# How Durable are Durables?

– In Progress –

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- Two ways the economics literature has thought about this
  - Supply Side, i.e. "Planned Obsolescence": Fullerton (JAERE, 2021), Bulow (QJE, 1986), Waldman (QJE, 1993)
  - Demand Side, i.e. replacement decisions : Gavazza and Lanteri (ReStud, 2021), Stolyarov (JPE, 2002)

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  - Demand Side, i.e. replacement decisions : Gavazza and Lanteri (ReStud, 2021), Stolyarov (JPE, 2002)
- This project:
  - Empirically: Document a decline in lifetimes of durables
  - Quantitatively: Decompose decline into “supply” and “demand” components

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  - Large set of durables covered - only stocks and flows
  - Purchase price and repair expenditures along with HH variables
- Energy Information Agency (RECS): track appliance details to estimate HH energy use
  - Cross-sectional survey, 1990-today (frequency is roughly every 4 years)
  - More narrow set of durables covered
  - Appliance age distribution along with HH variables

*Today is just first steps - more information in here we are working leveraging*

# Measuring Durability with EIA Data - Matching Age Distributions

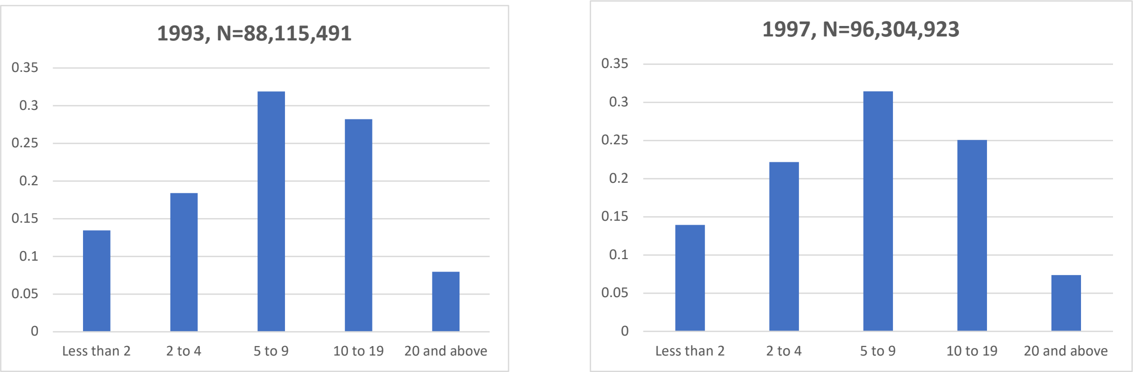


Figure: Ex: Refrigerator Age Distributions

# Measuring Durability - Algorithm

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- Simple algorithm:
  - For any $\delta \in (0,1)$, start in 1993, simulate forward and find entry flow $e$ to match $N_{1997}$
  - Search along locus of pairs to find the $(e^*, \delta^*)$ to minimize difference in the simulated and empirical age distributions in 1993.

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- Intuition: High $\delta^*$, high $e^*$ will have lots of young appliances, while low pairs will have relatively old appliances
- This allows us to account for changes both in survival ($\delta$) and adoption ($e$).

# Declining Durable Survival Rates (rising $\delta$)

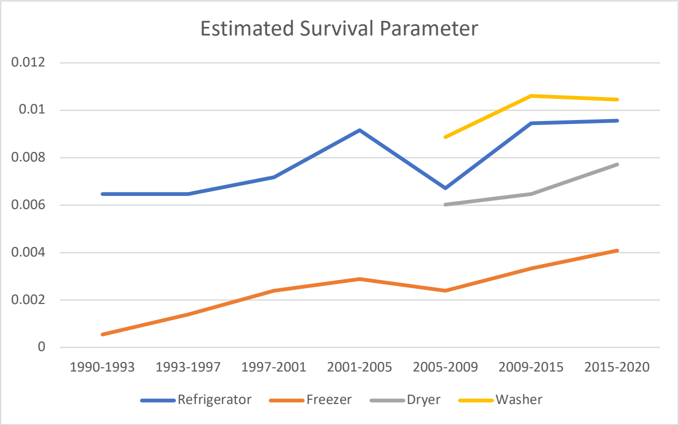


Figure: Survival parameter ($\delta$) for different durable goods (EIA)

# Prices relative to income are declining over time

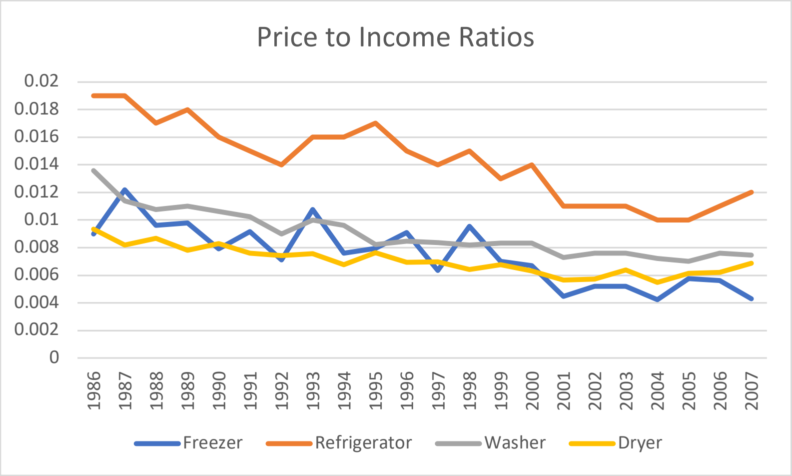


Figure: Price to income ratios for different durable goods (CEX)

# Unequal price declines?

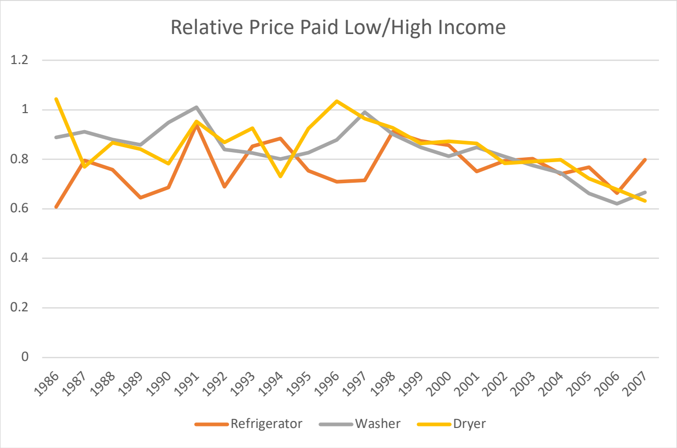


Figure: Ratio of mean price paid by bottom v. top half of income distribution (CEX)

- Lower end of prices appears to fall faster

# Simple Model of Replacement

- Partial equilibrium model of durable goods replacement
- Based on Gavazza and Lanteri (2020) framework
- Focus on household replacement decisions for differentiated durable goods
- Key elements:
  - Heterogeneous households with idiosyncratic income processes
  - Durable goods differentiated by age and quality
  - Replacement vs. continuation decisions

# Household Characteristics

## Basic Setup

- Continuum of unit mass, infinitely lived households indexed by $i$
- Preferences over durable and non-durable goods
- Idiosyncratic earnings process: $w_{it}$, first-order Markov

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## Utility Function

$$u(c_{it}, d_{it}) = \frac{(c_{it}^{\alpha} d_{it}^{1-\alpha})^{1-\gamma}}{1-\gamma}$$

where:

- $c_{it}$: non-durable consumption
- $d_{it}$: flow utility from durables
- $\alpha$: preference parameter
- $\gamma$: risk aversion parameter

# Durable Goods Structure

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## Flow Utility from Durables

$$d_{it} = d(n, j, \theta_i) = \begin{cases} \nu(j)q_n & \text{if owns good of quality } n \text{ of age } j \\ \theta_i & \text{if does not own any durable} \end{cases}$$

where:

- $q_n$: quality level of type $n$ durable
- $\nu(j)$: depreciation function, continuous, $\nu(0) = 1$, $\nu(J) = 0$, $\nu'(j) < 0$
- $\theta_i$: household-specific outside option (constant over time)

# Market Structure

## Current Assumptions

- Only market for new durables (age $j = 0$)
- Infinite supply of each quality type at price $p_n$
- No secondary market for used durables

## Implications

- Households can only purchase new durables
- No resale value for existing durables
- Replacement decision is discrete: keep current or buy new

# Continuation Decision

$$V^C(a, w, n, j; \theta) = \max_{a', c} u(c, d(n, j, \theta)) + \beta E[V(a', w', n, j+1; \theta)]$$

subject to:

$$c + a' = w + (1+r)a$$

- Household keeps current durable of quality $n$, age $j$
- Durable ages to $j+1$ next period
- Standard intertemporal consumption-saving problem
- Flow utility depends on current durable characteristics

# Replacement Decision

## Replacement Value for Specific Quality

$$V^R_{n'}(a, w, n', 0; \theta) = \max_{a', c} u(c, d(n', 0, \theta)) + \beta E[V(a', w', n', 1; \theta)]$$

subject to:

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## Optimal Quality Choice

$$V^{R}(a, w, n, j; \theta) = \max_{n' \in \{1, \ldots, N\}} V_{n'}^{R}(a, w, n', 0; \theta)$$

# Beginning-of-Period Value Function

$$V(a, w, n, j; \theta) = \max\{V^C(a, w, n, j; \theta), V^R(a, w, n, j; \theta)\}$$

## Replacement depends on

- HH characteristics (income, wealth)
- New durable prices
- Current durable age (due to depreciation $\nu(j)$)

# Quantitative Exercise

- Only use Refrigerator data for now
- Two quality types: $\{q_h, q_l\}$
- Calibrate the model to 1990-1993 period
  - Price income ratio, relative price paid by high and low income households and the tails of the age distribution
- Recalibrate parameters to 2005-2007: capture change in share of old machines and relative prices
- Ask: How much of the change is due to supply $(\nu(j))$ versus demand (relative prices)

# Calibration

Table: Calibration: Model and Data

| Target | 1990-1993 | | 2005-2007 | |
|---|---|---|---|---|
| | Model | Data | Model | Data |
| Share Machines $> 20$ | 7.58% | 8% | 4.75% | 4.65% |
| Price/Income Ratio | 1.47 | 1.5 | 1.14 | 1.1 |
| Avg. Price Low/High Income | 0.79 | 0.79 | 0.72 | 0.74 |

- Both prices and share of old machines fall

# Decomposing Forces

- Prices: low quality good becomes much cheaper relative to high quality
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  - $\frac{p_l}{p_h}$ falls from 0.57 to 0.08
- Technology: Depreciation rises
  - By age ten, this implies a 2% loss in services
- Counterfactual: Holding depreciation constant since 1990
  - Technological changes ($\delta$) account for roughly half the decline in the share of old machines

# Some (tentative) Conclusions

- What we are after: Has the lifecycle of durable goods changed and, if so, why?

- Empirically:
  - The lifetime of durables does appear to have to declined
  - Ongoing work to leverage CEX durables data going back to 1950

- Quantitatively:
  - Low quality machine prices fall significantly
  - Services depreciate slightly faster
  - Welfare gains across the income distribution? TBD.