Durables and Size-Dependence in the Marginal Propensity to Spend

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

December 2023
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.
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How does the marginal propensity to spend (MPX) vary as checks become larger?
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How does the marginal propensity to spend (MPX) vary as checks become larger?

Measuring size-dependence is hard. Wide range of empirical estimates.
**Motivation**

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

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*How does the marginal propensity to spend (MPX) vary as checks become larger?*

- Measuring **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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- Relevant quantity for policy, however, is total household spending.
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- Models of non-durables predict that the MPX falls sharply with the size of checks.
- Relevant quantity for policy, however, is total household spending.
- Empirically, durable spending accounts for a large share of the MPX.
  Conjecture: durable purchases could respond more as checks become larger (Parker et al., Fuster et al.)
This Paper

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

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. **Discipline the model** with micro moments. **Smooth hazard** is key to match evidence.

   Match MPX on durables and non-durables, price elasticity of durables, distribution of adjustments, etc.
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2. Quantify the **size-dependence** in the MPX. The **MPX declines, albeit slowly**.
   Flatter in a purely state-dependent model of durables. Declines sharply in 2A model of non-durables
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3. Embed the model in **HANK**. Evaluate effect of checks on output in recessions

   A large check of $2,000 increases output by 25 c/$, compared to 37 c/$ for a small $300 check

   Large checks remain effective, but extrapolating out of 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)
A Model with a Smooth Hazard

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

- **Preferences**: Durables and non-durables

\[
U_t \equiv u(c_t, d_t) + \beta \mathbb{E}_t[U_{t+1}],
\]

where

\[
u (c, d) = \frac{1}{1 - \sigma} U^{1-\sigma} \quad \text{with} \quad U(c, d) = \left[ \vartheta_c^{\frac{1}{\nu}} c^{-\frac{1}{\nu}} + \vartheta_d^{\frac{1}{\nu}} d^{-\frac{1}{\nu}} \right]^{-\frac{\nu}{\nu - 1}}
\]
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- Households are indexed by the following states

\[ x \equiv (d, m, y, \epsilon) \]

- Durables, Cash, Income, Preference shifters
A Model with a Smooth Hazard

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\begin{align*}
\text{Durables} & , & \text{Cash} & , & \text{Income}
\end{align*}
Canonical model of durables: Discontinuous hazard,

\[ V_t(x) = \max \left\{ V_{t}^{\text{not}}(x), V_{t}^{\text{adjust}}(x) - \kappa \right\}, \]

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

\[ S_t(x) = \begin{cases} 
1 & \text{if } V_t^{\text{adjust}}(x) - \kappa > V_t^{\text{not}}(x) \\
0 & \text{otherwise} 
\end{cases} \]

i.e., \((s, S)\) adjustment bands.
Adjustment Hazard

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\end{cases}
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- **This paper**: Smooth hazard, for any idiosyncratic state \( x \),

\[
S_t(x) = \frac{\exp \left( \frac{V_t^{\text{adjust}}(x) - \kappa}{\eta} \right)}{\exp \left( \frac{V_t^{\text{adjust}}(x) - \kappa}{\eta} \right) + \exp \left( \frac{V_t^{\text{not}}(x)}{\eta} \right)},
\]

which can be microfounded with preference shifters (McFadden)
**Adjustment Hazard**

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which can be microfounded with preference shifters (McFadden)

- Nest 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 the MPX.
The shape of the **adjustment hazard** is key for the **size-dependence** in the MPX.
Marginal propensity to spend on durables:

\[
\text{MPX}^d (T) \equiv \frac{1}{T} \int \int S (m, d) \times (m + d) \{d\mu (m - T, d) - d\mu (m, d) \}
\]
Marginal propensity to spend on durables:

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\]

Spending functions

\[
\text{MPX}^d\left( T > 0 \right) = \text{Distribution}
\]

\[
\text{MPX}^d\left( T = 0 \right) = \text{Intensive margin}
\]

\[
\text{MPX} = \frac{1}{T} \int \int S (m, d) \times (m + d) \left\{ d\mu (m - T, d) - d\mu (m, d) \right\}
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\[
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Marginal propensity to spend on durables:

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

Hazard and intensive margin (fixing $d, y$)

Adjustment Hazard and Size-Dependence
Marginal propensity to spend on durables:

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

Hazard and intensive margin (fixing \( d, y \))
Marginal propensity to spend on durables:

$$MPX^d (T) \equiv \frac{1}{T} \int \int S(m, d) \times (m + d) \{d\mu (m - T, d) - d\mu (m, d)\}$$

Hazard and intensive margin (fixing $d$, $y$)

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

 Bringing the Model to the Data

 Size-Dependence in the MPX

 Stimulus Checks in General Equilibrium
Consumer durables (cars, furniture, appliances), i.e., exclude housing.
Calibration

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

- 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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<tr>
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<th>Value</th>
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<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.944</td>
<td>Liquid assets / A Inc</td>
<td>26%</td>
<td>Kaplan et al.</td>
</tr>
<tr>
<td>$\vartheta$</td>
<td>Non-durable parameter</td>
<td>0.687</td>
<td>Durables / non-durables</td>
<td>26%</td>
<td>CEX</td>
</tr>
<tr>
<td>$\iota$</td>
<td>Maintenance</td>
<td>0.257</td>
<td>Maintenance / new investment</td>
<td>32.6%</td>
<td>CEX</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Location parameter</td>
<td>0.803</td>
<td>Frequency of adjustment</td>
<td>23.8%</td>
<td>PSID</td>
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<tr>
<td>$\eta$</td>
<td>Scale parameter</td>
<td>0.20</td>
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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 $500 (PE) and interest rate elasticity (GE)
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**Scale Parameter ($\eta$)**

**Evidence:** $\text{MPX}^d > \text{MPX}^c$ (Havranek-Sokolova) $\rightarrow$ not too time-dependent
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Scale Parameter ($\eta$)

**MPX ($500$ check)**

- **Scale parameter ($\eta$)**
  - Durables
  - Non-durables

- **MPX**
  - $0$ to $0.6$

- **Short-run price elasticity**
  - $0$ to $-30$

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

**MPX ($500 check)**

![MPX Graph](image)

- **Durables**
- **Non-durables**

**Short-run price elasticity**

![Short-run Price Elasticity Graph](image)

- **State-dependent**

**Benchmark calibration:** $\eta = 0.2$ (+ robustness checks)
**Scale Parameter ($\eta$)**

MPX ($500$ check)

![Graph showing MPX vs. Scale Parameter ($\eta$)]

Short-run price elasticity

![Graph showing Short-run price elasticity vs. Scale Parameter ($\eta$)]

- Benchmark calibration: $\text{MPX}^d \sim 1.5 \times \text{MPX}^c$ (Havranek-Sokolova) and elasticity $\sim -10$
**SCALE PARAMETER ($\eta$)**

MPX ($500 \text{ check}$)

- **Durables**
- **Non-durables**

State-dependent

- **MPX**:
  - $0 \rightarrow 0.15 \rightarrow 0.3 \rightarrow 0.45 \rightarrow 0.6$
  - $0.85 \rightarrow 0.5 \rightarrow 0.15 \rightarrow 0.0$

- **Short-run price elasticity**
  - $0 \rightarrow -30 \rightarrow -15 \rightarrow 0$
  - $0 \rightarrow 0.15 \rightarrow 0.3 \rightarrow 0.45 \rightarrow 0.6$

- **Benchmark calibration**: matches well **untargeted** moments
Matching the tails reasonably well is important (Alvarez et al.)
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2. Probability of Adjustment Since Last Purchase (PSID)

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

- Model-generated data discretized in PSID waves, CI are bootstrapped at 90%
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3. Other Untargeted Moments

1. **Annual MPX ($500).** 42% on durables and 50% on non-durables. Total MPX of 92% similar to the value reported in Fagereng-Holm-Natvik for small lottery gains.

2. **Hand-to-mouth.** 42% of households with $m \leq 1/2 \times M \text{inc}$ (Kaplan-Violante-Weidner). Almost the exact value reported in Kaplan-Violante and Aguiar-Bils-Boar.

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

4. **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.
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

- Our model
- State-dependent
- 2A non-dur.
Size-Dependence in the MPX

Modeling durables are important for the MPX on non-durables (complementarity)
Our model: **realistic total MPX** (level) that **decreases slowly** (size-dep.)
The size-dependence (concavity) is similar around $\eta = 0$.
Concavity in Aggregate Spending Response

Aggregate spending response

Elasticity of the spending response

- State-dependent
- Our model
- 2A non-durables

State-dependent

Our model
The size-dependence (concavity) is similar around $\eta = 0.2$. 

The aggregate spending response and elasticity of the spending response are shown in the diagrams. The spending response is plotted against the stimulus check amount, while the elasticity is plotted against the scale parameter $\eta$. The graphs indicate different spending responses for state-dependent and our model scenarios, with elasticity values around $\beta = 0.94$, $\beta = 0.87$, and $\beta = 0.73$. 

The concavity in aggregate spending response is discussed, focusing on the similarity around $\eta = 0.2$. 

State-contingency analysis is highlighted, with specific focus on the spending response and elasticity around $\eta = 0.2$.
A Model with a Smooth Hazard

Bringing the Model to the Data

Size-Dependence in the MPX

Stimulus Checks in General Equilibrium
How effective are large checks at stimulating output in recessions?
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- We embed our spending model into an open-economy HANK setup
  Imports account for 1/4 of durable spending
A GE Application to Stimulus Checks

How effective are large checks at stimulating output in recessions?

- We embed our spending model into an open-economy HANK setup
  Imports account for 1/4 of durable spending

- Focus: demand-driven recessions (2001, Great Recession)
  Labor markets are slack
How effective are large checks at stimulating output in recessions?

- We embed our spending model into an open-economy HANK setup
  Imports account for 1/4 of durable spending

- **Focus**: demand-driven recessions (2001, Great Recession)
  Labor markets are slack

- **Extension**: stronger supply-side effects (Orchard et al., Comin et al.)
  Shocks to potential output, and non-linear NKPC
Aggregate Demand and Supply

Aggregate demand

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

Aggregate supply
Aggregate Demand and Supply

Aggregate demand

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

2. Imports, e.g., for durables

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

Aggregate supply

1. NKPC for non-durables

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

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

\[
p_d_t \equiv X_{\text{dom}} / X_{\text{potent}}^{1/\zeta}
\]

3. $Y_{\text{potent}}$ and $X_{\text{potent}}$ as capacity constr.
Aggregate Demand and Supply

Aggregate demand

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

2. Imports, e.g., for durables

\[ x_t = \left[ \sum_{j \in \{H,F\}} \left( \alpha_j^d \right)^{\frac{1}{\rho}} \left( x_t^j \right)^{\frac{\rho - 1}{\rho}} \right]^\frac{\rho}{\rho - 1} \]

3. RoW symmetric (no checks)

Aggregate supply

1. NKPC for non-durables

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

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

\[ p_d t \equiv X_{dom}^t X_{potent}^t \]

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Aggregate Demand and Supply

Aggregate demand

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

2. Imports, e.g., for durables

\[
X_t = \left[ \sum_{j \in \{H,F\}} \left( \alpha_j^d \right)^{\frac{1}{\rho}} \left( X_j^d \right)^{\frac{\rho - 1}{\rho}} \right]^{\frac{\rho}{\rho - 1}}
\]

3. RoW symmetric (no checks)

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

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.)

\[
p_d t \equiv X_{dom}^t \sqrt{X_{potent}^t}
\]

3. \( Y_{potent}^t \) and \( X_{potent}^t \) as capacity constr.

Solve for \( \{z_t\} \) that generate recession
Aggregate Demand and Supply

Aggregate demand

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

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x_t = \left[ \sum_{j \in \{H,F\}} \left( \alpha^d_j \right)^{\frac{1}{\rho}} \left( x_t^d \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}
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K_t = \left\{ 1 - \delta^K + \Phi \left( I_t / K_{t-1} \right) + Z_t \right\} K_{t-1}
\]

Aggregate supply

1. NKPC for non-durables

\[
\pi_t = \kappa \log \left( \frac{Y_t^{\text{dom}}}{Y_t^{\text{potent}}} \right) + \beta \pi_{t+1}
\]
Aggregate Demand and Supply

Aggregate demand

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

2. Imports, e.g., for durables

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

3. RoW symmetric (no checks)

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

\[
p_t^d \equiv \left( \frac{X_{t, \text{dom}}}{X_{t, \text{potent}}} \right)^{1/\zeta}
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3. \( y_t^{\text{potent}} \) and \( x_t^{\text{potent}} \) as capacity constr.
Aggregate Demand and Supply

Aggregate demand

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2. Imports, e.g., for durables

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3. RoW symmetric (no checks)

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

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

Aggregate supply

1. NKPC for non-durables

$$\pi_t = \kappa \log \left( \frac{y_t^{dom}}{y_t^{potent}} \right) + \beta \pi_{t+1}$$

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

$$p_t^d \equiv \left( \frac{x_t^{dom}}{x_t^{potent}} \right)^{1/\zeta}$$

3. $y_t^{potent}$ and $x_t^{potent}$ as capacity constr.

Closing the model
General Equilibrium Response to Stimulus Checks

Aggregate output ($t = 0$)

- Benchmark
- Relative prices
- 2A non-dur.

Linear extrapolation

Stimulus check

Aggregate output ($t = 0$)
General Equilibrium Response to Stimulus Checks

Aggregate output ($t = 0$)

Large checks remain effective, but extrapolating from small checks overestimates impact.

Additional results
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3. We embed this demand block in a **HANK model** → effect of stimulus checks?
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1. The MPX declines slowly as stimulus checks become larger (≠ canonical models)
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2. Discipline this adjustment hazard carefully with rich set of micro moments

3. We embed this demand block in a **HANK model** → effect of stimulus checks?

Takeaways

1. The **MPX declines slowly** as stimulus checks become larger (≠ canonical models)

2. **Larger checks remain effective** at stimulating output in recessions, but extrapolating from responses out of small checks overestimates their bang-for-buck
Empirically, some households with large MPX (> 1) (Lewis et al., Fuster et al.)
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Standard LTV

\[ b_t \geq -(1 - \theta) d_t, \]  \hspace{1cm} (LTV)

where \( \theta \in (0, 1) \) is down payment.
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Tractability: 1. (DP) binding at origination — most buyers pay min DP (Green et al.)
Empirically, some households with large MPX ($> 1$) (Lewis et al., Fuster et al.)

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Tractability: 1. (DP) binding at origination — most buyers pay min DP (Green et al.)

2. (DP) remains binding — credit repaid at rate $\delta$ (Argyle et al.)
Empirically, some households with large MPX (> 1) (Lewis et al., Fuster et al.)

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We introduce two assets: illiquid credit \( b \leq 0 \) (\( r^b > 0 \)) and cash \( m \geq 0 \) (\( r^m \approx 0 \))

Tractability: 1. (DP) binding at origination — most buyers pay min DP (Green et al.)

2. (DP) remains binding — credit repaid at rate \( \delta \) (Argyle et al.)

Credit \( b \) is proportional to durables \( d \) and is not an extra state variable.
Recursive Formulation

- Discrete choice problem

\[
\mathcal{V}_t(x; \epsilon) = \max \left\{ \mathcal{V}^{\text{adjust}}_t(x) - \epsilon, \mathcal{V}^{\text{non}}_t(x) \right\}
\]

- When adjusting

\[
\mathcal{V}^{\text{adjust}}_t(x) = \max_{c,d',m'} u(c,d') + \beta \int \mathcal{V}_{t+1}(d',m',y';\epsilon') \, d\mathcal{E}(\epsilon') \, \Gamma(dy';y)
\]

s.t. \( \theta d' + m' + c \leq \mathcal{Y}_t(x; T_t) + \{(1 - \delta) - (1 - \theta)\} \, d \)

\( m' \geq 0. \)

- When not adjusting

\[
\mathcal{V}^{\text{not}}_t(x) = \max_{c,m'} u(c,d') + \beta \int \mathcal{V}_{t+1}(d',m',y';\epsilon') \, dG(\epsilon') \, \Gamma(dy';y)
\]

s.t. \( m' + c \leq \mathcal{Y}_t(x; T_t) - \nu \delta d - (1 - \theta) (d - d') \)

\( m' \geq 0. \)
3. Annual MPX

**Durables**

- $500 check
- $9,240 check

**Non-durables**

- Year 1: 0.6
- Year 2: 0.2
- Year 3: 0.1
Empirically, distribution declines smoothly and large MPX (> 1) (Lewis et al., Fuster et al.)
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**State-dependence index:**

\[
\text{share with } A_t(x'; \psi') = 1 \text{ and } A_{t-1}(x; \psi) = 0
\]
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**State-dependence index:**

$$SD = \frac{\text{share with } A_t(x'; \psi) = 1 \text{ and } A_{t-1}(x; \psi) = 0}{\text{share with } A_t(x'; \psi') = 1 \text{ and } A_{t-1}(x; \psi) = 0}$$
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$$SD = \frac{\text{share with } A_t(x'; \psi') = 1 \text{ and } A_{t-1}(x, \psi) = 0}{\text{share with } A_t(x'; \psi') = 1 \text{ and } A_{t-1}(x, \psi) = 0}$$

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

![Graph showing state-dependence (SD) vs. scale parameter (η)]
State- and Time-Dependent Adjustments

![Graph showing state-dependence (SD) vs. scale parameter (η) for Annual and Quarterly data.](image-url)
Extensive and Intensive Margins

▶ Why does the MPX ↓ in our model? **Smooth hazard** dampens the extensive margin.

**Extensive margin**

\[
\int \{ S_0 (d, m + T, y) - S_0 (d, m, y) \} \times x(d, m, y) \times d\pi (x) 
\]

▶ Extensive margin ≃ Intensive margin
▶ **Selection** dominates (car ⇔ fridge)
▶ Contrasts with purely state-dep. model
Sensitivity

Durables

Non-durables

- Baseline calibration
- Less liquidity
- More down payment
- Higher frequency

MPX vs. Stimulus check

Stimulus check

$100 $1000 $2000 $3000

$3000

$2000

$1000

$100

$0.28

$0.24

$0.2

$0.16

$0.12

$0.24

$0.2

$0.16

$0.12

$0.08

$0.04

$0.0

$0.04

$0.08

$0.12

$0.16

$0.2

$0.24

$0.28
CALVO PLUS: DATA

Distribution of Investments

- Net investment (standardized)

Conditional Adj. Probability

- Years since last adjustment

Data
Calvo-Plus
Calvo Plus: Size-Dependence

![Graph showing MPC (Marginal Propensity to Consume) against Stimulus check. The graph compares Durables and Non-durables. The MPC decreases as the Stimulus check increases.](image-url)
STATE-CONTINGENCY IN THE MPX

Our model

State-dependent model
Monetary policy

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

Monetary policy

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

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

Market clearing

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

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

(checks \( t_0 \) financed over 15 years)
Closing the Model

**Monetary policy**

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

**Fiscal policy**

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

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

**Market clearing**

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

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

**Incomes**

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

(with dividend smoothing)
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\[ B_t^g = \frac{1 + r_t}{1 + \pi_t} B_{t-1}^g + \mathcal{T}_t - t_t - G_t \]

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(with dividend smoothing)
Sectoral and Distributional Outcomes

Sectoral output gaps

Non-durable good

Investment good

Spending multipliers

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

2. Reduction in \( Y_t^{\text{potent}} \) and \( X_t^{\text{potent}} \) by 50% of initial gap

3. Relative price movements

\[ p_t^d = \left( \frac{X_t^{\text{dom}}}{X_t^{\text{potent}}} \right)^{1/\zeta} \]

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