Durables and Size-Dependence in the Marginal Propensity to Spend

Martin Beraja (MIT & NBER)   Nathan Zorzi (Dartmouth)

May 2024
Stimulus checks have become an important policy tool in recent US recessions.
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We know little about the effectiveness of stimulus checks as they become larger. $2,000 could be barely more effective than $300 if households spend less and less of each additional dollar.
**Motivation**

- **Stimulus checks** have become an important policy tool in recent US recessions.

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- Measuring this **size-dependence** is hard. Wide range of **empirical** estimates.
- Models of non-durables predict that the MPX falls sharply with the size of checks.
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- Models of non-durables predict that the MPX falls sharply with the size of checks.
- Relevant quantity for policy: total spending, including durables (large share of MPX)
Stimulus checks have become an important policy tool in recent US recessions. The table below shows the average amount of stimulus checks during different recessions:

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- Measuring this size-dependence is hard. Wide range of empirical estimates.
- Models of non-durables predict that the MPX falls sharply with the size of checks.
- Relevant quantity for policy: total spending, including durables (large share of MPX).
- Conjecture: HH might tilt spending towards durables for large checks (Parker et al.). This could dampen / reverse decline in MPX predicted by models of non-durables.
This Paper

Build a rich and flexible model → micro data → size-dependence? checks?
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Lumpy durables
This Paper

Build a rich and flexible model → micro data → size-dependence? checks?

Lumpy durables + smooth adjustment hazard (McFadden)
Build a rich and flexible model $\rightarrow$ micro data $\rightarrow$ size-dependence? checks?

Lumpy durables $+$ **smooth adjustment hazard** (McFadden) $+$ Open Econ HANK
1. Smooth hazard is key to explain a rich set of micro facts that existing models miss.

   Discipline the shape of this hazard by matching: (i) relative MPX on durables; (ii) short-run price elasticity of durables; (iii) distribution of adjustments sizes; (iv) conditional probability of adjustment, etc.
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2. Quantify the size-dependence in the MPX. The MPX declines, albeit slowly.
   MPX is flatter in purely state-dependent model of durables, declines faster in 2A model of non-durables
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3. Embed the model in HANK. Evaluate effect of checks on output in recessions.
   Larger checks remain effective, but extrapolating from small checks overestimates their impact
A Model with a Smooth Hazard

Bringing the Model to the Data

Size-Dependence in the MPX

Stimulus Checks in General Equilibrium
A Model with a Smooth Hazard

- HA model with lumpy durables (Berger-Vavra) with smooth hazard (+ down payment)

Preferences: Durables and non-durables

\[ u(t) = u(c_t, d_t) + \beta E_t [u(t+1)], \]

where \( u(c_t, d_t) = \frac{1}{1 - \sigma} U(c_t, d_t) \)

\( U(c_t, d_t) = \frac{\vartheta^1}{\nu^0 + \vartheta^1}, \)

Households are indexed by the following states:

\[ x \equiv (d_t | \{\text{Durables}\}, m_t | \{\text{Cash}\}, y_t | \{\text{Income}\}), \]

Down payment

Recursive formulation
HA model with lumpy durables (Berger-Vavra) with smooth hazard (+ down payment)

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\[ U(c, d) = \left[ \varphi_c^{1/\nu} c^{1-1/\nu} + \varphi_d^{1/\nu} d^{1-1/\nu} \right]^{\nu - 1} \]
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Durables, Cash, Income, Preference shifters
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- **Down payment**
- **Recursive formulation**
Adjustment Hazard

Canonical model of durables: Discontinuous hazard,

\[ V_t(x) = \max \left\{ V_{\text{non}}^t(x), V_{\text{adjust}}^t(x) - \kappa \right\}, \]

where \( \kappa > 0 \) is the (utility) cost of adjustment.
 Canonical model of durables: Discontinuous hazard,

\[
S_t(x) = \begin{cases} 
1 & \text{if } V_t^{\text{adjust}}(x) - \kappa > V_t^{\text{non}}(x) \\
0 & \text{otherwise}
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i.e., \((s, S)\) adjustment bands.
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- **This paper:** **Smooth hazard**, for any idiosyncratic state \(x\),

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which can be microfounded with preference shifters (McFadden)
ADJUSTMENT HAZARD

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▶ Next two polar cases: fully state-dependent \((\eta \to 0)\) and time-dependent \((\eta \to +\infty)\)
Figure 1: Adjustment hazard (fixing $d$ and $y$)
The shape of the adjustment hazard is key for the size-dependence in MPX.
Marginal propensity to spend on durables:

\[ MPX^d (T) \equiv d\mu (m, d) \]
Marginal propensity to spend on durables:

\[
\text{MPX}^d (T) \equiv \mu (m-T, d) - \mu (m, d)
\]
Marginal propensity to spend on durables:

\[ MPX^d (T) \equiv \left( S (m, d) \times (m + d) \right) \{ d\mu (m-T, d) - d\mu (m, d) \} \]

extensive \hspace{1cm} intensive
Marginal propensity to spend on durables:

\[
\text{MPX}^d(T) \equiv \frac{1}{T} \int \int S(m,d) x(m+d) \left\{ d\mu(m-T,d) - d\mu(m,d) \right\} 
\]

Adjustment Hazard and Size-Dependence
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Spending functions (fixing \( d \))
Marginal propensity to spend on durables:

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Spending functions (fixing \( d \))

Getting the shape of hazard right is crucial for size-dependence.
Adjustment Hazard and Size-Dependence

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\text{MPX} (\text{fixing } d)
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Spending functions (fixing \(d\))

- Intensive margin
- Hazard (steep)
- Hazard (flat)

Getting the shape of hazard right is crucial for size-dependence
Marginal propensity to spend on durables:

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Spending functions (fixing \( d \))

Getting the **shape of hazard** right is crucial for **size-dependence** + match data
A Model with a Smooth Hazard

Bringing the Model to the Data

Size-Dependence in the MPX

Stimulus Checks in General Equilibrium
Calibration

- Consumer durables (cars, furniture, appliances), i.e., exclude housing.
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- External: $\sigma = 2$ (Berger-Vavra), $\nu \rightarrow 1$ (Orchard et al.), $\theta = 0.20$ (Adams et al.), $\delta = 0.05$ (CEX)
### Calibration

#### Consumer durables (cars, furniture, appliances), i.e., exclude housing.

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#### External: $\sigma = 2$ (Berger-Vavra), $\nu \to 1$ (Orchard et al.), $\theta = 0.20$ (Adams et al.), $\delta = 0.05$ (CEX)
Two moments are informative: MPX out of $500 (PE) and user cost elasticity (GE)
Scale Parameter ($\eta$)

- Capture: (i) relative importance of durables; and (ii) strength of extensive margin.
**Capture:** (i) relative importance of durables; and (ii) strength of extensive margin.
Evidence: $\text{MPX}^d > \text{MPX}^c$ (Havranek-Sokolova) $\rightarrow$ not too time-dependent
**Scale Parameter ($\eta$)**

- **MPX ($500$ check)**
  - **MPX**
    - Durables
    - Non-durables
  - **Short-run price elasticity**

▶ **Evidence:** $\text{MPX}^d > \text{MPX}^c$ (Havranek-Sokolova) $\rightarrow$ not too time-dependent
**Evidence:** $\text{MPX}_d^d > \text{MPX}_c^c$ (Havranek-Sokolova) → not too time-dependent
 SCALE PARAMETER ($\eta$)

Evidence: Elasticity $\geq -15$ (Bachmann et al.) $\rightarrow$ not too state-dependent (McKay-Wieland)

MPX ($500$ check)

Short-run price elasticity
**Scale Parameter ($\eta$)**

![Graph showing MPX (\$500 check) and Short-run price elasticity](image)

- **Evidence:** Elasticity $\geq -15$ (Bachmann et al.) $\rightarrow$ not too state-dependent (McKay-Wieland)
Benchmark calibration: $\eta = 0.2$ (+ robustness checks)
- Benchmark calibration: MPX\textsuperscript{d} \sim 1.5 \times MPX\textsuperscript{c} (Havranek-Sokolova) and elasticity \sim -7
**Benchmark calibration:** matches well **untargeted** moments
1. Distribution of Adjustments (PSID)

Data

Net investment rate (standardized)
Reflects the **shape of hazard**: \( \int_{-\infty}^{z} f(s) \, ds = \int 1_{\{\log(d'(x)/d) \in (-\infty,z)\}} S(x) \mu(dx) \)
1. Distribution of Adjustments (PSID)

- State-dependent model: misses the overall shape, the tails, etc.
Our model: fits the distribution closely, i.e., the data supports our smooth hazard.
2. Probability of Adjustment Since Last Purchase (PSID)

Adjustment probability conditional on not having adjusted so far (Kaplan-Meier)
2. **Probability of Adjustment Since Last Purchase (PSID)**

- Also informative about the overall **shape of hazard** (probability flat or steep)
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▶ Also informative about the overall shape of hazard (probability flat or steep)
- Model-generated data discretized in PSID waves, CI are bootstrapped at 90%
Again, the evidence rejects the purely state- and time-dependent models.
Our model has both state-dependent and time-dependent features
3. Other Untargeted Moments

1. **Timing of response ($500).** MPX of 65% (6M), 75% (9M), 92% (12M)
   
   Lines up closely with the estimates of Hausman, Agarwal-Qian, Fagereng-Holm-Natvik

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Dynamics

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2. **Large shocks**

   MPX of 67% (12M) out of $10,000 lottery gain
   
   Similar to the estimate in Fagereng et al. where the mean lottery gain is $10,000

3. **Hand-to-mouth**

   42% of households with $\frac{1}{2} \times M^{inc}$ (Kaplan-Violante-Weidner)
   
   Almost the exact value reported in Kaplan-Violante and Aguiar-Bils-Boar

4. **Secondary market**

   52% of purchases on secondary market
   
   Used cars represent roughly 55% of total spending on cars in the US

5. **Distribution of MPX**

   Distribution is skewed (some have MPX > 1)
   
   Resembles the distribution in Lewis-Melcangi-Pilossoph, model of non-durables cannot match this

---

Overall, our model provides a good description of households' spending behavior
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2. **Large shocks.** MPX of 67% (12M) out of $10,000 lottery gain
   
   Similar to the estimate in Fagereng et al. where the mean lottery gain is $10,000

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A Model with a Smooth Hazard

Bringing the Model to the Data

Size-Dependence in the MPX

Stimulus Checks in General Equilibrium
Size-Dependence in the MPX

MPX on durables and non-durables

MPX on durables

MPX on non-durables

Stimulus check
SIZE-DEPENDENCE IN THE MPX

MPX on durables and non-durables

MPX on durables

MPX on non-durables

Our model
State-dependent
Modelling **durables** is important for the **MPX on non-durables** (complementarity)
Our model: realistic total MPX (level) that decreases slowly (size-dependence)
Size-Dependence in the MPX

MPX on durables and non-durables

MPX on durables

MPX on non-durables

More results: Decomposition, Sensitivity
Aggregate Spending, Concavity, and the Role of $\eta$

The size-dependence (concavity) is very constant around $\eta = 0$.
Aggregate Spending, Concavity, and the Role of $\eta$

**Aggregate Spending**

State-dependent
- $\gamma = 0.94$

Our model
- $\gamma = 0.87$

2A non-durables
- $\gamma = 0.73$

**Size-depend. ($\gamma$): $d \log (\text{Spend}) / d \log (\text{Check})$**

- State-dependent: $\gamma = 0.93$
- Our model: $\gamma = 0.87$

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The size-dependence (concavity) is very constant around $\eta = 0.2$.
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Size-Dependence in the MPX

Stimulus Checks in General Equilibrium
How effective are large checks at stimulating output in recessions?
A GE Application to Stimulus Checks

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▶ We embed our spending model into an open-economy HANK setup
  Imports account for 1/4 of durable spending
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- **Focus**: demand-driven recessions (2001, Great Recession)
  Labor markets are slack
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- **Focus:** demand-driven recessions (2001, Great Recession)
  Labor markets are slack

- An extension with **supply-side constraints** (Orchard et al., Comin et al.)
  Shocks to potential output, non-linear NKPC, and relative price movements
# Aggregate Demand and Supply

## Aggregate demand

1. Eligible for checks if $e \leq 75,000$

## Aggregate supply

1. NKPC for non-durables

\[
\pi_t = \kappa \log Y_{dom, t} + \beta \pi_{t-1}
\]

2. Elastic supply of $d_t$ (Orchard et al.)

\[
p_{dt} \equiv \frac{X_{dom, t}}{X_{potent, t}}^{1/\zeta}
\]

3. $Y_{potent, t}$ and $X_{potent, t}$ as capacity constr.
Aggregate Demand and Supply

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1. Eligible for checks if $e \leq $75,000

2. Imports, e.g., for durables

$$x_t = \left[ \sum_{j \in \{H,F\}} \left( \alpha^d_j \right)^{\frac{1}{\rho}} \left( x^j_t \right)^{\frac{\rho - 1}{\rho}} \right]^\frac{\rho}{\rho - 1}$$

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4. Firm $I$ shifts AD (Justiniano et al.)

\[ K_t = \left\{ 1 - \delta^K + \Phi \left( I_t/K_{t-1} \right) + z_t \right\} K_{t-1} \]

Aggregate supply

Solve for $\{z_t\}$ that generate recession
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Closing the model
Aggregate output ($t = 0$)

- Benchmark
- Relative prices
- Linear extrapolation

Stimulus check vs. Aggregate output (dynamics)

Large checks remain effective, but extrapolating from smaller ones overestimates the impact.

Additional results
General Equilibrium Response to Stimulus Checks

Large checks remain effective, but extrapol. from smaller ones overestimates impact
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Aggregate output ($t = 0$)

Aggregate output (dynamics)

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- Aggregate output (dynamics)

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Additional results 16/18
Perfect storm: shocks to potential output, non-linear NKPC
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\underline{Takeaways}
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Takeaways

1. The MPX declines slowly with the size of stimulus checks
2. Larger checks remain effective at stimulating output in recessions, but extrapolating from small checks overestimates their impact
Empirically, some households with large MPX (> 1) (Lewis et al., Fuster et al.)
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Standard LTV

$$m_t \geq -(1 - \theta) d_t,$$

where $$\theta \in (0, 1)$$ is LTV parameter / down payment.
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This paper: credit \((r^b > r^m)\) equals a share \(1 - \theta\) of the value of durables in every \(t\).
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Credit tracks \( d_t \): households repay at the rate at which durable depreciates.
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Empirically, typical car loan is 5-6 years while car depreciates at 20%, pre-determined payments (Argyle et al.), and prepayments are rare for consumer durables (Heitfield-Sabarwal), and households make minimum down payment (Green et al.).
Recursive Formulation

- Discrete choice problem
  \[
  V_t(x; \epsilon) = \max \left\{ V_{\text{adjust}}^t(x) - \epsilon, V_{\text{non}}^t(x) \right\}
  \]

- When adjusting
  \[
  V_{\text{adjust}}^t(x) = \max_{c, d', m'} u(c, d') + \beta \int V_{t+1}(d', m', y'; \epsilon') d\mathcal{E}(\epsilon') \Gamma(dy'; y)
  \]
  \[\text{s.t. } [1 - (1 - \theta)(1 - \delta)] d' + m' + c \leq Y_t(x; T_t) + \theta (1 - \delta) d \]
  \[m' \geq 0,\]

- When not adjusting
  \[
  V_{\text{non}}^t(x) = \max_{c, m'} u(c, d') + \beta \int V_{t+1}(d', m', y'; \epsilon') dG(\epsilon') \Gamma(dy'; y)
  \]
  \[\text{s.t. } m' + c \leq Y_t(x; T_t) - \iota \delta d - (1 - \theta) [(1 - \delta) d - d'] \]
  \[m' \geq 0\]
3. **Annual MPX**

**Quarterly MPX**

![Graph of Quarterly MPX](image)

**Annual MPX**

![Graph of Annual MPX](image)
4. Distribution of MPXs ($500 Check)

- Empirically, distribution declines smoothly and large MPX (> 1) (Lewis et al., Fuster et al.)
State- and Time-Dependent Adjustments

- Our model has both state-dependent (SD) and time-dependent (TD) features

State-dependence index:
By definition, SD = 1 in state-dependent model and SD = 0 in Calvo model.
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By definition, SD = 1 in state-dependent model and SD = 0 in Calvo model.
State- and Time-Dependent Adjustments

- **Graph:**
  - **Y-axis:** State-dependence (SD)
  - **X-axis:** Scale parameter (η)
  - **Legend:** Quarterly

The graph shows a decreasing trend of state-dependence (SD) as the scale parameter (η) increases. The data points are marked with triangles representing the quarterly data. The graph indicates that the state-dependence decreases significantly as the scale parameter increases.
State- and Time-Dependent Adjustments
Why does the MPX ↓ in our model? **Smooth hazard** dampens the **extensive margin**.

\[
\text{Extensive margin} \approx \text{Intensive margin}
\]

**Selection** dominates (car ⇝ fridge)

Contrasts with purely state-dep. model
Figure 9: Annual MPX

MPX

Durables
Non-durables

Stimulus check

$100 $1000 $2000 $3000
MPX on durables (18%) is smaller than in our model (25%) and Orchard et al. (30%)
MPX on durables and non-durables ~ same vs. our model + data (ratio 150%)
The proportions are reversed compared to our model that matches the data!
Calvo Plus: Size-Dependence

\[ \text{MPC} \]

\[ \text{Stimulus check} \]

- Durables
- Non-durables
STATE-CONTINGENCY IN THE MPX

Our model

State-dependent model

MPX vs. Expansion

Bust | Boom

MPX vs. Expansion

Bust | Boom
CLOSING THE MODEL

Monetary policy

\[ r^m_t = \max \left\{ r^m + \phi \pi_t + \phi_y \hat{Y}_t, r \right\} \]
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Fiscal policy

\[ B^g_t = \frac{1 + r_t}{1 + \pi_t} B^g_{t-1} + T_t - t_t - G_t \]

(checks \( t_0 \) financed over 15 years)
**CLOSING THE MODEL**

**Monetary policy**

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**Market clearing**

\[ P^c_t (C_t + G_t) + F^{-1} \left( X^c_{t, \text{dom}} \right) + N X^c_{t, \text{real}} = Y^\text{dom}_t \]

\[ P^d_t X_t + p^d_t l_t + N X^d_{t, \text{real}} = p^d_t \left( X^\text{dom}_t + A_1 K_{t-1} \right) \]
CLOSING THE MODEL

Monetary policy

\[ r_t^m = \max \left\{ r^m + \phi \Pi \pi_t + \phi_y \hat{Y}_t, r \right\} \]

Fiscal policy

\[ B_t^g = \frac{1 + r_t}{1 + \pi_t} B_{t-1}^g + T_t - t_t - G_t \]

(checks \( t_0 \) financed over 15 years)

Market clearing

\[ P_t^c (C_t + G_t) + F^{-1} \left( X_t^{\text{dom}} \right) + NX_t^{c, \text{real}} = Y_t^{\text{dom}} \]

\[ P_t^d X_t + p^d_l t_t + NX_t^{d, \text{real}} = p^d_t \left( X_t^{\text{dom}} + A_1 K_{t-1} \right) \]

Incomes

\[ E_t^{\text{net}} (x) = \psi_{0,t} \left\{ y (Y_t + \text{Div}_t) \right\}^{1-\psi_1} \]

(with dividend smoothing)
**CLOSING THE MODEL**

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\[ r^m_t = \max \left\{ r^m + \phi \Pi_t + \phi_y \hat{Y}_t, r \right\} \]

**Fiscal policy**

\[ B^g_t = \frac{1 + r_t}{1 + \pi_t} B^g_{t-1} + \mathcal{T}_t - t_t - G_t \]

(checks \( t_0 \) financed over 15 years)

**Market clearing**

\[ P_t^c (C_t + G_t) + F^{-1} \left( X^c_{t, \text{dom}} \right) + NX_t^{c, \text{real}} = \Gamma_t^{\text{dom}} \]

\[ P_t^d X_t + P_t^d I_t + NX_t^{d, \text{real}} = p^d_t \left( X^c_{t, \text{dom}} + A_1 K_{t-1} \right) \]

**Incomes**

\[ E_t^{\text{net}}(x) = \psi_{0,t} \left\{ y \left( Y_t + \text{Div}_t \right) \right\}^{1-\psi_1} \]

(with dividend smoothing)
Additional Results

Sectoral output gaps

Non-durable good

Year

Investment good

Year

Decomposing households’ responses ($500)

Quartile (last year’s labor income)
1. Non-linear Phillips curve

\[ \pi_t = \kappa \hat{y}_t + \kappa^* \max \{ \hat{y}_t, 0 \}^2 + \beta \pi_{t+1} \]

with \( \kappa = 0.0031 \) (Hazell et al.) and \( \kappa^* = 0.1 \) (Mavroeidis et al., Cerrato-Gitti)

2. Reduction in \( Y_{potent}^t \) and \( X_{potent}^t \) by 50% of initial gap

3. Relative price movements

\[ p^d_t \equiv \left( \frac{X_{dom}^t}{X_{potent}^t} \right)^{1/\zeta} \]

with \( \zeta = 1/0.049 \) (McKay-Wieland)