# Formative Experiences and the Price of Gasoline

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# Motivation

Some people drive, some people do not. Why?

- Standard controls typically do not fully explain behavior.
- *Where do idiosyncratic differences in behavior come from?*

*Here*: **Formative** experiences during **narrow window** shape later-life behavior

- A positive gas price shock during ages 15-18 $\rightarrow$
  1. Less likely to drive to work as adult
  2. Drive less conditional on driving as adult
- Price *changes* (rather than levels) drive behavior
- Non-behavioral explanations do not explain differences (e.g., graduating into a recession, costly skill acquisition)

Contrasts with other, standard behavioral explanations:

- Recency bias (recent experiences drive perception) (Bronnenberg et al. 2012; Malmendier & Nagel 2011; Malmendier, Nagel, Shen 2018; Simonsohn 2006)
- Habit formation (cumulative behavior shapes preferences) (Pollak 1970; Becker & Murphy 1988)
- Mental plasticity during youth (Alesina & Giuliano 2011; Giuliano & Spilimbergo 2013)

# Motivation

Observe effect and interpret using several approaches

- Case study of 1970s oil crises
- Compare cohorts across states using all space-time variation in gas prices, exploit differences in min. driving age
- Contrast to cumulative exposure measures (Malmendier & Nagel 2011)
- Mediation analysis explores confounding channels; little effect
- Do not observe path dependent effects of skill acquisition shocks

Results relevant for other literatures:

- Enviro/Energy/Urban: Why do people drive (so much)?
- Behavior/Exp: Price levels vs. price shocks.
- Macro: Long-run demand effects of energy shocks.

# Roadmap

1. Case study: 1970s oil crises
2. Long run effects of gasoline price movements
3. Mediation and robustness
4. Formative window and cumulative experience
5. Mechanisms and interpretation

# Case study: 1970s oil crises

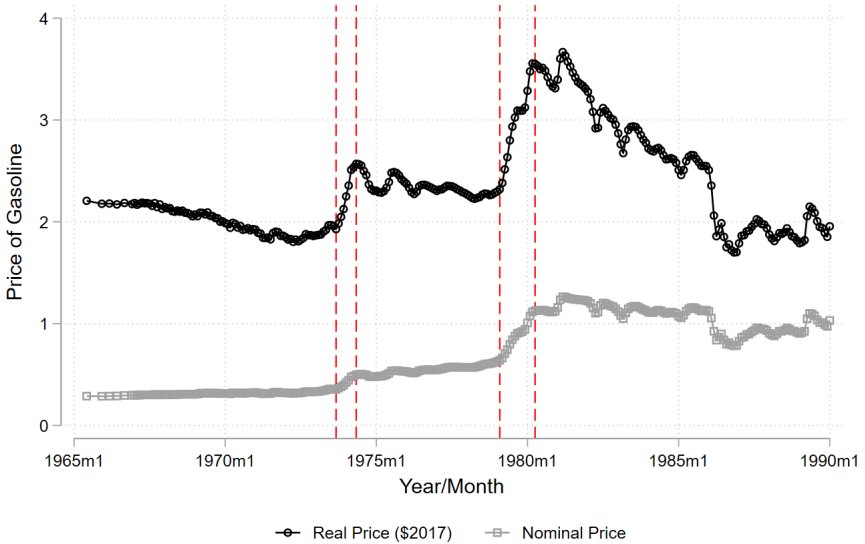
**Gas price shocks:** Unexpected, large increase in gasoline prices

- Two primary shocks: during 1973/4 and 1978/9
- Exogenous for teen drivers

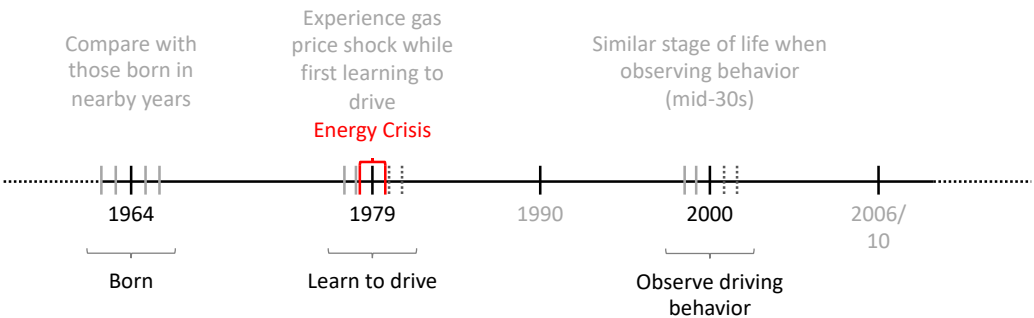
**Sample:** Compare 2000 driving/commuting behavior across cohorts

- Outcomes (Census Journey-to-Work):
  - 1[Drove in a car/truck/van to work]
  - 1[Car in household]
  - 1[Transit to work]
- All aged in mid-30s by 2000
- All face *same contemporaneous gas price* in 2000
- Age $\leftrightarrow$ Birth-year require specific interpretation in (pre-ACS) census
  - *Ex*: born 5/1964, age 35 in 4/2000 $\rightarrow$ appears born 1965 (=15 in 1980)
  - People are slightly older than they appear

# Gasoline Prices during 1970s

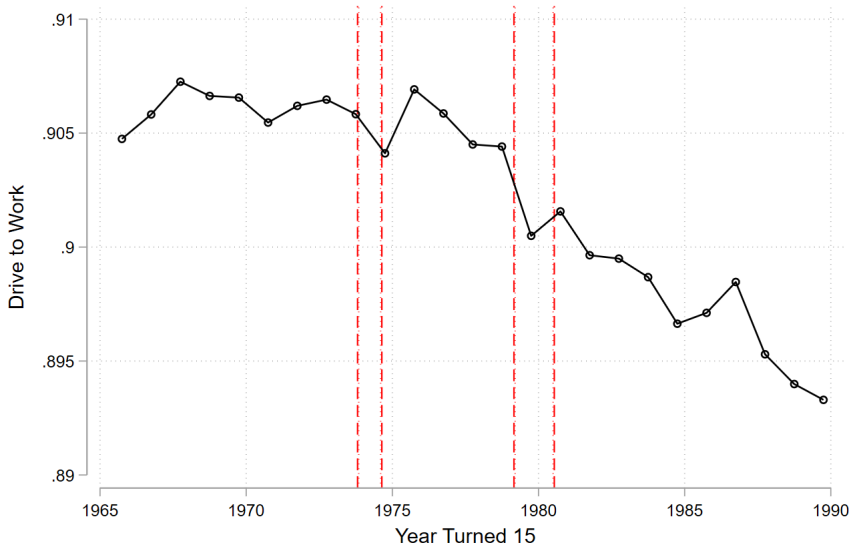


# Timing (e.g., 1978/9 crisis)



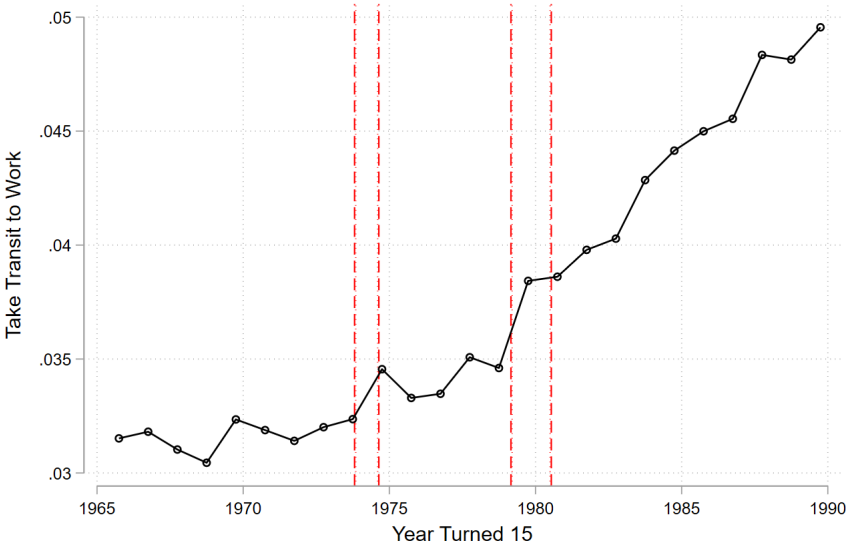
# Drive to Work in 2000

Employed and at work



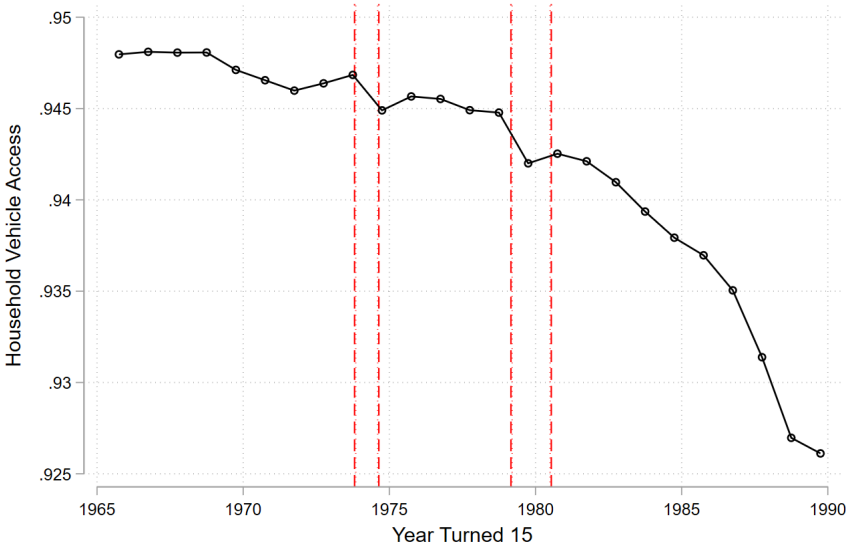
# Transit in 2000

Employed and at work



# No Car Access in 2000

All people




- Large declines in 15-in-late-80s group; in their mid-late 20s

# Event Study: The 1979/80 Oil Crisis

Event study/RD-in-time estimates:

- Turning 15 in 1980 or later $\rightarrow$ **(-0.21, -0.50)pp** drive in 2000

$\sim$50-100% substitution to **mass transit** (bus or rail)

Results robust to covariates

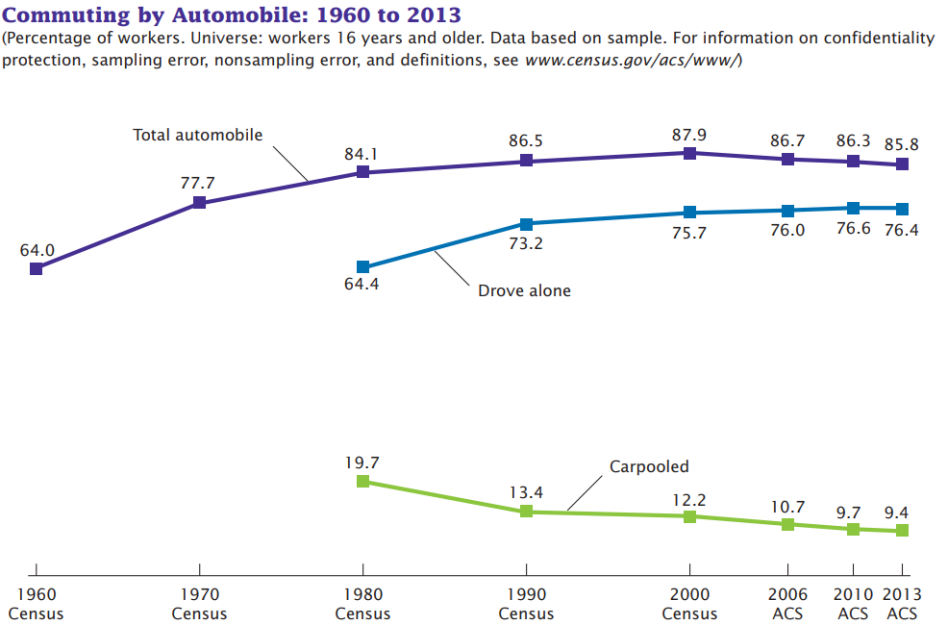
- Covariates here are tricky – many potential bad controls
- But help control for wealth, geography, etc.

Heterogeneity — effects strongest for

- Principal city (**urban core**) residents: (-0.9,-1.9)pp
- African Americans: (-0.7,-1.8)pp Details
- Lowest decile of income: -1.3pp Details

# Why is this notable?

Stable distribution of driving in U.S. since 1980 . . .



# Panel Analysis

Directly estimate effect of **teen gas price shocks** on later-life driving

- Pool all census/ACS data from 1980–2017
- State-by-year gasoline prices since 1966

Match to gas price in state of birth (Census), state of residence (Census/NHTS)

- Primary sample uses **stayers**: state of birth = state of residence (64%)
- Some specifications use everyone

Merge to formative ages in two ways:

i) by year turned $X = \{\dots, 15, 16, 17, \dots\}$ years old

ii) by $\pm 0, 1, 2, \dots$ years from minimum (full privilege) driving age

- introduces variation in formative window across states
- ... and over time (as regs change) ▸ DL ages over time

# Empirical design

$$Y_{icst} = \theta T_{cs} + \kappa_s + \delta_t + \eta_a + X'_{it}\lambda + \varepsilon_{icst}$$

Person $i$, of cohort $c$, in state $s$, sampled in (census/ACS) year $t$:

- Treatment $T_{cs}$ varies by cohort and state
- Fixed effects regime:
  - State FEs $\kappa_s$ – control for time-invariant differences across states
  - Sample year FEs $\delta_t$ – control for current gas prices, business cycles, etc.
  - Age FEs $\eta_a$ – capture life-cycle trends in transportation behavior
  - State-X-sample year FEs – capture local, contemporaneous shocks
- Covariates are still tricky ...

Identification: No latent differences between cohorts correlated with outcomes

- Add *quadratic birth year trends* for continuous changes across cohorts
- Further variation induced by minimum DL age
- Robustness + placebo tests + mediation analysis support causal statements
- Can relax with cohort FEs (some loss of power) ▸ Gas Price (random walk)

# Defining treatment

**Treatment:** levels or changes in the price of gas during formative years

$P_{cs}^{a}$: real price of gas at age $a$

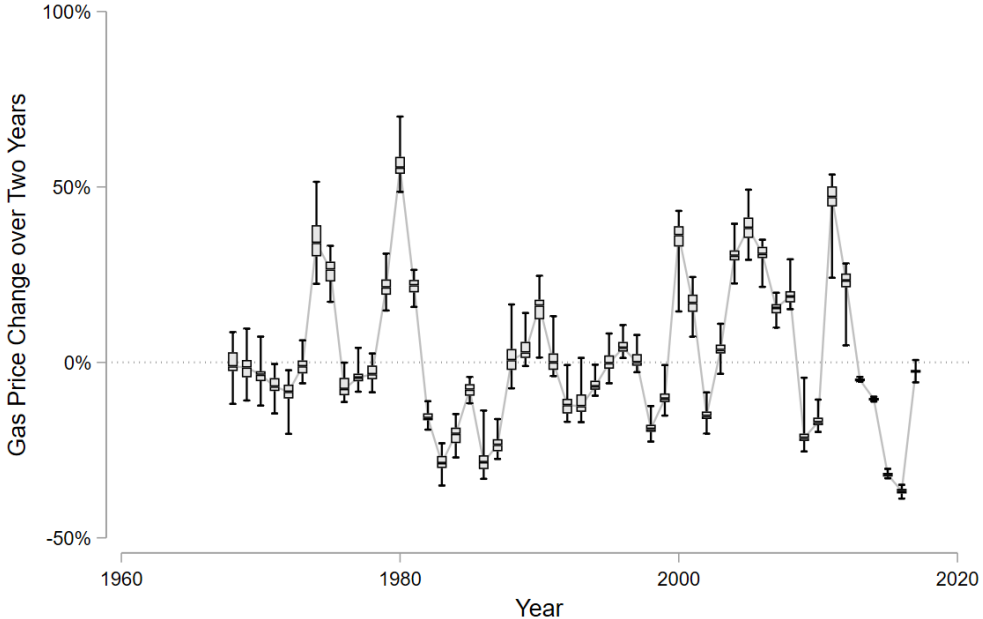
$$P_{cs}^{\Delta(a+j,a-k)} = \frac{P_{cs}^{a+j} - P_{cs}^{a-k}}{P_{cs}^{a}}$$

$P_{cs}^{m_{cs}}$: price at minimum driving age $m_{cs}$

$$P_{cs}^{\Delta(m_{cs}+j,m_{cs}-k)} = \frac{P_{cs}^{m_{cs}+j} - P_{cs}^{m_{cs}-k}}{P_{cs}^{m_{cs}}}$$

- Use 2-year window after able to drive (roughly 15-17)
  - Similar (but smaller) effects with 1-year window
- Look at levels, but changes wind up more important
- Use other ages as placebo

# Gasoline Price Fluctuations, 2-Year: $P_{cs}^{\Delta(year,year-2)}$



# Panel Results – Extensive Margin (Drive to Work)

| | 1[drive] (1) | 1[drive] (2) | 1[drive] (3) | 1[drive] (4) | 1[drive] (5) | 1[drive] (6) | 1[drive] (7) |
|---|---|---|---|---|---|---|---|
| $P_{cs}^{\Delta 17,15}$ | -0.0038*** | -0.0028** | -0.0031*** | -0.0037*** | -0.0039*** | -0.0039*** | -0.0043*** |
| | (0.0010) | (0.0008) | (0.0009) | (0.0010) | (0.0010) | (0.0010) | (0.0009) |
| $P_{cs}^{16}$ | -0.0007 | 0.0012+ | -0.0029*** | -0.0009 | -0.0011 | -0.0011 | -0.0011 |
| | (0.0010) | (0.0006) | (0.0007) | (0.0008) | (0.0009) | (0.0008) | (0.0008) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs}-1)}$ | -0.0041*** | -0.0038*** | -0.0040*** | -0.0040*** | -0.0040*** | -0.0042*** | -0.0045*** |
| | (0.0010) | (0.0008) | (0.0008) | (0.0011) | (0.0010) | (0.0011) | (0.0010) |
| $P_{cs}^{m_{cs}}$ | -0.0012 | 0.0006 | -0.0012 | -0.0013 | -0.0015 | -0.0015+ | -0.0015+ |
| | (0.0010) | (0.0006) | (0.0010) | (0.0009) | (0.0009) | (0.0008) | (0.0008) |
| Census year FEs | Y | Y | Y | Y | Y | - | - |
| State of birth FEs | Y | Y | Y | Y | Y | - | - |
| Age FEs | Y | Y | Y | Y | Y | Y | Y |
| Demographics | - | - | - | Y | Y | Y | Y |
| ln HH income | - | - | - | - | Y | Y | Y |
| State-X-Year FEs | - | - | - | - | - | Y | Y |
| Quad. birth year | - | - | - | - | - | - | Y |
| Price in state of | Birth | Birth | Res | Birth | Birth | Birth | Birth |
| Sample | Stay | All | All | Stay | Stay | Stay | Stay |

- Variation in formative window (DL age) increases strength
- ∼50-75% shift to transit Details

# Panel Results

Estimates slightly larger in magnitude than event-study

- **-0.4pp** versus **-0.5pp** $\times$ **60%**
- Robust to many different definitions of treatment
  - So long as between ages 15 and 18 ...
- Robust to dropping to 1979/80 cohorts

Similar effects when using cohort FEs

- Only when using DL-age merge (some loss of power) Details

Changes matter more than levels

- Frictions to skill acquisition
- Learning that driving expenses are volatile
- Negative shocks | levels increase present bias (Haushofer and Fehr 2019)

# Panel Results – Intensive Margin (VMT)

| | | | | | |
|---|---|---|---|---|---|
| $P_{cs}^{\Delta 17,15}$ | -0.0786** | -0.0822** | -0.0771** | -0.0773** | -0.0624* |
| | (0.0264) | (0.0260) | (0.0261) | (0.0259) | (0.0255) |
| $P_{cs}^{16}$ | 0.0213+ | 0.0202+ | 0.0190+ | 0.0198+ | 0.0032 |
| | (0.0109) | (0.0110) | (0.0109) | (0.0111) | (0.0096) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs}-1)}$ | -0.0502* | -0.0567** | -0.0470* | -0.0478* | -0.0344+ |
| | (0.0193) | (0.0197) | (0.0201) | (0.0204) | (0.0196) |
| $P_{cs}^{m_{cs}}$ | 0.0147 | 0.0127 | 0.0108 | 0.0108 | -0.0027 |
| | (0.0120) | (0.0120) | (0.0117) | (0.0118) | (0.0107) |
| NHTS year FEs | Y | Y | Y | - | - |
| State FEs | Y | Y | Y | - | - |
| Age FEs | Y | Y | Y | Y | Y |
| Controls | - | Y | Y | Y | Y |
| Income-by-Yr Bin FEs | - | - | Y | Y | Y |
| State-X-Yr FEs | - | - | - | Y | Y |
| Quad. birth year | - | - | - | - | Y |

- Again, changes matter more than levels
- Change in vehicle choice? Details
  - Gallons-per-mile: no effect, but noisily measured
  - 1[light-duty truck]: modest suggestive evidence for negative effect

# Interpreting the Results

## Extensive margin

Negative, long-run wage effects of coming of age during recession (Oreopoulus et al. 2012; Stuart 2019)

- Recessions often associated with large gas price movements

**Are results due to an indirect effect of 'unlucky' timing into adulthood?**

1. Controlling for contemporaneous income barely changes $\hat{\theta}$
2. Dropping those coming of age around 1979 barely changes $\hat{\theta}$
   - 1979/80 recession more about oil prices than others
3. Mediation: *Do unemployment at age 18 or current wage explain effect?*
   - Unemployment rate at age 18 explains 0% of effect
   - Income channel explains 2-24% of effect

Most of the effect is **not** due to income (or correlates)

- Points to a preference channel

# Mediation Analysis

Jointly model both

- Joint effect of gas price shock $T$ and mediator $M$ on driving $Y$
- Effect of gas price shock $T$ on mediator $M$

$$\begin{pmatrix} Y \\ M \end{pmatrix} = \begin{pmatrix} \theta^Y \\ \theta^M \end{pmatrix} T + \begin{pmatrix} \gamma \\ 0 \end{pmatrix} M + \begin{pmatrix} \delta^Y \\ \delta^M \end{pmatrix} X + \begin{pmatrix} \epsilon^Y \\ \epsilon^M \end{pmatrix}$$

- $\theta^Y$ – *Direct effect* of $T$ on $Y$
- $\theta^M$ – Strength of confounding channel
- $\gamma\theta^M$ – *Indirect effect* of $T$ on $Y$ through $M$
- $\theta^Y + \gamma\theta^M$ – *Total effect* of $T$ on $Y$ from all channels

Two different mediators meant to capture potential scarring:

- Unemployment rate in state of treatment at age 18 (likely exogeneous)
- Contemporaneous income (less exogenous)

Interpret as providing data-consistent bounds on alternative stories

# Mediation Analysis

| Mediator ($M$): | Unempl. Rate at 18 | | Household income | | Wage income | | Personal income | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **Effects of $M$ and $T$ on $Y$** | 1[drive] | 1[drive] | 1[drive] | 1[drive] | 1[drive] | 1[drive] | 1[drive] | 1[drive] |
| $\theta^Y$ | -0.0042*** | -0.0044*** | -0.0038*** | -0.0041*** | -0.0032** | -0.0037** | -0.0031** | -0.0037** |
| | (0.0011) | (0.0010) | (0.0010) | (0.0011) | (0.0009) | (0.0010) | (0.0011) | (0.0012) |
| $\gamma$ | 0.0001 | 0.0000 | 0.0223*** | 0.0223*** | 0.0170*** | 0.0170*** | 0.0216*** | 0.0216*** |
| | (0.0002) | (0.0002) | (0.0024) | (0.0024) | (0.0045) | (0.0045) | (0.0044) | (0.0045) |
| **Effect of $T$ on $M$** | $M$ | $M$ | $\ln(M)$ | $\ln(M)$ | $\ln(M)$ | $\ln(M)$ | $\ln(M)$ | $\ln(M)$ |
| $\theta^M$ | 1.0286*** | 0.0451 | -0.0053 | -0.0062+ | -0.0488*** | -0.0371*** | -0.0460*** | -0.0335*** |
| | (0.2875) | (0.3481) | (0.0034) | (0.0036) | (0.0034) | (0.0034) | (0.0035) | (0.0033) |
| Direct effect ($\theta^Y$) | -0.0042*** | -0.0044*** | -0.0038*** | -0.0041*** | -0.0032** | -0.0037** | -0.0031** | -0.0037** |
| | (0.0011) | (0.0010) | (0.0010) | (0.0011) | (0.0009) | (0.0010) | (0.0011) | (0.0012) |
| Indirect effect ($\gamma\theta^M$) | 0.0001 | 0.0000 | -0.0001 | -0.0001 | -0.0008** | -0.0006** | -0.0010*** | -0.0007*** |
| | (0.0002) | (0.0000) | (0.0001) | (0.0001) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Total effect ($\theta^Y + \gamma\theta^M$) | -0.0041*** | -0.0044*** | -0.0040*** | -0.0042*** | -0.0040*** | -0.0043*** | -0.0041*** | -0.0044*** |
| | (0.0010) | (0.0010) | (0.0010) | (0.0010) | (0.0008) | (0.0043) | (0.0010) | (0.0010) |
| Treatment definition ($T$) | $P_{cs}^{\Delta 17,15}$ | $P_{cs}^{\Delta(m_{cs}\pm 1)}$ | $P_{cs}^{\Delta 17,15}$ | $P_{cs}^{\Delta(m_{cs}\pm 1)}$ | $P_{cs}^{\Delta 17,15}$ | $P_{cs}^{\Delta(m_{cs}\pm 1)}$ | $P_{cs}^{\Delta 17,15}$ | $P_{cs}^{\Delta(m_{cs}\pm 1)}$ |

# Placebo Tests – the Formative Window

| | Extensive margin | | Intensive margin | |
|---|---|---|---|---|
| | 1[drive] (1) | 1[drive] (2) | ln(VMT) (3) | ln(VMT) (4) |
| $P_{cs}^{\Delta 13,12}$ | | -0.0007 | | -0.0633 |
| | | (0.0018) | | (0.0587) |
| $P_{cs}^{\Delta 14,13}$ | -0.0002 | -0.0002 | 0.0009 | 0.0084 |
| | (0.0015) | (0.0016) | (0.0334) | (0.0415) |
| $P_{cs}^{\Delta 15,14}$ | -0.0002 | -0.0003 | 0.0162 | 0.0002 |
| | (0.0019) | (0.0022) | (0.0433) | (0.0450) |
| $P_{cs}^{\Delta 16,15}$ | -0.0057** | -0.0057** | -0.1012* | -0.0929+ |
| | (0.0019) | (0.0021) | (0.0480) | (0.0520) |
| $P_{cs}^{\Delta 17,16}$ | -0.0027+ | -0.0026 | -0.0795+ | -0.0960* |
| | (0.0015) | (0.0017) | (0.0413) | (0.0411) |
| $P_{cs}^{\Delta 18,17}$ | -0.0024 | -0.0023 | -0.0847* | -0.0658+ |
| | (0.0017) | (0.0019) | (0.0386) | (0.0384) |
| $P_{cs}^{\Delta 19,18}$ | -0.0013 | -0.0013 | -0.0545 | -0.0712 |
| | (0.0017) | (0.0018) | (0.0495) | (0.0465) |
| $P_{cs}^{\Delta 20,19}$ | | -0.0006 | | -0.0143 |
| | | (0.0019) | | (0.0458) |
| Sample year FEs | Y | Y | Y | Y |
| State FEs | Y | Y | Y | Y |
| Age FEs | Y | Y | Y | Y |

Significant effects concentrate between ages 15 and 18

- No significant effects at younger ages
- Smaller, mostly insignificant effects at older ages
- Similar pattern across extensive and intensive margin!

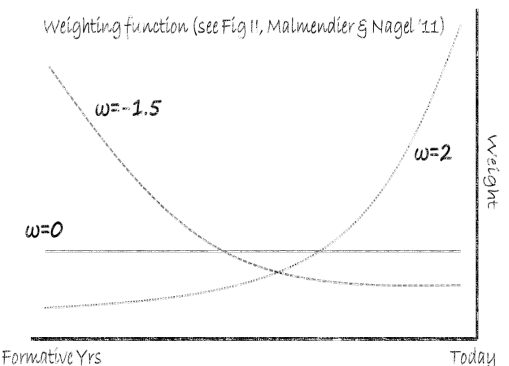
# Cumulative Exposure Function

Malmendier & Nagel (2011) propose a cumulative exposure function

- Weights a vector of experiences (monotonically)
- Parameter determines whether weights are increasing/decreasing/flat
- We adapt to our setting (we exploit **state-level** variation in $T$)
  - Using prior results, exposure 'turns on' at age 15

$$Y_{icst} = \beta A_{cst}(\omega, \mathbf{T}_{st}) + \kappa_s + \delta_t + \eta_a + X'_{it}\lambda + \varepsilon_{icst}$$

$$A_{cst}(\omega, \mathbf{T}_{st}) = \sum_{k=15}^{\text{age}_{ct}-1} \frac{(k-14)^{\omega} \times T_{s,t-(\text{age}_{ct}-k)}}{\sum_{k=15}^{\text{age}_{ct}-1}(k-14)^{\omega}}$$



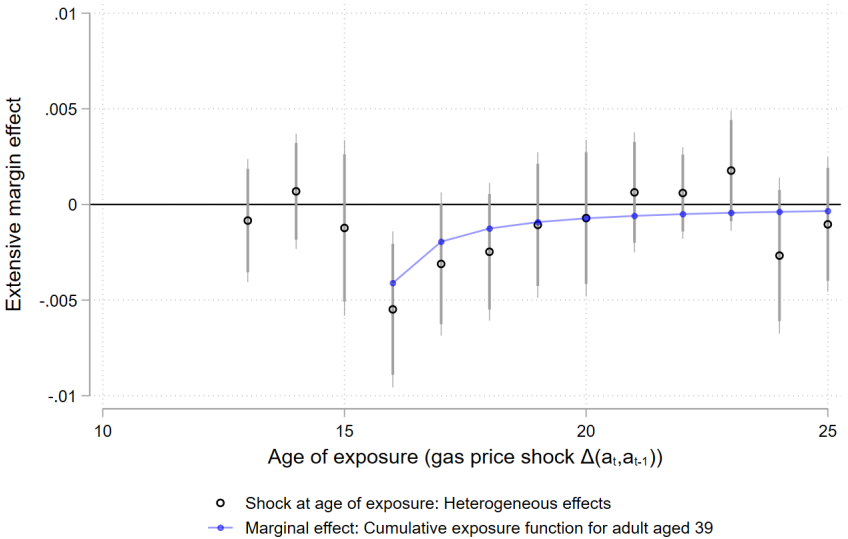
# Cumulative Exposure Function – Results

| | Extensive margin | Intensive margin |
|---|---|---|
| | 1[drive] | ln(VMT) |
| | (1) | (2) |
| $\beta$ $(A_{cst}(\omega, \mathbf{P}_s^{\Delta 1yr}))$ | -0.0140** | -0.6796*** |
| | (0.0045) | (0.1809) |
| $\omega$ (shape) | -1.0786*** | -0.3294* |
| | (0.2796) | (0.1617) |
| Sample year FEs | Y | Y |
| State FEs | Y | Y |
| Age FEs | Y | Y |

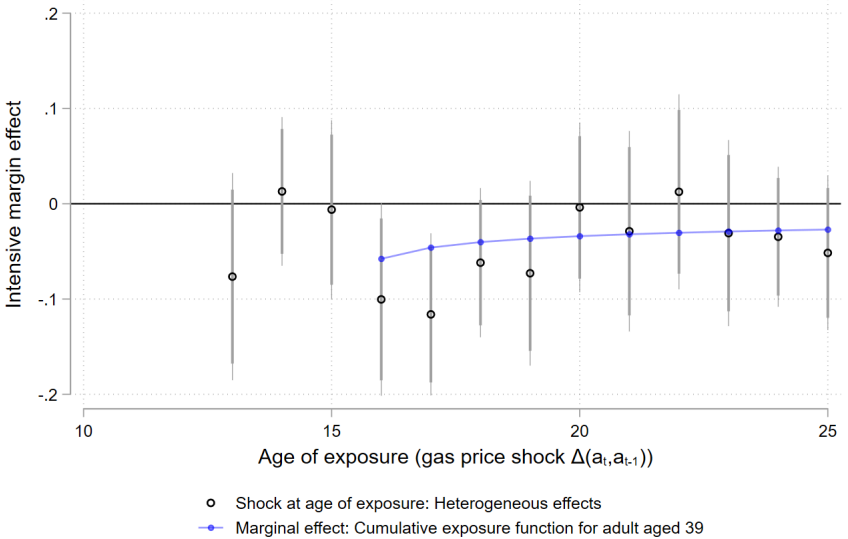
- Estimation via NLLS with grid-search for starting values
- Magnitude is specific to current age (ave. is 39) and age-at-exposure $k$
- To translate:

$$\frac{\partial Y_{icst}}{\partial T_{s,t-(\text{age}_{ct}-k)}} = \theta_{[k]} = \beta \times \frac{(k-14)^{\omega}}{\sum_{k=15}^{\text{age}_{ct}-1}(k-14)^{\omega}}$$

# Placebo Tests & Cumulative Exposure Function (Extensive)



# Placebo Tests & Cumulative Exposure Function(Intensive)



# Mechanism – Did Fewer People Learn How to Drive?

Learning to drive is costly (time, vehicles, and fuel)

- Especially in U.S., driver learning takes placed during teen years
- Parental/family inputs important

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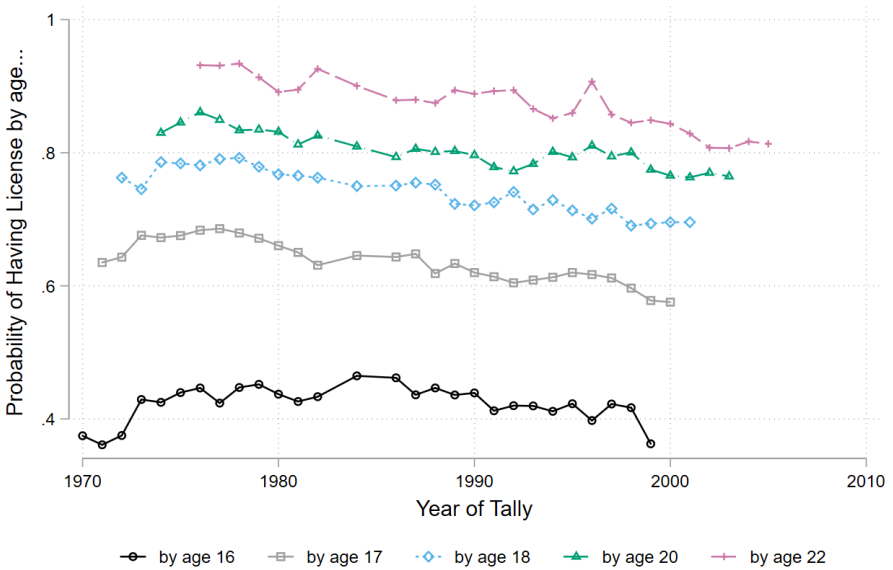
Do higher learning costs (due to gasoline price shocks) keep people from learning to drive in the long run?

**Probably not** (if so, not quantitatively large)

1. No straightforward explanation for intensive margin effect
2. No strong evidence teens reduce take up of licenses around '79 crisis
3. Explicit minimum driver licensing age requirements do not have negative effect on later-life driving rates

# Driver License Uptake




**Data:** FHWA DL-220 (2016) "Licensed Drivers, by Sex and Age Group" (data from 1963 to 2016; 1983 and 1985 imputed). SEER data on population by age

# Effects of Driver Licensing Restrictions

If increasing costs delay licensing, and fewer people learn to drive, **explicit minimum age requirements** likely do the same

We test for the effect of the full-privilege and intermediate minimum driving age on later-life driving and VMT

- Misc. changes in the 70s and 80s
- Widespread GDL adoption starting in the mid-90s

Legal restrictions **more extreme** than gas price hikes

- Youngsters caught driving without a license can be disallowed a license until the age of 18 in most states
- If legal minimum driving age has no effect, unlikely that gas prices affect driving through reduced license takeup

# Effects of Driver Licensing Restrictions

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **Extensive (1[drive])** | | | | | | |
| Minimum Full Privilege Age | 0.0078 | 0.0048 | 0.0071 | 0.0072 | 0.0082+ | 0.0092 |
| | (0.0052) | (0.0040) | (0.0047) | (0.0048) | (0.0048) | (0.0056) |
| Minimum Intermediate License Age | -0.0107 | -0.0088 | -0.0091 | -0.0097 | -0.0137 | -0.0124 |
| | (0.0147) | (0.0122) | (0.0136) | (0.0138) | (0.0127) | (0.0121) |
| Sample | Stay | All | Stay | Stay | Stay | Stay |
| **Intensive (ln(person VMT))** | | | | | | |
| Minimum Full Privilege Age | 0.0012 | | 0.0010 | -0.0030 | -0.0108 | 0.0196 |
| | (0.0129) | | (0.0132) | (0.0159) | (0.0182) | (0.0143) |
| Minimum Intermediate License Age | -0.0269 | | -0.0239 | -0.0270 | -0.0007 | 0.0239 |
| | (0.0651) | | (0.0565) | (0.0592) | (0.0699) | (0.0588) |
| Sample year FEs | Y | Y | Y | Y | - | - |
| State FEs | Y | Y | Y | Y | - | - |
| Age (FEs) | Y | Y | Y | Y | Y | Y |
| Dem. Controls | - | - | Y | Y | Y | Y |
| Income controls | - | - | - | Y | Y | Y |
| State-X-Yr FEs | - | - | - | - | Y | Y |
| Quad. birth year | - | - | - | - | - | Y |

- Combined effect on 1[drive] of raising age by one year is small-ish
- Combined VMT coefficients small relative to doubling of gas prices
- Therefore, our earlier effects most likely reflect a shift in preferences

# Summary, Interpretation, Conclusion

Gas price shocks during early driving years (15-18) alter later life travel behavior

- Results robust to observable controls and mechanisms (e.g., graduating into recession)
- Price changes matter more than levels
- Skill acquisition costs do not appear to explain

**Formative experiences** inconsistent with standard explanations:

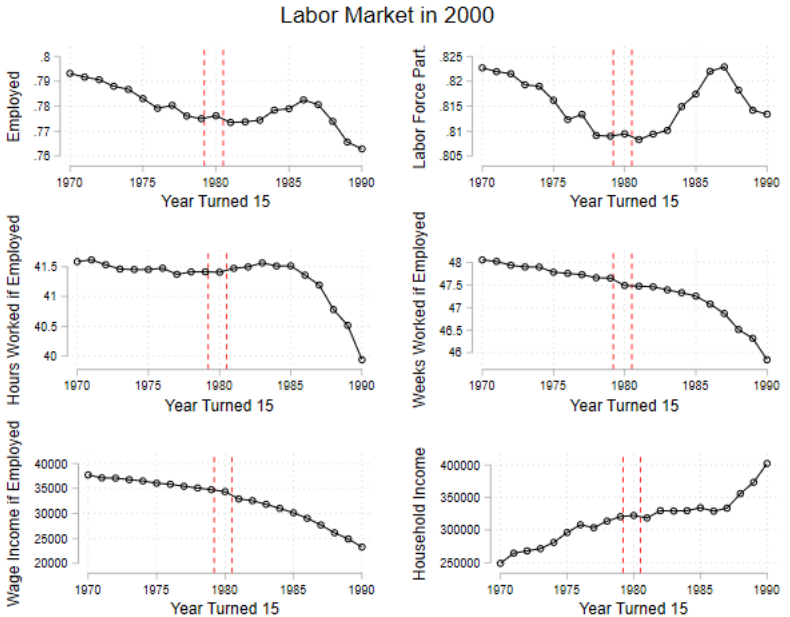
- Recency bias overweights recent experience, not distant past
- Habit formation would depend on (total) cumulative exposure (flat or increasing weights on exposure)
  - Past price levels might matter, but not price changes
- Mental plasticity posits a decade-long era of impressionable years, not a narrow window

Initial consumer experiences can 'imprint' future behavior

- Formative experiences can be more important than subsequent experiences

**Thank you!**

# The 1979/80 Oil Crisis – Covariate Smoothness




Back

# The 1979/80 Oil Crisis – with Covariates

Event study estimates without covariates: -0.21 to -0.50pp

| Model | Poly. order | Bandwidth (years) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Panel A: Effect on driving, no controls* | | | | | | | | | | |
| | 1 | -0.0050* | -0.0029+ | -0.0026+ | -0.0032** | -0.0026* | -0.0027** | -0.0032** | -0.0032** | -0.0029** |
| | | (0.0022) | (0.0016) | (0.0014) | (0.0012) | (0.0011) | (0.0010) | (0.0009) | (0.0009) | (0.0008) |
| | 2 | | | | -0.0033 | -0.0039* | -0.0032+ | -0.0021 | -0.0027+ | -0.0032* |
| | | | | | (0.0022) | (0.0019) | (0.0016) | (0.0015) | (0.0014) | (0.0013) |
| *Panel B: Effect on driving, controls:* | | | | | | | | | | |
| *+ demographics* | 1 | -0.0046* | -0.0025 | -0.0023+ | -0.0029* | -0.0025* | -0.0024* | -0.0028** | -0.0026** | -0.0021* |
| | | (0.0022) | (0.0016) | (0.0014) | (0.0012) | (0.0011) | (0.0010) | (0.0009) | (0.0009) | (0.0008) |
| | 2 | | | | -0.0028 | -0.0035+ | -0.0030+ | -0.0020 | -0.0026+ | -0.0034** |
| | | | | | (0.0022) | (0.0018) | (0.0016) | (0.0015) | (0.0014) | (0.0013) |
| *Panel C: Effect on driving, controls:* | | | | | | | | | | |
| *+ demographics, state of birth FEs* | 1 | -0.0046* | -0.0023 | -0.0019 | -0.0025* | -0.0020+ | -0.0019+ | -0.0022* | -0.0020* | -0.0014+ |
| | | (0.0022) | (0.0016) | (0.0013) | (0.0012) | (0.0011) | (0.0010) | (0.0009) | (0.0009) | (0.0008) |
| | 2 | | | | -0.0027 | -0.0031+ | -0.0027+ | -0.0019 | -0.0024+ | -0.0030* |
| | | | | | (0.0021) | (0.0018) | (0.0016) | (0.0015) | (0.0014) | (0.0013) |
| *Panel D: Effect on driving, controls:* | | | | | | | | | | |
| *+ demographics, state of birth FEs* | 1 | -0.0046* | -0.0022 | -0.0018 | -0.0024* | -0.0019+ | -0.0017+ | -0.0021* | -0.0019* | -0.0013 |
| *+ ln(income)* | | (0.0022) | (0.0016) | (0.0013) | (0.0012) | (0.0011) | (0.0010) | (0.0009) | (0.0009) | (0.0008) |
| | 2 | | | | -0.0027 | -0.0030+ | -0.0026 | -0.0018 | -0.0023 | -0.0029* |
| | | | | | (0.0021) | (0.0018) | (0.0016) | (0.0015) | (0.0014) | (0.0013) |
| *N* | | 545k | 811k | 1075k | 1343k | 1614k | 1888k | 2148k | 2398k | 2642k |

Back

# The 1979/80 Oil Crisis – Other Outcomes

| Poly. order | Bandwidth (years) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| *Panel A: Transit usage* | | | | | | | | | |
| 1 | 0.0036* | 0.0027* | 0.0027** | 0.0023** | 0.0017* | 0.0016* | 0.0016** | 0.0015** | 0.0018** |
| | (0.0015) | (0.0011) | (0.0009) | (0.0008) | (0.0007) | (0.0007) | (0.0006) | (0.0006) | (0.0005) |
| 2 | | | | 0.0038** | 0.0037** | 0.0030** | 0.0023* | 0.0024** | 0.0018* |
| | | | | (0.0014) | (0.0012) | (0.0011) | (0.0010) | (0.0009) | (0.0009) |
| *N* | 545k | 811k | 1075k | 1343k | 1614k | 1888k | 2148k | 2398k | 2642k |
| *Panel B: No vehicle access* | | | | | | | | | |
| 1 | 0.0033* | 0.0026* | 0.0020* | 0.0016+ | 0.0009 | 0.0007 | 0.0005 | -0.0002 | -0.0012* |
| | (0.0016) | (0.0011) | (0.0010) | (0.0008) | (0.0008) | (0.0007) | (0.0007) | (0.0006) | (0.0006) |
| 2 | | | | 0.0037* | 0.0034** | 0.0027* | 0.0023* | 0.0028** | 0.0034** |
| | | | | (0.0015) | (0.0013) | (0.0012) | (0.0011) | (0.0010) | (0.0009) |
| *N* | 698k | 1038k | 1376k | 1717k | 2061k | 2409k | 2739k | 3058k | 3370k |

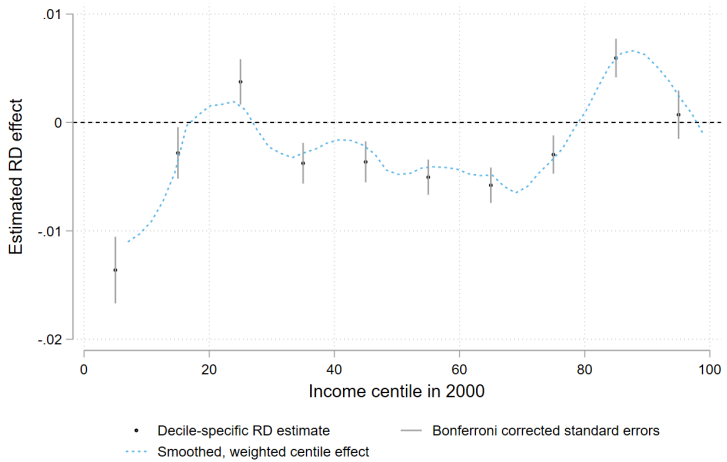
Back

# The 1979/80 Oil Crisis – Subgroup Analysis

| Model | Poly. order | Bandwidth (years) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Panel A: Effect on driving* | | | | | | | | | | |
| *Sample: Principal city* | 1 | -0.0185* | -0.0120+ | -0.0108* | -0.0124** | -0.0092* | -0.0061 | -0.0090* | -0.0096** | -0.0094** |
| | | (0.0089) | (0.0065) | (0.0054) | (0.0047) | (0.0043) | (0.0039) | (0.0037) | (0.0035) | (0.0033) |
| | 2 | | | | -0.0157+ | -0.0167* | -0.0163* | -0.0087 | -0.0085 | -0.0096+ |
| | | | | | (0.0085) | (0.0073) | (0.0065) | (0.0059) | (0.0055) | (0.0051) |
| | *N* | 62k | 92k | 122k | 154k | 187k | 220k | 252k | 283k | 313k |
| *Panel B: Effect on driving* | | | | | | | | | | |
| *Sample: Not in metro* | 1 | -0.0030 | 0.0004 | 0.0000 | 0.0013 | 0.0008 | 0.0014 | 0.0002 | 0.0003 | 0.0006 |
| | | (0.0042) | (0.0030) | (0.0025) | (0.0022) | (0.0020) | (0.0019) | (0.0017) | (0.0017) | (0.0016) |
| | 2 | | | | -0.0016 | 0.0003 | -0.0002 | 0.0022 | 0.0013 | 0.0006 |
| | | | | | (0.0041) | (0.0035) | (0.0031) | (0.0028) | (0.0026) | (0.0024) |
| | *N* | 114k | 170k | 225k | 280k | 336k | 393k | 447k | 500k | 552k |
| *Panel C: Effect on driving* | | | | | | | | | | |
| *Sample: Black* | 1 | -0.0168* | -0.0099 | -0.0107* | -0.0107* | -0.0067+ | -0.0052 | -0.0048 | -0.0019 | 0.0002 |
| | | (0.0083) | (0.0061) | (0.0050) | (0.0045) | (0.0040) | (0.0037) | (0.0035) | (0.0033) | (0.0031) |
| | 2 | | | | -0.0145+ | -0.0176* | -0.0144* | -0.0118* | -0.0135** | -0.0136** |
| | | | | | (0.0080) | (0.0068) | (0.0061) | (0.0056) | (0.0052) | (0.0048) |
| | *N* | 57k | 84k | 111k | 139k | 166k | 193k | 220k | 245k | 270k |
| *Panel D: Effect on driving* | | | | | | | | | | |
| *Sample: No college* | 1 | -0.0037 | -0.0017 | -0.0022 | -0.0027* | -0.0020+ | -0.0023* | -0.0028** | -0.0023* | -0.0016+ |
| | | (0.0025) | (0.0018) | (0.0015) | (0.0014) | (0.0012) | (0.0011) | (0.0011) | (0.0010) | (0.0009) |
| | 2 | | | | -0.0021 | -0.0033 | -0.0022 | -0.0016 | -0.0027+ | -0.0036* |
| | | | | | (0.0025) | (0.0021) | (0.0019) | (0.0017) | (0.0016) | (0.0015) |
| | *N* | 394k | 585k | 774k | 965k | 1157k | 1350k | 1534k | 1711k | 1883k |

Back

# The 1979/80 Oil Crisis – Subgroup Analysis by Income




Estimated with a 5 year window and linear trends in time.

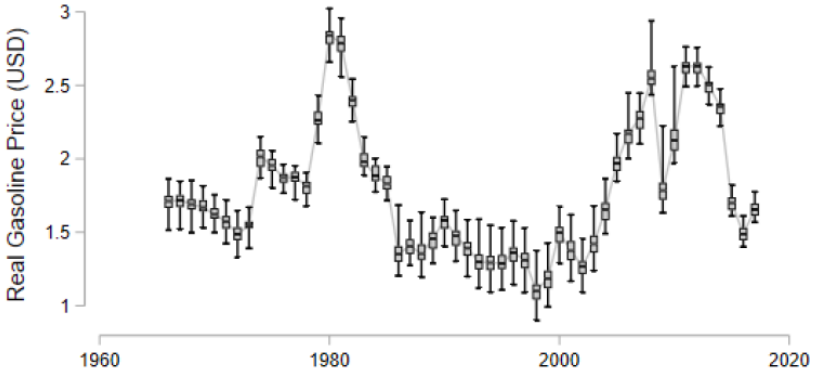
Back

# Minimum Driver Licensing Ages

| Year | [14,14.5) | [14.5,15.5) | [15.5,16.5) | [16.5,17.5) | [17.5,18] |
|---|---|---|---|---|---|
| **Minimum Full Privilege License Age** | | | | | |
| 1970 | 1 | 5 | 38 | 4 | 3 |
| 1980 | 0 | 5 | 39 | 5 | 2 |
| 1990 | 0 | 5 | 39 | 5 | 2 |
| 2000 | 0 | 2 | 24 | 18 | 7 |
| 2010 | 0 | 0 | 4 | 32 | 15 |
| **Minimum Provisional License Age** | | | | | |
| 1970 | 2 | 7 | 39 | 3 | 0 |
| 1980 | 2 | 7 | 40 | 2 | 0 |
| 1990 | 1 | 7 | 41 | 2 | 0 |
| 2000 | 1 | 4 | 41 | 5 | 0 |
| 2010 | 1 | 2 | 39 | 9 | 0 |
| **Learner's Permit Minimum Age** | | | | | |
| 1972 | 8 | 18 | 24 | 1 | 0 |
| 1980 | 8 | 21 | 22 | 0 | 0 |
| 1988 | 7 | 22 | 22 | 0 | 0 |
| 1994 | 6 | 24 | 21 | 0 | 0 |
| 2010 | 6 | 25 | 20 | 0 | 0 |

Back

# Gasoline Prices in Levels




Back

# Panel Results – Extensive Margin (Other Outcomes)

| | Transit Usage | | Vehicle Available | | | |
|---|---|---|---|---|---|---|
| | 1[transit] (1) | 1[transit] (2) | 1[vehicle] (3) | 1[vehicle] (4) | 1[vehicle] (5) | 1[vehicle] (6) |
| $P_{cs}^{\Delta 17,15}$ | 0.0029*** | 0.0024** | -0.0014 | -0.0009 | -0.0019* | -0.0018** |
| | (0.0007) | (0.0009) | (0.0008) | (0.0006) | (0.0009) | (0.0006) |
| $P_{cs}^{16}$ | 0.0001 | 0.0004 | 0.0004 | 0.0007 | -0.0007 | -0.0001 |
| | (0.0007) | (0.0005) | (0.0007) | (0.0005) | (0.0009) | (0.0007) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs})}$ | 0.0028* | 0.0021 | -0.0025 | -0.0023+ | -0.0019 | -0.0022 |
| | (0.0012) | (0.0013) | (0.0016) | (0.0013) | (0.0016) | (0.0013) |
| $P_{cs}^{m_{cs}}$ | 0.0006 | 0.0008 | 0.0001 | 0.0003 | -0.0008 | -0.0005 |
| | (0.0007) | (0.0005) | (0.0007) | (0.0005) | (0.0008) | (0.0006) |
| Census year FEs | Y | - | Y | - | Y | - |
| State of birth FEs | Y | - | Y | - | Y | - |
| Age FEs | Y | Y | Y | Y | Y | Y |
| Demographics | - | Y | - | Y | - | Y |
| ln HH income | - | Y | - | Y | - | Y |
| State-X-Year FEs | - | Y | - | Y | - | Y |
| Quad. birth year | - | Y | - | Y | - | Y |
| Sample | Empl | Empl | Empl | Empl | All | All |

Back

# Panel Results – Cohort FEs

Back

| | 1[drive] (1) | 1[drive] (2) | 1[drive] (3) | 1[drive] (4) |
|---|---|---|---|---|
| **2-year price change** | | | | |
| $P_{cs}^{\Delta(m_{cs}+2,m_{cs})}$ | -0.0041+ | -0.0039+ | -0.0038+ | -0.0037+ |
| | (0.0023) | (0.0021) | (0.0021) | (0.0020) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs}-1)}$ | -0.0016 | -0.0016 | -0.0012 | -0.0017 |
| | (0.0019) | (0.0019) | (0.0019) | (0.0019) |
| **1-year price change** | | | | |
| $P_{cs}^{\Delta(m_{cs}+2,m_{cs}+1)}$ | -0.0057* | -0.0053* | -0.0054* | -0.0048* |
| | (0.0024) | (0.0022) | (0.0021) | (0.0021) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs})}$ | -0.0019 | -0.0018 | -0.0016 | -0.0019 |
| | (0.0025) | (0.0025) | (0.0025) | (0.0025) |
| $P_{cs}^{\Delta(m_{cs},m_{cs}-1)}$ | -0.0009 | -0.0009 | -0.0004 | -0.0008 |
| | (0.0024) | (0.0023) | (0.0024) | (0.0024) |
| **Levels** | | | | |
| $P_{cs}^{m_{cs}}$ | -0.0013 | -0.0015 | -0.0020 | -0.0022 |
| | (0.0026) | (0.0024) | (0.0024) | (0.0019) |
| Census year FEs | Y | Y | Y | Y |
| State of birth FEs | Y | Y | Y | Y |
| Age FEs | Y | Y | Y | Y |
| Birth year FEs | Y | Y | Y | Y |
| Demographics | - | Y | Y | Y |
| ln HH income | - | - | Y | Y |
| State-X-year FEs | - | - | - | Y |

# Effect on Vehicle Efficiency and Type

| | Gallons per mile | | | | Truck, SUV, etc. | | | |
|---|---|---|---|---|---|---|---|---|
| | Ave GPM (1) | Ave GPM (2) | GPM (3) | GPM (4) | Any Big (5) | Any Big (6) | 1[Big] (7) | 1[Big] (8) |
| $P_{cs}^{\Delta(18,16)}$ | -0.0000 | -0.0001 | -0.0001 | -0.0001 | -0.0265** | -0.0245* | -0.0193* | -0.0194+ |
| | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0095) | (0.0101) | (0.0092) | (0.0097) |
| $P_{cs}^{\Delta(17,15)}$ | 0.0000 | -0.0002 | -0.0002 | -0.0003 | -0.0213+ | -0.0173 | -0.0155 | -0.0141 |
| | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0111) | (0.0112) | (0.0106) | (0.0104) |
| $P_{cs}^{\Delta(m_{cs}+2,m_{cs})}$ | 0.0001 | 0.0001 | -0.0001 | -0.0000 | -0.0203* | -0.0169+ | -0.0141 | -0.0110 |
| | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0090) | (0.0085) | (0.0094) | (0.0085) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs}-1)}$ | -0.0002 | -0.0003 | -0.0003 | -0.0004 | -0.0238+ | -0.0209 | -0.0193 | -0.0179 |
| | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0126) | (0.0125) | (0.0117) | (0.0116) |
| NHTS year FEs | Y | - | Y | - | Y | - | Y | - |
| State FEs | Y | - | Y | - | Y | - | Y | - |
| Age FEs | Y | Y | Y | Y | Y | Y | Y | Y |
| Demographic Controls | - | Y | - | Y | - | Y | - | Y |
| Income-by-Yr Bin FEs | - | Y | - | Y | - | Y | - | Y |
| State-X-Yr FEs | - | Y | - | Y | - | Y | - | Y |
| Vehicle Age | - | - | Y | Y | - | - | Y | Y |
| Quad. Vehicle year | - | - | Y | Y | - | - | Y | Y |
| Sample | Person | Person | Vehicle | Vehicle | Person | Person | Vehicle | Vehicle |

Back

# Persistence

| | Extensive | | Intensive | |
|---|---|---|---|---|
| | 1[drive] (1) | 1[drive] (2) | ln(VMT) (3) | ln(VMT) (4) |
| $P_{cs}^{\Delta 17,15} \times$ | | | | |
| 1[25-34] | -0.0050** | -0.0054*** | -0.0890* | -0.0552 |
| | (0.0018) | (0.0013) | (0.0433) | (0.0425) |
| 1[35-44] | -0.0001 | 0.0006 | -0.0529 | -0.0328 |
| | (0.0014) | (0.0014) | (0.0578) | (0.0524) |
| 1[45-54] | -0.0050*** | -0.0054*** | -0.0925+ | -0.1111* |
| | (0.0014) | (0.0013) | (0.0516) | (0.0497) |
| $P_{cs}^{\Delta(m_{cs}+1,m_{cs}-1)} \times$ | | | | |
| 1[25-34] | -0.0031* | -0.0039* | -0.0464 | -0.0279 |
| | (0.0015) | (0.0015) | (0.0341) | (0.0323) |
| 1[35-44] | -0.0038* | -0.0019 | -0.0595 | -0.0581 |
| | (0.0019) | (0.0014) | (0.0479) | (0.0474) |
| 1[45-54] | -0.0056** | -0.0069** | -0.0445 | -0.0406 |
| | (0.0019) | (0.0020) | (0.0427) | (0.0425) |
| Sample year FEs | Y | Y | Y | Y |
| State FEs | Y | Y | Y | Y |
| Age FEs | Y | Y | Y | Y |
| Demographics | - | Y | - | Y |
| Income | - | Y | - | Y |
| State-X-Year FEs | - | Y | - | Y |
| Quad. birth year | - | Y | - | Y |

Back

# Habit Formation

**Is this just habit formation at work?** Consider simple model ($d$, driving)

$$\max_{c,d} U(c_t, d_t, d_{t-1}) \text{ s.t. } c_t + p_t^d d_t \leq I$$

Model predictions

1. $d_{t-1} \to d_t$
2. $p_{t-1}^d \to d_{t-1} \to d_t$
3. $p_{t-1}^d | d_{t-1} \not\to d_t$

We see:

- Past prices matter, even conditional on past use ~~(3)~~
- Price shocks matter more than price levels
- Intensive and extensive margins effects
- Don't see past consumption effect ~~(2)~~
- Shock only matters in a narrow window