

# Dynamic Heuristics

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# One Slide Summary

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- Daily petrol price data.

## Empirics:

- Describe heuristics in transaction-level data.
- Responses of heuristics & visits to price changes.



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Who cares about UK?

### CULTURE

**More Than 4.1 Billion Watch Queen's Funeral,  
Surpassing Every Royal Wedding**

BY JON JACKSON ON 9/19/22 AT 3:14 PM EDT



# Heuristics Important To Study

Decades of psychology literature studying **heuristics** 'mental rules-of-thumb used to simplify decisions'. Gilovich, Griffin & Kahneman, 12

Many economic studies find consumers use heuristics across domains:

- Naive diversification in pensions  
(e.g. Read & Loewenstein, 95; Benartzi & Thaler, 01)
- Left-digit bias in used car purchases  
(e.g. Lacetera, Pope, & Sydnor, 12)
- Balance-matching heuristic in credit cards  
(e.g. Gathergood, Mahoney, Stewart & Weber, 21)

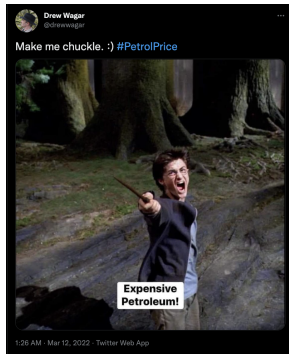
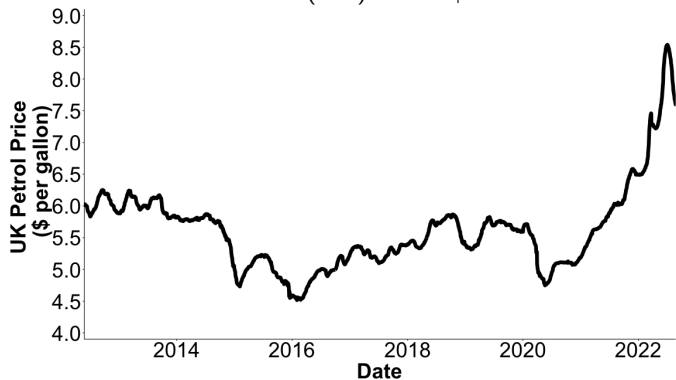
Heuristics in financial domains often find money non-fungible:

**Mental accounting** (e.g. Thaler, 85, 90, 99).

e.g. Hastings & Shapiro (13) evidence in US gas: when  $P \uparrow$ , choose regular-share more.

# UK consumers face volatile petrol prices. Large squeeze on consumer finances.

UK Petrol (Gas) Prices ↑ 82% 2020 to 2022 (Source: BEIS).



*In old money...peaked at 192 pence per litre in July 2022.*

# Institutional Details: How to Pay for Petrol in UK



- $P$  is price per litre.
- As you fill the  $(PQ)$  and  $Q$  (Litres) update.



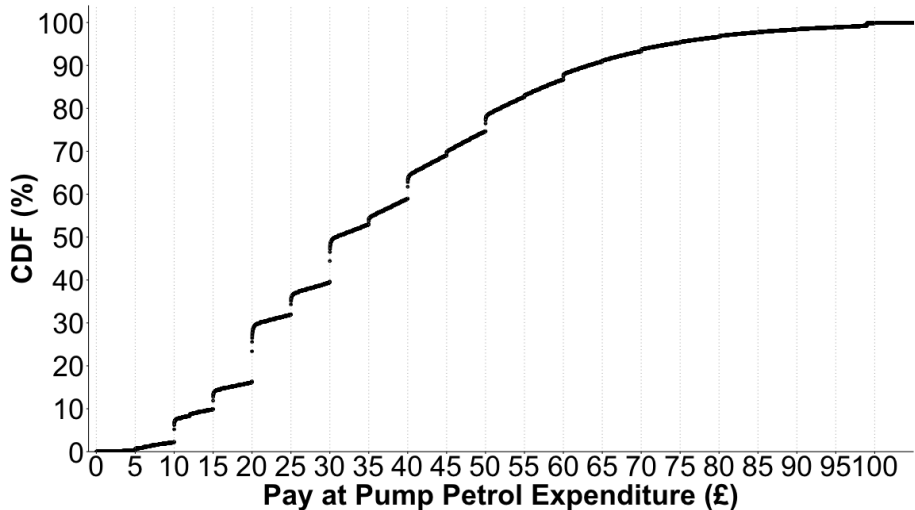
- No 'hold-open clips'. Need to physically keep holding to keep pumping. Can stop & restart.

Study using UK credit card transaction data where observe pay at pump expenditures & visits.



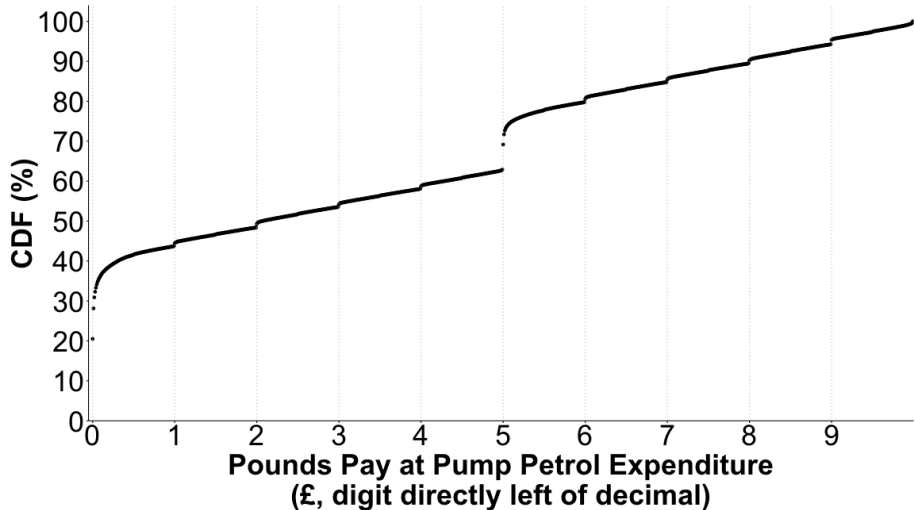
## Petrol Expenditures Commonly at Round Numbers

- Expenditures (XXX.XX)



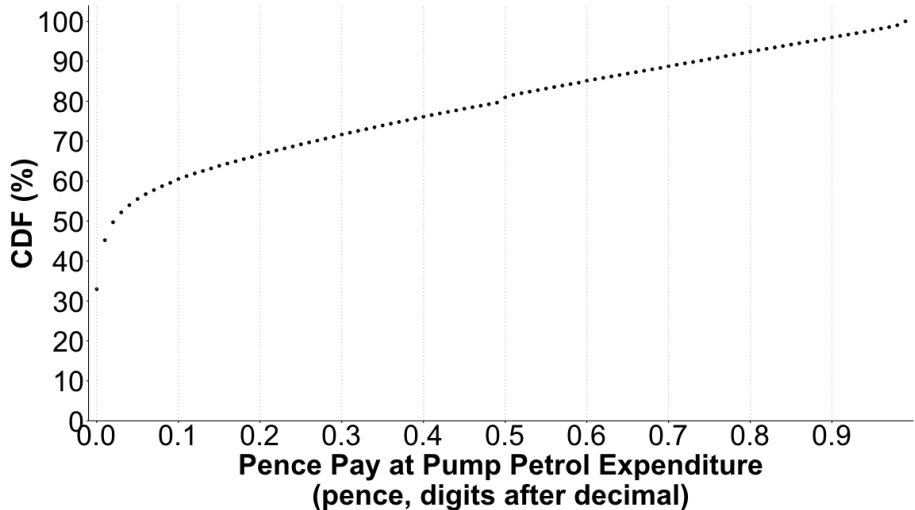
# UK Petrol (Gas) Expenditures Commonly at Round Numbers

- Pounds (X.XX)





# UK Petrol (Gas) Expenditures Commonly at Round Numbers

- Pence (.XX)




# External Validity Check

## British Reddit








0



 **r/britishproblems** · Posted by u/Robestos86 3 years ago

Decided to play where you're y get the pump as close as you can to a round number at the petrol station. Got it bang on £20 first try.


No one saw :(

 0 Comments  Share  Save  Hide  Report


50% Upvoted

 **r/britishproblems**

You can only whinge if it makes us chuckle

 Created Sep 8, 2011

**718k**  
Cold cups of tea

 **1.7k**  
Broken biscuits

- Replicates psychology study of 1,301 US pay at pump transactions at 1 convenience store in New York, 2005 (Ly, Flynn & Helion, 13).

# Empirical Facts on Round-Numbered Expenditures

## 1. Highly-prevalent

- 33% end in .00 (vs. 1% if chance).
- 50% end in .00, .01, .02 (vs. 3% if chance).

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- 27% end in 0.00 or 5.00 (vs. 0.2% if chance)
- 41% end in 0.00, 0.01, 0.02, 5.00, 5.01 or 5.02 (vs. 0.6% if chance)

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⇒ Targeting (PQ) ending in 5.00 or 0.00 is a common budgeting heuristic.

## Elasticity of heuristics ( $H$ ) to $P$ ?

Define  $H$  % using round-numbered heuristic.

Define Round-Numbered Heuristic if ( $PQ$ ) ending in 0.00 or 5.00 (can relax).

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3. **Stop Using Heuristic**  $\frac{\partial \log(H)}{\partial \log(P)} < 0$ 
  - If budget constraint binding, consume constrained max.
  - If budget constraint non-binding &  $E[P_{t+j}] > 0$  then switch to filling tank.
  - More attentive to budget.

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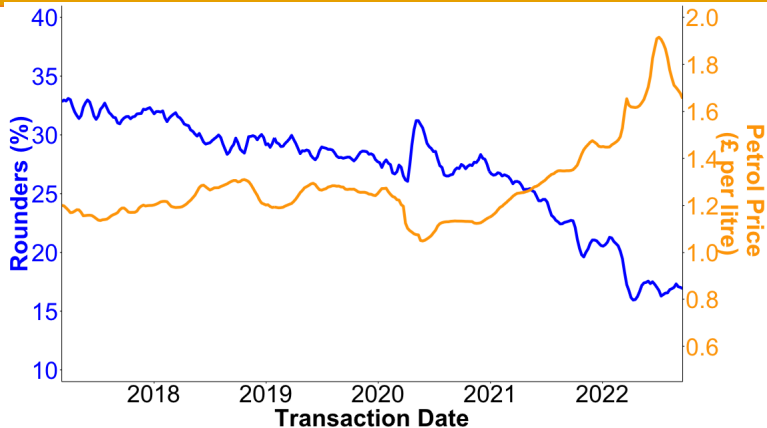
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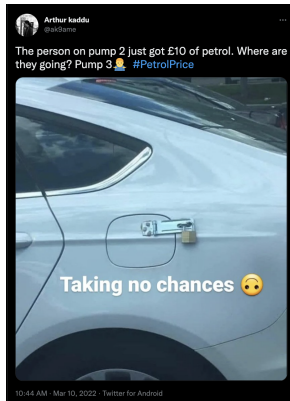
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4. **Start Using Heuristic**  $\frac{\partial \log(H)}{\partial \log(P)} > 0$ 
  - Consumers previously filling tank, become more attentive or consume constrained max.

# Weekly Petrol Prices (orange) Vs. Round Number Expenditures (blue)

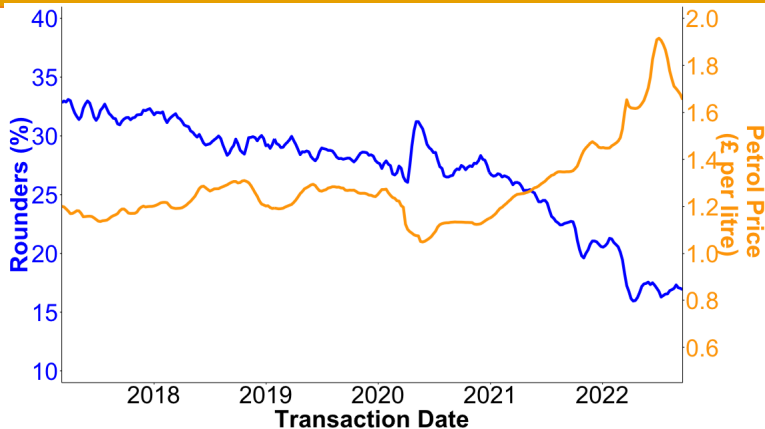


**Correlation: -0.86**



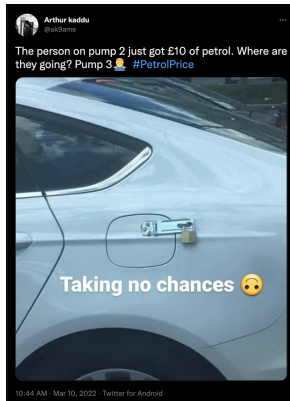


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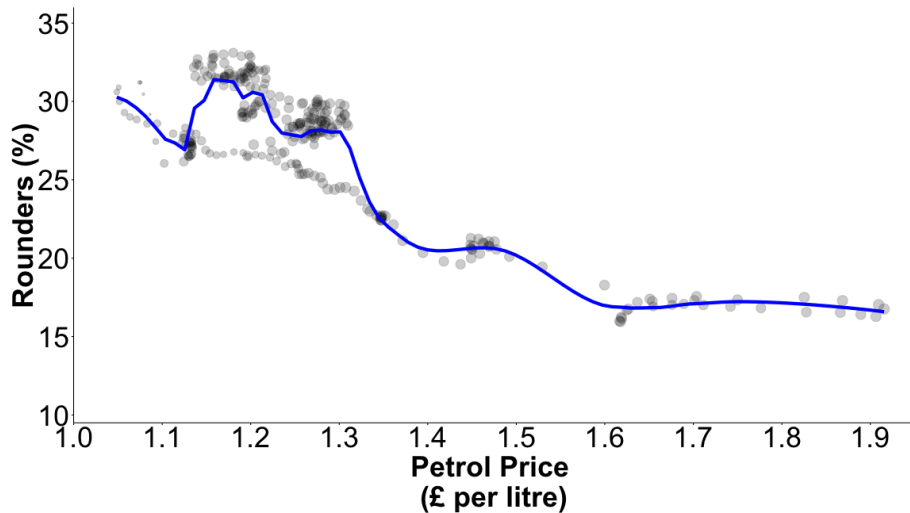


**Correlation: -0.86**

Relationship holds in regression with individual-level F.E.



## 'Demand' for Round Number Heuristics



## When $\uparrow P \Rightarrow$ Gas Station Visits $\uparrow$ 50%

Regression run separately for rounders (R) vs. non-rounders (NR).

$$Y_{i,t} = \delta \log(P_t) + \theta_i + u_{i,t}$$

	# visits in 28 days	
	Rounders (1)	Non-Rounders (2)
$\log(P_t)$	1.988*** (0.196)	1.232*** (0.084)
Baseline Mean	4.00	2.58
% Change	50%	48%

\*\*\* where significant at 0.1%. Balanced panel, August 2020 - 2022. S.E. clustered card & day.

'Rounders' defined as consumer rounded in days t-1 to t-29.

## So Far

- Consumers Use Round-Numbered Heuristics.
- Use of Heuristics Responds to Changes in Prices.
- When  $\uparrow$  Prices  $\Rightarrow$  Visits  $\uparrow$

## Not shown today:

- Ruled out alternative heuristics  
(e.g. Quantity-Targeting, % Tank-Targeting).
- Heuristics have similar estimated incomes. i.e. behavioral types.

Thank you!

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# Motivation in Literature

- **Petrol** macroeconomically important household expenditure (with volatile prices)  
(e.g. Hastings & Shapiro, 13; Lynn, Flynn & Helion, 13; Levin et al., 17; Gelman et al., 22; Gelman & Roussanov, 22)
- Large literature on **heuristics** / mental accounts...  
(e.g. Thaler, 85; Loewenstein & Prelec, 98; Heath, Larrick & Wu, 99; Pope & Simonsohn, 10; Lacetera, Pope & Sydnor, 12; Drexler, Fischer & Schoar, 14; Gathergood, Mahoney, Stewart & Weber, 19; Argyle, Nadauld & Palmer, 20; Köszegi & Matejka, 20; Dube, Manning & Naidu, 20; Akepanidtaworn, Di Mascio, Imas & Schmidt, 22; Strulov-Shlain, 22; Zhang, Sussman, Wang-Ly & Lyu, 22)  
...but little known about dynamics.  
(e.g. Hastings & Shapiro, 13; Thakral & Lo, 20)
- Large macroeconomics literature estimating **consumption** showing heterogeneity matters  
(e.g. Shapiro, 05; Parker, 14, Kaplan & Violante, 14; Kueng, 18; Ganong & Noel, 19; Fagereng, Holm & Natvik, 20, Havranek & Sokolova, 20; Ganong et al. 21; Golosov et al., 21)

## Hastings & Shapiro (13 QJE)

- Uses US data. (1) monthly aggregated national data and (2) transaction data from US grocery retailer with gasoline station: panel covers 2006 - 2009. Data includes fuel choice.
- When prices  $\uparrow$ , consumers substitute towards lower quality fuel.
- Effect larger than can be explained by income effects.
- Data most consistent with category budgeting (gas money non-fungible).

## Stylized Example

Suppose consumer uses petrol expenditure heuristic:

$$(PQ) = \text{£}30 \text{ each petrol station visit.}$$

**What happens when  $P \uparrow$ ?**



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  - Switch heuristic value e.g.  $(PQ) = \text{£}30$  to  $\text{£}20$  or  $\text{£}40$ , target  $Q$ , filling tank.
  - Stop filling tank  $\rightarrow$  start using heuristic.
3. **Change driving**  $\rightarrow \downarrow \#$  visits  
(e.g.  $\downarrow$  miles,  $\uparrow$  efficiency,  $\uparrow$  search for cheaper fuel).

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Petrol heuristic choice may also spill-over to non-petrol expenditures.

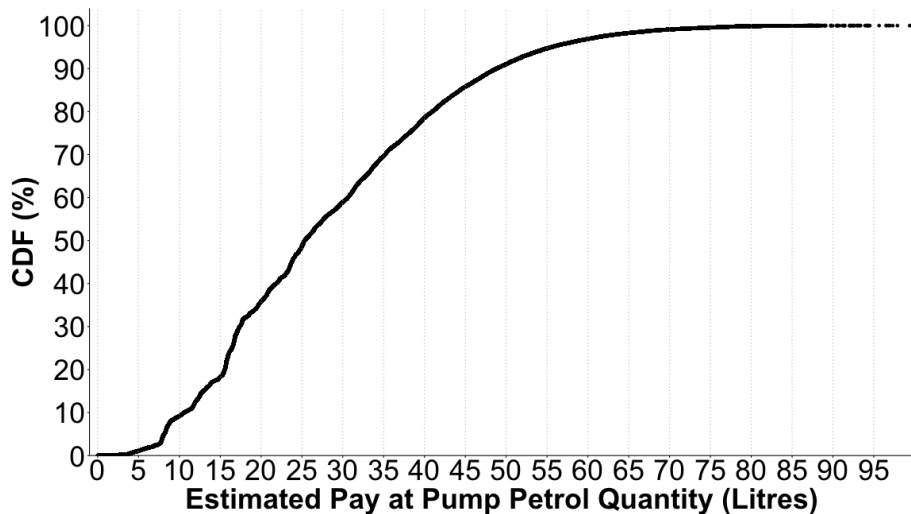
## 1. Real-time transaction data

- UK credit card expenditures (2017 - 2022).
- Data fully disaggregated at transaction-level (e.g. £30.00 spent at Shell on 5 January 2020.)
- Repeated cross-section. Additional data follows cards over time.
- Observe ( $PQ$ ), # visits. Imputing  $Q$  & max fuel tank capacity ( $L$ ).

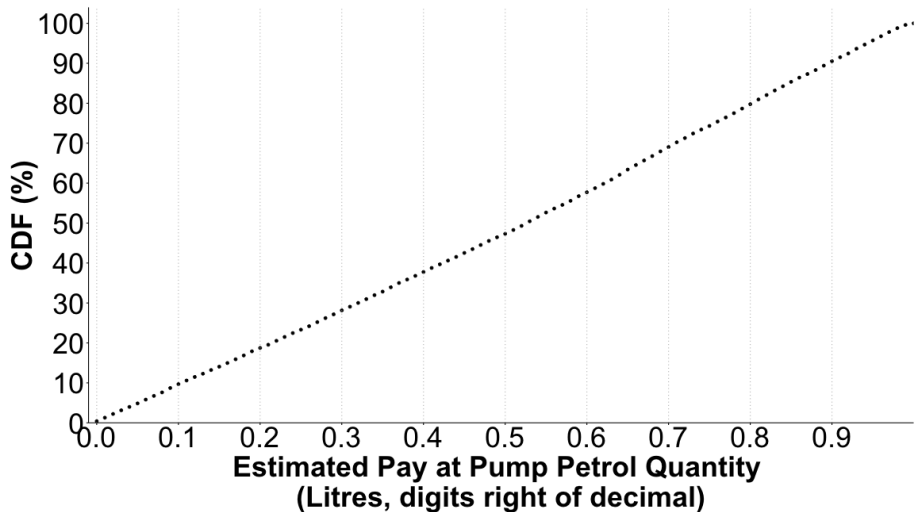
## 2. Petrol price data

- Daily (RAC Foundation) & weekly (BEIS) UK road fuel retail pump prices.

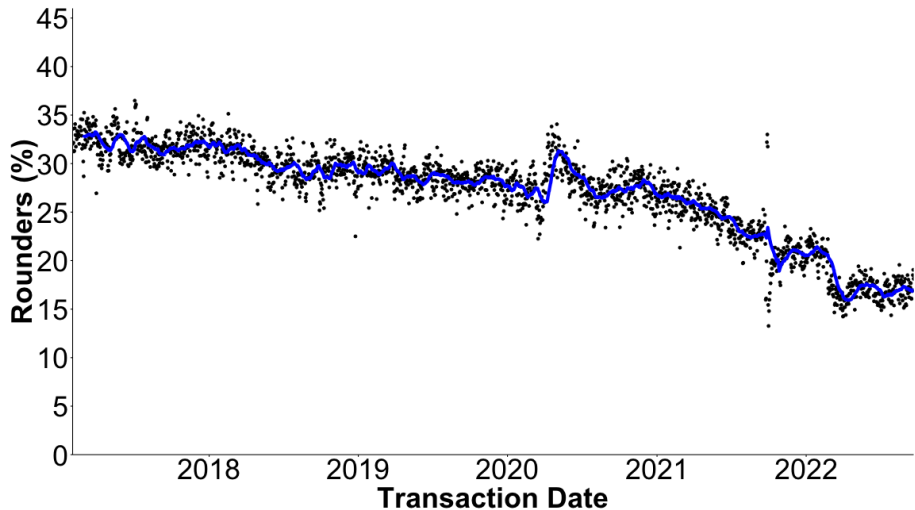
## Consumers Don't Appear to Be Targeting Round Numbers of Quantity



## Consumers Don't Appear to Be Targeting Round Numbers of Quantity - Linear in .XX



## Round Number Expenditures (% Pay at Pump Expenditures) Over Time



Rounders is 7 day moving average.



## Consumer Responses Estimated on Daily Balanced Panel

$$Y_{i,t} = \delta \log(P_t) + \theta_i + u_{i,t} \quad (1)$$

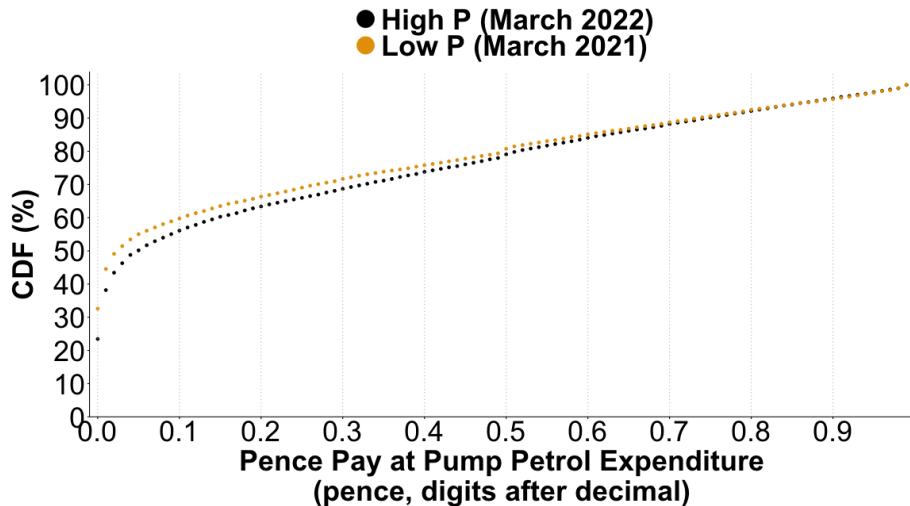
	<b>Heuristic</b>	<b>Visits</b>	<b>(PQ)</b>	$\hat{Q}$
$\log(P_t)$	-0.191*** (0.009)	0.009*** (0.002)	2.219*** (0.119)	-0.051 (0.082)
Baseline Mean	0.169	0.054	2.343	1.678
Card F.E.	X	X	X	X
$R^2$	0.26	0.02	0.02	0.05

\*\*\* where significant at 0.1%. Balanced panel, August 2020 - 2022. S.E. clustered card & day.

Heuristic estimated conditional on visit.

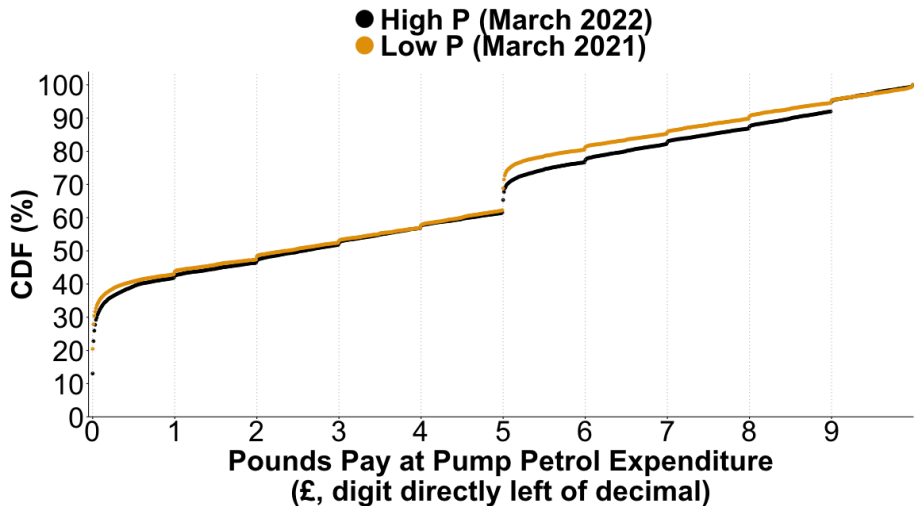
## Low vs. High P Comparison

- Pence (.XX)



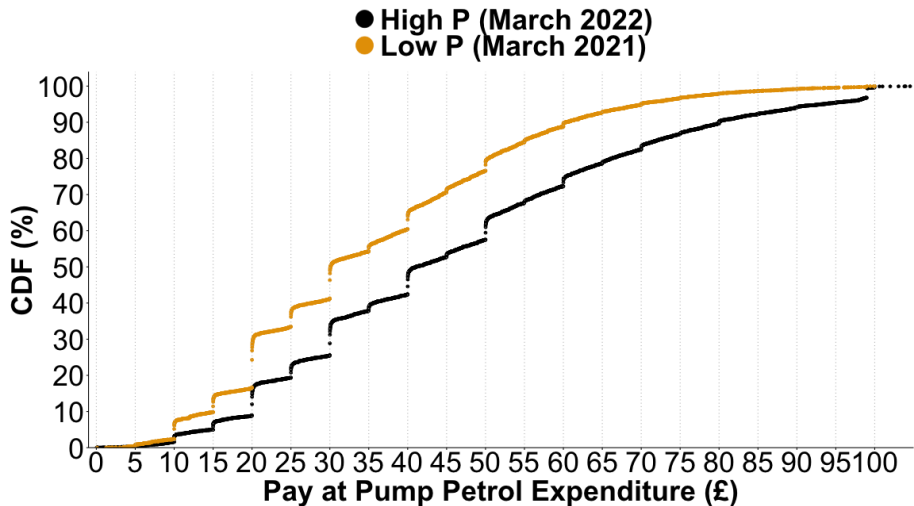
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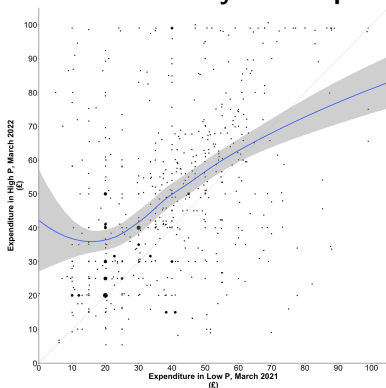
- Expenditures (XXX.XX)



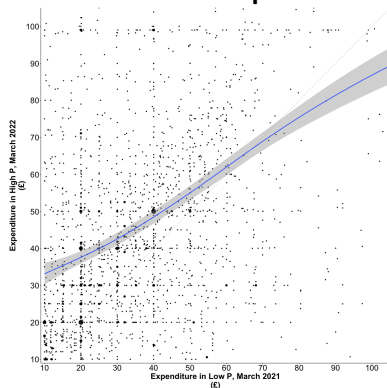
# What $(PQ)$ are consumers changing to? Within-person, 7-days 21 vs. 22

1.  $P \uparrow \rightarrow \Pr(H = 1) \downarrow$
2.  $P \uparrow \rightarrow (PQ) \uparrow$  and if still choose round number is generally larger one.

## NARROW: Pay at Pump



## BROAD: Petrol Expenditures



$\Delta P$  from £1.25 (March 2021) to £1.65 (March 2022) per litre.