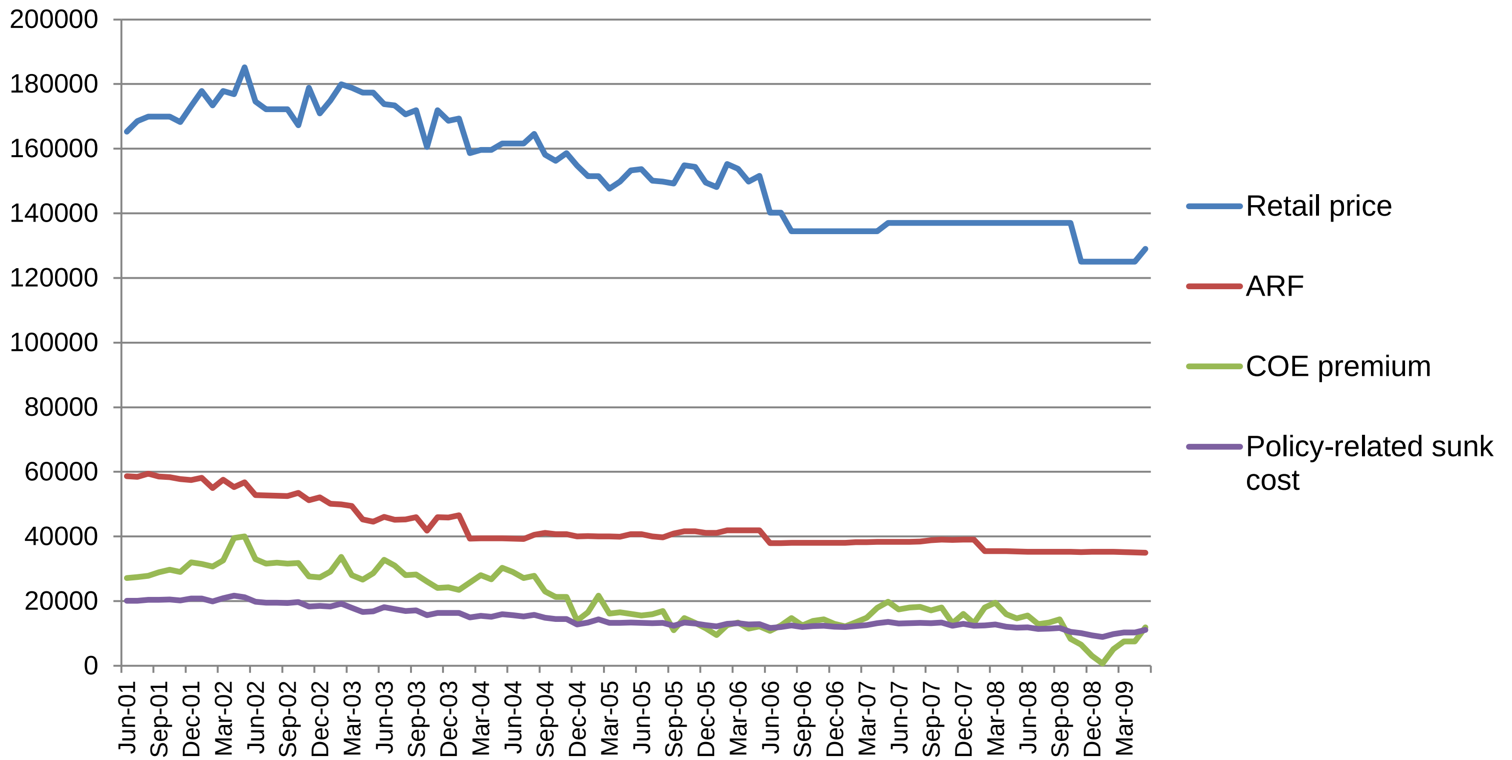


Hypothesis 5: Reduction in price – selection effect (H5.)

- Average price of two most popular models in our sample:

Year of Purchase	Model A	Model C
2003	$174,578	$212,140
2007	$145,347	$171,920

Model of driving behavior

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

Model of driving behavior

Standard model

- Usage in period t is q_t
- Driver's utility in period t,

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

- $V(q_t)$: Usage value
- $G(q_t, t)$: Gasoline cost
- $C(q_t, t)$: Congestion cost
- $D(t)$: Depreciation cost

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

$Notes: \theta_0, \theta_1, \theta_2, \beta_1, \beta_2, \gamma, \delta_0, \delta_1, \delta_2 > 0, \quad P \text{ is ex} - \text{policy price}$

Model of driving behavior

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

Usage value = $\theta_0 + (\theta_1 + \underbrace{e^{-\theta_2 t}}_{\text{Novelty effect}})q_t - \theta_3 q_t^2$

Gasoline cost = $\beta_1 g_t q_t$

Congestion cost = $\beta_2 c_t q_t$

Optimal usage – standard model

- Optimal usage in $t = 1, 2, \dots T$,

$$q_t^* = \frac{1}{2\theta_3}\{\theta_1 + e^{-\theta_2 t} - \beta_1 g_t - \beta_2 c_t\}$$

Incorporating sunk-cost fallacy

Psychological Sunk Cost

- ✓ 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

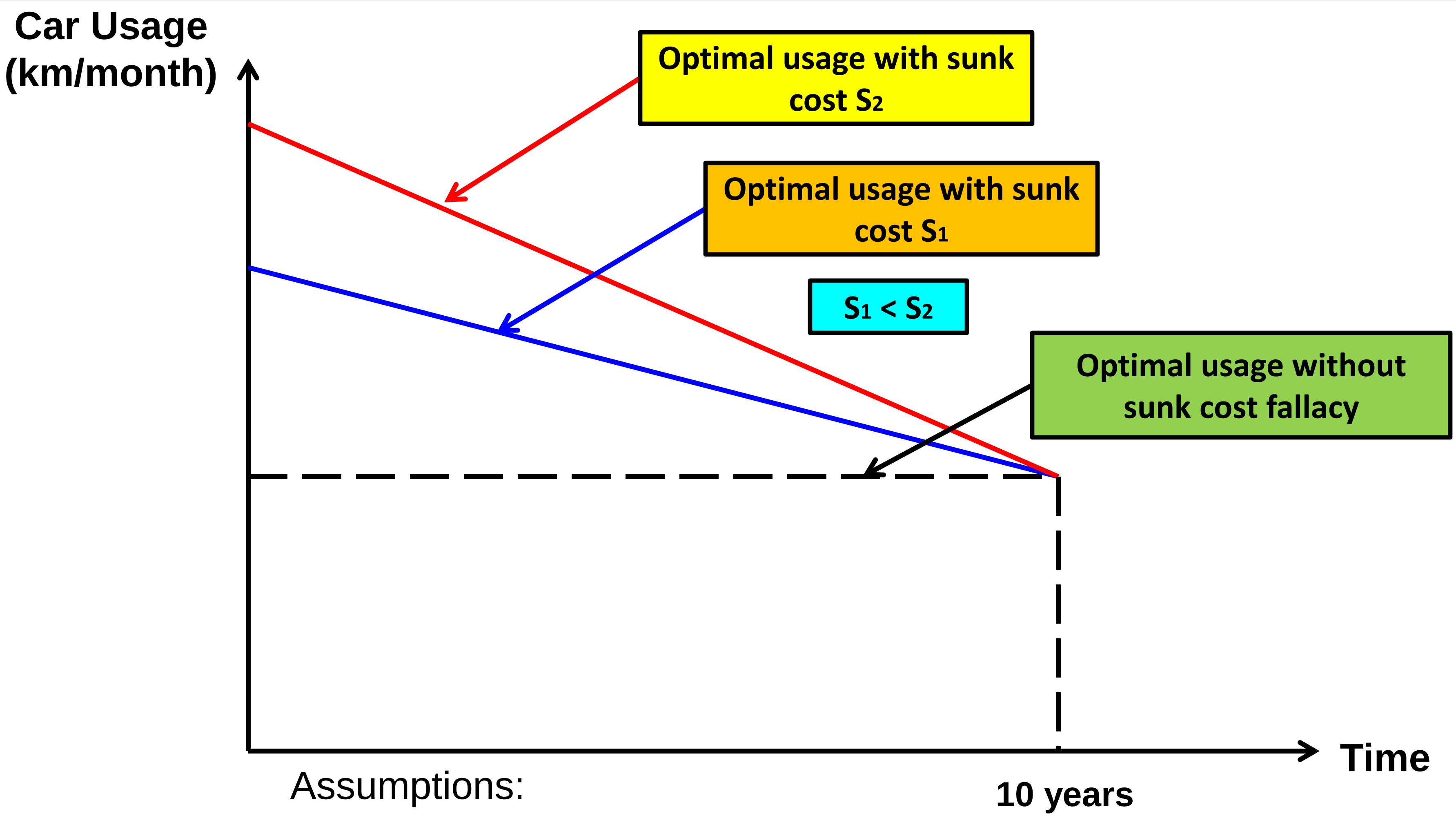
Optimal usage with sunk costs

- Optimal usage in $t = 1, 2, \ldots T$,

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

H1. **H2.** **H3.** **H4.** *(confounded by H5.)*

Diminishing effect of sunk-cost fallacy



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 λ.

Sunk cost definition

- 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:

$$\Delta q_{it}^{*} = \Delta e^{-\theta_2 t} - \beta_1 \Delta g_t - \beta_2 \Delta c_t - \frac{\lambda[\,0.25 \times ARF_i + 0.2 \times COE_i + s_0 P_i]}{\widehat{Q_i}} + \epsilon'_{it}$$

- $\lambda > 0$ 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

Alternative specifications for robustness check

- 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***):

  Usage value = $\exp(\mu.Total\ Price).(\theta_0 + \theta_1 q_t + e^{-\theta_2 t} q_t - \theta_3 q_t^2)$

- ✓ Alternative definition of sunk cost (specification ***d***):

  Sunk cost, $S = \alpha.Total\ Price,\ \alpha \in (0,1)$

- ✓ 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

Variable	(a) Convent-ional rationality	(b) Mental accounting for sunk cost	(c) Scaled marginal benefit	(d) Sunk cost proportional to retail price	(e) Smaller cars	(f) Larger cars	(g) Hetero-geneous target usage
Gasoline cost, β_1	-0.0001	-0.0003	-0.0006*	-0.0003	-0.0006*	-0.0001	-0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Congestion cost, β_2	0.027***	0.010***	0.009**	0.010***	0.011***	0.003	0.011***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
Age, θ_2	0.010***	0.004***	0.000	0.005***	0.003**	0.003**	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Sunk cost, λ		0.094***	0.237***		0.074***	0.060**	0.095***
		(0.012)	(0.031)		(0.011)	(0.022)	(0.008)
Sunk cost part of ex-policy price, α		0.125***	0.208***		0.233***	0.326*	0.094***
		(0.038)	(0.039)		(0.080)	(0.186)	(0.023)
Sunk cost, $\lambda\rho$				0.024***			
				(0.002)			
No. of observations	6474	6474	6474	6474	3581	2893	6474
Mean log likelihood	-2.77204	-2.752	-2.748	-2.755	-2.693	-2.819	-2.752
Log likelihood	-17946.2	-17815.1	-17788.7	-17833.8	-9643.3	-8155.7	-17819.2
Elasticity	n.a.	0.56***	0.64***	0.85***	0.53***	0.73***	0.51***
		(0.072)	(0.190)	(0.071)	(0.079)	(0.269)	(0.043)

Estimates: Controlling for Self-selection

Variable	(a) Convent-ional rationality	(b) Mental accounting for sunk cost	(c) Scaled marginal benefit	(d) Sunk cost proportional to retail price	(e) Smaller cars	(f) Larger cars	(g) Hetero-geneous target usage
Gasoline cost, β_1	-0.0001	-0.0003	-0.0006*	-0.0003	-0.0006*	-0.0001	-0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Congestion cost, β_2	0.027***	0.010***	0.009**	0.010***	0.011***	0.003	0.011***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
Age, θ_2	0.010***	0.004***	0.000	0.005***	0.003**	0.003**	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Sunk cost, λ		0.094***	0.237***		0.074***	0.060**	0.095***
		(0.012)	(0.031)		(0.011)	(0.022)	(0.008)
Sunk cost part of ex-policy price, α		0.125***	0.208***		0.233***	0.326*	0.094***
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		(0.072)	(0.190)	(0.071)	(0.079)	(0.269)	(0.043)

Estimates: Alternative Specification of Sunk Cost

Variable	(a) Conventional rationality	(b) Mental accounting for sunk cost	(c) Scaled marginal benefit	(d) Sunk cost proportional to retail price	(e) Smaller cars	(f) Larger cars	(g) Hetero-geneous target usage
Gasoline cost, β_1	-0.0001	-0.0003	-0.0006*	-0.0003	-0.0006*	-0.0001	-0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Congestion cost, β_2	0.027***	0.010***	0.009**	0.010***	0.011***	0.003	0.011***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
Age, θ_2	0.010***	0.004***	0.000	0.005***	0.003**	0.003**	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Sunk cost, λ		0.094***	0.237***		0.074***	0.060**	0.095***
		(0.012)	(0.031)		(0.011)	(0.022)	(0.008)
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		(0.072)	(0.190)	(0.071)	(0.079)	(0.269)	(0.043)

Estimates: Small versus Large Cars

Variable	(a) Convent-ional rationality	(b) Mental accounting for sunk cost	(c) Scaled marginal benefit	(d) Sunk cost proportional to retail price	(e) Smaller cars	(f) Larger cars	(g) Hetero-geneous target usage
Gasoline cost, β_1	-0.0001	-0.0003	-0.0006*	-0.0003	-0.0006*	-0.0001	-0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
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Sunk cost part		0.125***	0.208***		0.233***	0.326*	0.094***
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		(0.072)	(0.190)	(0.071)	(0.079)	(0.269)	(0.043)

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

Variable	(a) Conventional rationality	(b) Mental accounting for sunk cost	(c) Scaled marginal benefit	(d) Sunk cost proportional to retail price	(e) Smaller cars	(f) Larger cars	(g) Heterogeneous target usage
Gasoline cost, β_1	-0.0001	-0.0003	-0.0006*	-0.0003	-0.0006*	-0.0001	-0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Congestion cost, β_2	0.027***	0.010***	0.009**	0.010***	0.011***	0.003	0.011***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
Age, θ_2	0.010***	0.004***	0.000	0.005***	0.003**	0.003**	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
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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

Policy effect

- ✓ 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