Inequality and Asset Prices during Sudden Stops[1]

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Federal Reserve Board

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[1] The views expressed in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

Motivation

- In the last 30 years, there have been 58 Sudden Stop crises across EE and AE
- Crises characterized by declines in asset prices, which affect households differently
  - Mexico during the 2009 SS: high-leveraged HHs decreased their expenditures by 6.2% while non-leveraged HHs increased by 5.4%
- Inequality plays an important role in determining the aggregate effects of a crisis
  - Dampening and amplifying effects depending on the leverage and wealth distribution

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2. Proposes a small-open-economy, asset-pricing Bewley model with aggregate risk
   - The model can explain Sudden Stops' key stylized facts
   - Unlike a comparable RA framework, the model predicts persistent Sudden Stops and
   - asset prices drop less but consumption drops more, consistent with the data

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   - asset prices drop less but consumption drops more, consistent with the data
3. Uses the model to quantitatively asses the effect that different degrees of inequality have on the severity of crises
   - Differences between emerging and advanced economies: more unequal $\rightarrow$ more severe SS
   - Effects of a dividend tax that reduces wealth inequality: effective preventing C dropping but ineffective for asset prices
   - Future work on macro-prudential policies that interact with domestic risk-sharing

Related Literature

Study the role of heterogeneity in financial crises triggered by a debt-deflation mechanism

Sudden Stop crises and the debt-deflation mechanism in Rep-Agent economies

- Mendoza and Smith (2006), Mendoza (2010), Bianchi (2011), ...

Asset prices in closed economies with individual incomplete markets

- Aiyagari and Gertler (1991, 1999), Heaton and Lucas (1996), Storesletten et al. (2007), ...

Macroeconomy with aggregate shocks and individual incomplete markets

- Krusell and Smith (1997), Mendoza et al. (2009), Kaplan and Violante (2014), Guerrieri and Lorenzoni (2017), Huo and Rios-Rull (2016), Ferra et al. (2020), ...
- Limited heterogeneity and financial crises: Bordo and Meissner (2012), Morelli and Atkinson (2015), Kumhof et al. (2016), Paul (2020), ...

Empirical Evidence: Cross-sectional Effects

- Mexico had a severe Sudden Stop in 2009: EMBI spread $\uparrow$ 200 b.p. and Cons. $\downarrow$ 5%
- Micro-data: different effects depending on the composition of their balance sheets:

Median % Real Estate Change 2005-09

	Net Wealth	
Leverage Ratio	Non-Wealthy (I-IX)	Wealthy (X)
Low-Leverage (I-VIII)	-1.1	59.4
High-Leverage (IX)	-1.9	-15.0
Top-Leverage (X)	-1.4	-36.5

- Low-leveraged wealthy HHs increased their assets during the crisis
- Top-leveraged wealthy HHs decreased the most their assets during the crisis followed by the High-leveraged wealthy

Stats   Asset Prices   Cons Dynamics

Small-open-economy, asset-pricing Bewley model

Agents:

- Heterogeneous households $(b, a, \epsilon^w, \epsilon^d)$ with endogenous distributions Ω
- Rest of the world

Financial Markets and Frictions:

- Two financial assets: risk-free international bond and illiquid risky domestic asset
- HHs face a LtV credit constraint by which international debt cannot exceed a fraction of the market value of their asset:

$$R(\epsilon^R)^{-1} b' \geq -\kappa q(\Omega, \epsilon^R) a'$$

Exogenous Aggregate Shocks:

- Shock to the international interest rate, ϵ^R

Deriv. CC HH problem

Recursive Problem of the Household

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$$v(\underbrace{b, a, \epsilon^w, \epsilon^d}_{\text{Individual states}}; \underbrace{\Omega, \epsilon^R}_{\text{Aggregate states}}) = \max_{\{c, b', a' \geq 0\}} \frac{c^{1-\nu}}{1-\nu} + \beta \mathbb{E}[v(b', a', \epsilon^{w'}, \epsilon^{d'}; \Omega', \epsilon^{R'})] \quad \text{s.t.}$$

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$$c + R(\epsilon^{R})^{-1} b' + q(\Omega, \epsilon^{R})(a' + \Phi(a', a)) = \epsilon^{w} w + a(q(\Omega, \epsilon^{R}) + \epsilon^{d} d) + b \,, \quad \text{with mult: } \lambda(\cdot)$$

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$$R(\epsilon^R)^{-1} b' \geq -\kappa q(\Omega, \epsilon^R) a' \ , \quad \text{with mult: } \mu(\cdot)$$

$$\Phi(a', a) = \frac{\phi}{2}(a' - a)^2$$

$$\Omega' = H^{\Omega}(\Omega, \epsilon^R)$$

Equilibirum Conditions
Deriv. CC

Model: Individual Market Incompleteness and Risk Exposure

Idiosyncratic persistent labor productivity: ϵ^w

- With an inelastic labor supply it implies a fixed exposure to earnings risk

Idiosyncratic persistent dividend productivity: ϵ^d

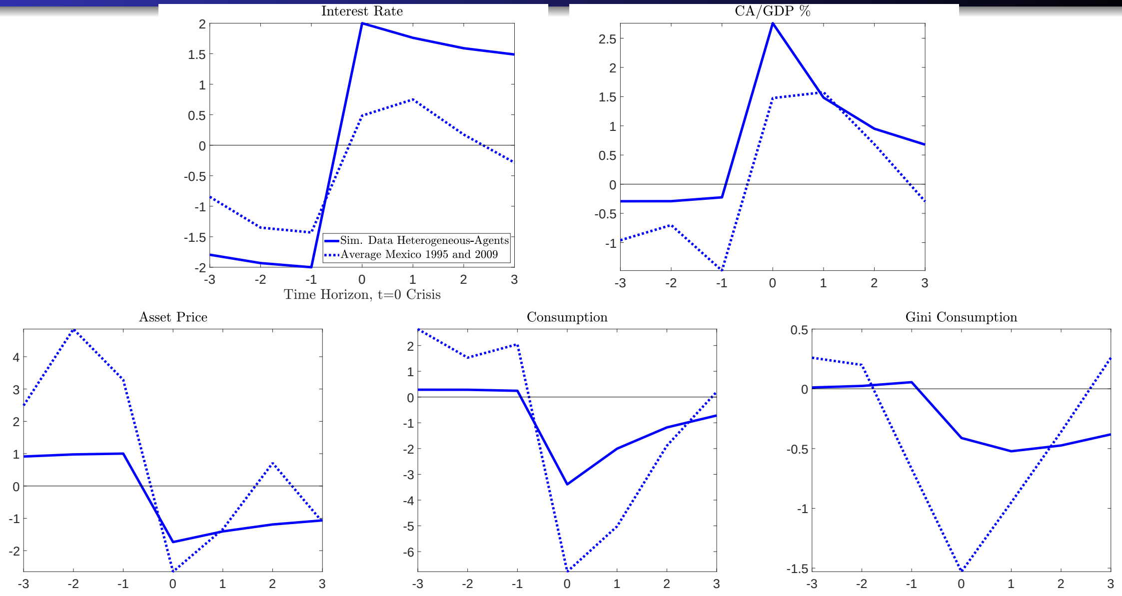
- Combined with the LtV debt constraint generates an *asset-wealth trade-off* from getting more assets:
    1. HH gets larger debt capacity that allows for better smoothing and reduces consumption volatility. Since $b' \geq -R\kappa q a'$
    2. HH gets higher future exposure to the dividend risk that for the same level of bonds increases consumption volatility
- In equilibrium, (2) dominates for high dividend asset-rich HHs which end up holding more bonds
- This behavior generates unconstrained wealthy HHs

Quantitative Analysis Roadmap

Quantitative Analysis

- Calibrate the stationary model to match Mexico's data moments ▸ Calibration
- Solve and simulate the aggregate risk model ▸ Solution
- Event study of Sudden Stops: capital outflows larger than 2 s.d. above the mean
- Analyze Sudden Stops under different degrees of inequality

Simulation and Event Study of Sudden Stops



Asset and Consumption Dynamics during a Crisis

In line with the empirical evidence during 2009 (reproduced in parenthesis), simulated data from the event study of a Sudden Stop captures that:

- Unconstrained wealthy HHs buy the assets fire-saled by constrained wealthy HHs

Cross-Sectional Effects

Median % Asset Change in a Crisis

	Non-Wealthy (I-IX)	Wealthy (X)
Low Leverage (I-VIII)	-0.1 (-1.1)	3.8 (59.4)
High Leverage (IX)	1.7 (-1.9)	2.3 (-15.0)
Top Leverage (X)	0.8 (-1.4)	-9.8 (-36.5)

- HHs closer to the debt limit adjust more the consumption during crises

Consumption Dynamics

Median % Consumption Change in a Crisis

Non Leverage (I)	-1.5 (5.4)
Moderate Leverage (II-IX)	-2.0 (3.6)
Top Leverage (X)	-4.3 (-6.2)

Effect of different degrees of inequality

- Advanced economy
  - Dividend risk is one half of the benchmark: Lower confiscation and informal high dividends
  - Lower precautionary motive $\rightarrow$ Net foreign debt is twice as large
  - Sudden Stops are less severe: C and asset price drop 30% less

  Lower Div Risk Plots

- Redistributive dividend tax Dividend Tax

Sudden Stop Deviations: Heterogeneous and Representative-Agent Models

	(1) Het. Agents Benchmark EE	(2) Rep. Agent with lower κ Match Ave. Lev. Ratio	(3) Het. Agents Adv Eco. ($\sigma^d/2$)	(4) Het. Agents EE with div. tax
Current Account / GDP p.p.	2.8	0.3	1.4	1.9
Consumption	-3.4%	-1.3%	-2.6%	-2.4%
Asset Price (q)	-1.7%	-3.0%	-1.3%	-1.7%

Conclusions

- This paper studies the cross-sectional dimension of the debt-deflation mechanism
- Document empirically two reasons why inequality matters during a crisis:
  1. Wealthy unconstrained buy depressed assets, relieving downward pressure on the price
  2. Financially vulnerable fire-sale assets, generating downward pressure on the price
- Using the proposed small-open-economy model with heterogeneous households I find that:
  1. The model can explain Sudden Stops' key stylized facts and generate persistent crises
  2. The dampening effect dominates: asset prices drop less in HA vs RA economies, but agg. consumption drops more
  3. Calibrating the model to an advanced economy: larger debt positions are supported and Sudden Stop crises are less severe, as observed in the data

Empirical Evidence: Heterogeneous Consumption Dynamics

- HHs closer to the debt limit end up adjusting the most their consumption:

Median % Consumption Change 2005-09	
Non Leverage (I)	5.4
Moderate Leverage (II-IX)	3.6
High Leverage (X)	-6.2

- Non-leveraged HHs, that have no or very little debt, increased their consumption
- Moderately leveraged HHs (decile II-IX) increased consumption in a smaller magnitude
- High-leveraged HHs decreased the most their consumption

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Table: Mean net wealth and its composition by deciles in 2005

	I	II	III	IV	V	VI	VII	VIII	IX	X
Net Wealth	-796	732	2,507	5,346	9,222	14,566	20,697	29,622	45,068	203,451
Real Estate Assets	-62.4%	21.9%	47.1%	69.5%	75.9%	80.9%	82.7%	83.2%	82.3%	74.7%
Other Assets	-85%	89.8%	50.2%	30.8%	23.8%	20%	15.8%	14.2%	14%	10.2%
Financial Assets	-6.4%	9.7%	12%	7.4%	5.2%	4.7%	3.8%	5.1%	6.1%	16.3%
Debt	253.8%	-21.4%	-9.3%	-7.6%	-4.8%	-5.6%	-2.2%	-2.5%	-2.4%	-1.1%
Leverage Ratio										
Mean	0.8	0.05	0	0.01	0.01	0.03	0.01	0	0	0
p90	1.83	0.36	0.18	0.15	0.12	0.09	0.05	0.06	0.05	0.04
p10	0	0	0	0	0	0	0	0	0	0

Notes: Deciles ordered by the net wealth. Net wealth in dollars of 2005.
Source: MxFLS.

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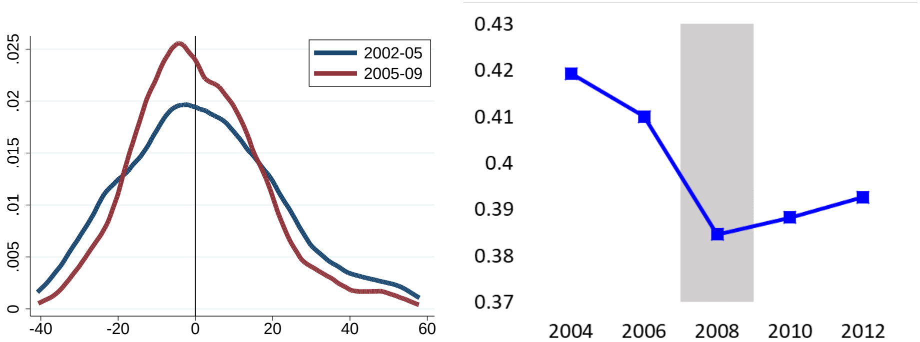
Appendix: Distribution of Consumption Change and Gini

Consumption Change and Gini



Notes: Source: MxFLS and ENIGH survey.

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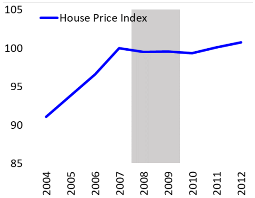
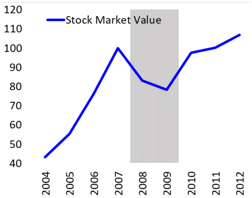
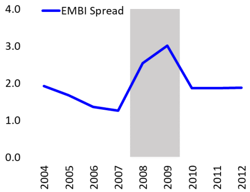
Figure: Asset Prices



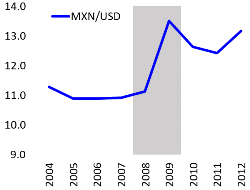
(a) House Price Index (2007=100)



(b) Stock Market Value Index (2007=100)



(c) J.P. Morgan EMBI Spread for Mexico in %



(d) Mexican Peso Exchange Rate for USD

Notes: The grey area corresponds to the crisis. Source: Sociedad Hipotecaria Federal, Moodys Analitics, INEGI, World Bank.

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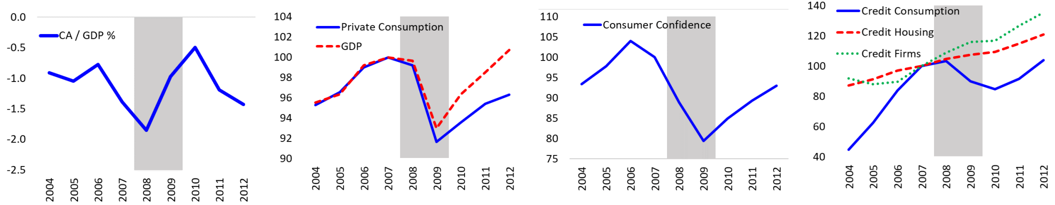
Figure: Quantities and Consumption determinants



(a) CA/GDP %

(b) Consumption and GDP Index (2007=100)

(c) Consumer Confidence Index (2007=100)

(d) Credit Index (2007=100)

Notes: The grey area corresponds to the crisis. Source: INEGI, World Bank, Banxico.

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Empirical Evidence: Heterogeneous Consumption Dynamics

- Changes across the net wealth and leverage distribution

Median % Consumption Change 2005-09

	Net Wealth	
Leverage Ratio	Non-Wealthy (I-IX)	Wealthy (X)
Non Leverage (I)	13.2	-31.3
Moderate Leverage (II-IX)	4.8	-13.0
High Leverage (X)	-6.0	-33.8

- Wealthy non-leverage HHs optimally choose to adjust consumption to buy more assets

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$$\Phi(a', a) = \frac{\phi}{2}(a' - a)^2$$

$$\Omega' = H^\Omega(\Omega, \epsilon^R)$$

Equilibirum Conditions | Deriv. CC | Back

Appendix: Equilibrium Conditions

From the FOC of the HH's problem we get the Euler Equation for the individual bonds and assets:

$$\lambda^i - \mu^i = \beta R \mathbb{E}[\lambda^{i\prime}]$$

$$q(\lambda^i(1 + \Phi_1^i) - \kappa\mu^i - \psi^i) = \beta\mathbb{E}[\lambda^{i\prime}(q' + d^{i\prime} - q'\Phi_2^{i\prime})]$$

- The households have a well defined non-degenerate portfolio choice due to the trading costs of the assets and the collateral constraint
- Given an Aggregate Law of Motion and a current asset price conjectures, we can solve the households problem using *FiPIt* without the need of a non-linear solver

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Collateral Constraint based on Bianchi and Mendoza (JPE, 2018)

Derivation of the LtV as an IC constraint resulting from a limited enforcement problem

$$R_t^{-1} b_{t+1}^i \geq -\kappa q_t a_{t+1}^i$$

- Debt contracts are signed with creditors in a competitive environment
- HHs can always switch to another creditor at any point in time
- At the beginning of the period credit and asset markets open
- Production happens and HH i chooses b_{t+1}^i with price R_t^{-1} and a_{t+1}^i with price q_t
- Markets close and HH decides to divert the resources from the credit and default
- Local competitive financial intermediaries monitor costlessly who diverts resources and seize a fraction κ of the HH's market valued assets which are $q_t a_{t+1}^i$
- After defaulting, the HH regains access to credit markets instantaneously and repurchases the assets that investors sell in open markets at a price q_t

$$\Rightarrow$$

- A HH that borrows $-R_t^{-1} b_{t+1}^i$ and engages in diversion activities gains $-R_t^{-1} b_{t+1}^i$ and loses $\kappa q_t a_{t+1}^i$. HH repays if and only if $-R_t^{-1} b_{t+1}^i \leq \kappa q_t a_{t+1}^i$

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Calibration of the stationary model

Parameter		Value	Source or Target
Calibrated exogenously			
ν	Risk aversion	2	Common in the literature
$\bar{R} - 1\%$	Interest rate	3%	Mean interest rate Mexico
κ	Debt fraction of collateral	0.14	Equal to the average leverage ratio in 2005
$\bar{K}$	Net asset supply	1	Normalization
Calibrated by simulation			
β	Discount factor	0.90	Match average NFA/GDP ratio of -40%
ϕ	Trading cost	3.5	Match average transaction cost of 5%

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Calibration of the stationary model: AR(1) Earning Process

- GMM estimation of the earnings process where the log income risk follows a stationary process with a persistent and transitory component

$$\log(Y^i_{a,t}) = \beta' X^i_{a,t} + D_t + y^i_{a,t} \ , \quad y^i_a = z^i_a + \epsilon^i_a \ , \quad z^i_a = \rho_w z^i_{a-1} + \sigma_w \eta^i_a$$

- Using a households quarterly rotating panel from 2005-I to 2014-IV: lower autocorrelation and higher variance than the estimates for the US

Annual income process estimates with labor income share of 2/3

	Mexico	Mexico Formal Emp.	U.S. STY (2004)	U.S. Guvenen (2009)	U.S. KMP (2016)
ρ_w	**0.906**	0.922	0.999	0.988	0.970
σ^2_w	**0.039**	0.038	0.017	0.015	0.038

- The combination of a large informal labor market and the lack of unemployment insurance accounts for part of the difference

Estimation Details

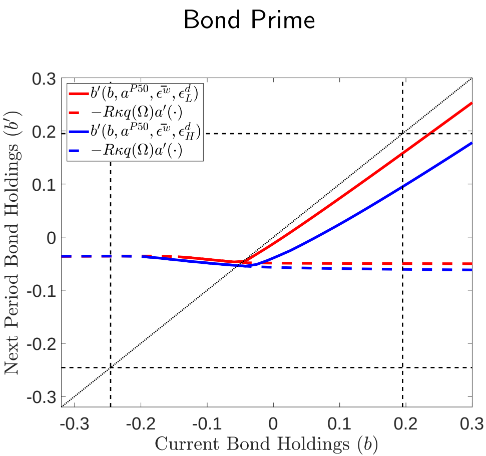
Calibration of the stationary model: AR(1) Dividend Process

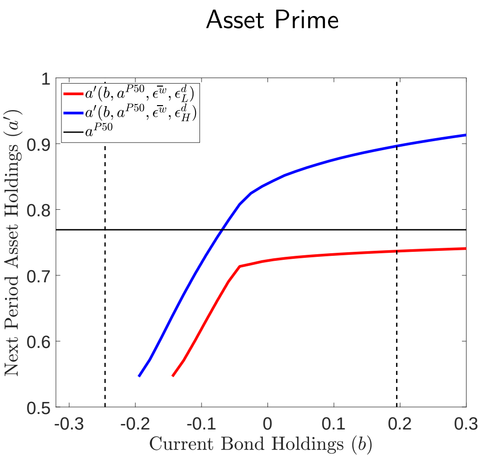
- Estimation of this process is infeasible due to the lack of available data
- Strategy: jointly calibrate $(\epsilon^d d)$ to match the leverage ratio distribution of households, where $\log(\epsilon^{d'}) = \rho_d \log(\epsilon^d) + \sigma_d \eta$
- Solution: $(d = 3.6\%, \rho_d = 0.94, \sigma_d = 83\%)$

Leverage Ratio Distribution of Households in %

	Data in 2005	Stationary Model
Savers (leverage ratio ≤ 0)	24.6	25.1
Indebted not constrained (leverage ratio $\in (0, 0.144)$)	57.2	57.0
Financially constrained (leverage ratio $\geq 0.144]$)	18.2	17.9

Policy Functions: $(b, a^{P50}, \epsilon^{\bar{w}}, \epsilon_L^d$ or $\epsilon_H^d)$

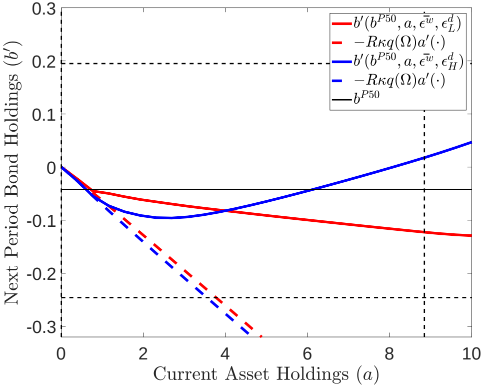




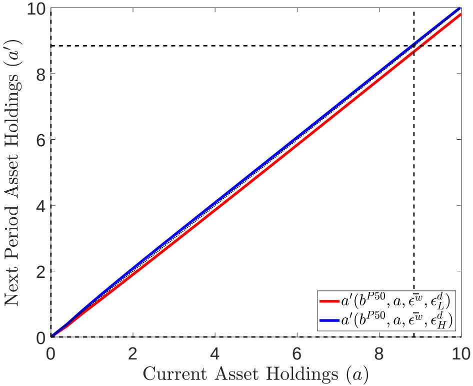
- Households fire-sale their assets as they become debt constrained

Policy Functions: $(b^{P50}, a, \epsilon^{\bar{w}}, \epsilon^d_L \text{ or } \epsilon^d_H)$

Bond Prime



Asset Prime



- Asset-rich HHs that bear more risk move away from their debt limit and high-div HHs deaccumulate debt

Solution of the Stationary Model

- The stationary model, in which the interest rate is kept constant at its steady state value of 3%, does a good job capturing the wealth and consumption inequality
- Although only 18% of the HHs are constrained, the aggregate collateral constraint effect account for 39% of the equity premium

Non-targeted Inequality Measure

	Model	Data
Wealth Gini	0.68	0.73
Consumption Gini	0.31	0.50

Decomposition of the Equity Premium

	Model	Data
Equity Premium	4.9%	6.5%
Constraint Effect	39.1%	-
Risk Effect	59.7%	-
Trading Cost Effect	2.7%	-
Short-Sales Effect	-1.5%	-

Note: Data in 2005.

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Solution of the Aggregate Risk Model

- Interest rate follows a 2-state Markov process: $R - 1\% \in \{1,\ 5\}$ with persistence of 0.9
- Adapt the *non-trivial* market clearing algorithm proposed by Krusell and Smith (1997) to a small-open-economy setup:
- Replace the distribution with the aggregate bond position B and use the interest rate $R - 1$ to approximate the next period's bond position B' and the asset price q
- The solution of the aggregate law of motions are:

$$B' = -0.005 + 0.870\ B + 0.054\ (R - 1), \quad R^2 = 0.99$$

$$q = 0.517 + 0.126\ B - 0.301\ (R - 1), \quad R^2 = 0.92$$

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Calibration of the stationary model: AR(1) Earning Process

Following Krueger et al. (2016), I do a GMM estimation of the earning's process:

1. Estimate a Mincer log-earnings equation with time fixed effects

$$\log(Y^i_{a,t}) = \beta' X^i_{a,t} + D_t + y^i_{a,t}$$

2. Let the income risk follow a stationary process with a persistent and transitory component:

$$\begin{aligned} y^i_a &= z^i_a + \epsilon^i_a \\ z^i_a &= \rho_w z^i_{a-1} + \sigma_w \eta^i_a \text{ , with } \eta^i_a \sim (0,1), \; z^i_0 \sim (0, \sigma^2_{z_0}), \; \epsilon^i_a \sim (0, \sigma^2_\epsilon) \end{aligned}$$

3. Using the ENOE rotating panel from 2005-I to 2014-IV I estimate the vector of parameters $\theta = (\rho_w, \sigma^2_w, \sigma^2_{z_0}, \sigma^2_\epsilon)$: lower autocorrelation and higher variance

Table: Annual Income Process Estimates

	Mexico Own Calc.	U.S. STY (2004)	U.S. Guvenen (2009)	U.S. KMP (2016)
ρ_w	0.906	0.982	0.988	0.970
σ^2_w	0.039	0.024	0.015	0.038

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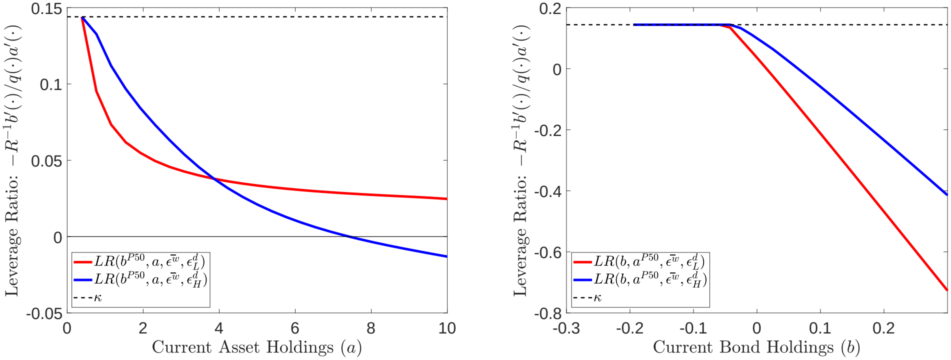
Stationary model: Leverage Ratio Policy Function

Figure: Stationary Leverage Ratio Policy Functions $LR(b^{P\#}, a^{P\#}, \epsilon^{\bar{w}}, \epsilon^d_L \text{ or } \epsilon^d_H)$



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Appendix: Descriptive Statistics from the Model

Table: Variables relative to the median, ordered by net wealth

	I	II	III	IV	V	VI	VII	VIII	IX	X
Net Wealth relative to median										
Data	-0.1	0.1	0.3	0.6	1	1.6	2.2	3.2	4.9	22.1
Model	0	0.1	0.4	0.7	1	1.5	2.2	3.3	5.8	16.5
Assets relative to median										
Data	0.1	0.1	0.3	0.6	1	1.6	2.2	3.1	4.8	21.3
Model	0	0.1	0.3	0.6	1	1.5	2.2	3.4	5.9	17
Debt relative to median										
Data	4.3	0.4	0.5	0.9	1	1.8	1	1.6	2.4	5.2
Model	0.1	0.2	0.3	0.5	1	1.5	2.3	3.5	6.2	9.5

Notes: Deciles ordered by the net wealth.

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Asset and Consumption Dynamics during a Crisis

In line with the empirical evidence during 2009 (reproduced in parenthesis), simulated data from the event study of a Sudden Stop captures that:

- Unconstrained wealthy HHs buy the assets fire-saled by constrained wealthy HHs

Cross-Sectional Effects

Median % Asset Change in a Crisis

	Non-Wealthy (I-IX)	Wealthy (X)
Low Leverage (I-VIII)	-0.1 (-1.1)	3.8 (59.4)
High Leverage (IX)	1.7 (-1.9)	2.3 (-15.0)
Very High Leverage (X)	0.8 (-1.4)	-9.8 (-36.5)

- HHs closer to the debt limit adjust more the consumption during crises

Consumption Dynamics

Median % Consumption Change in a Crisis	
Non-Leverage (I)	-1.5 (5.4)
Moderate-Leverage (II-IX)	-2.0 (3.6)
High-Leverage (X)	-4.3 (-6.2)

Counterfactual Advanced Economies

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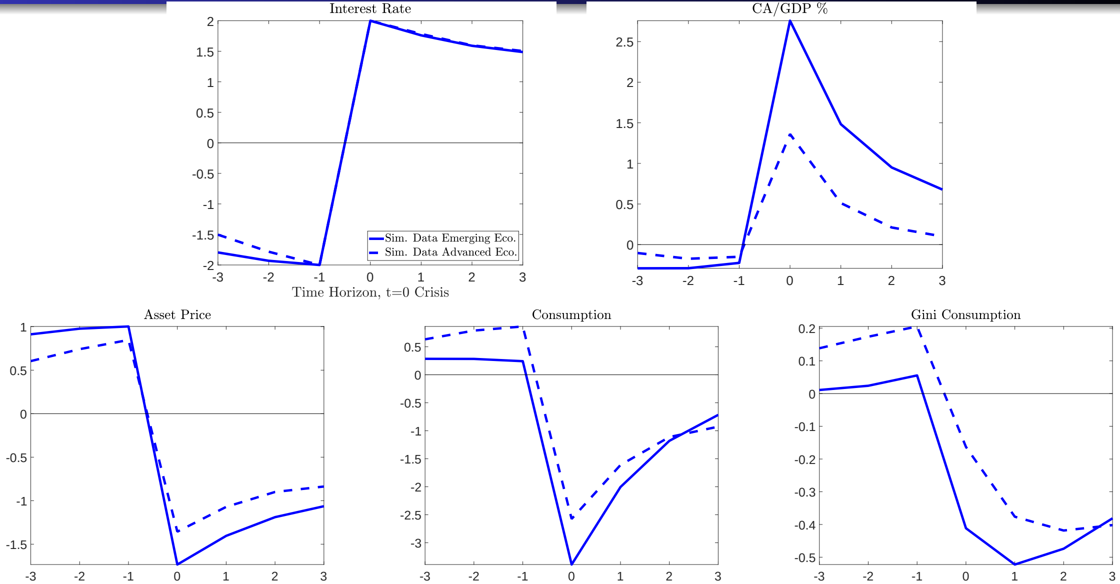
Effect of different degrees of inequality

- Advanced economy
  - Dividend risk is one half of the benchmark: Lower confiscation and informal high dividends
  - Lower precautionary motive → Net foreign debt is twice as large
  - Sudden Stops are less severe: C and asset price drop 30% less

Sudden Stop Deviations: Heterogeneous and Representative-Agent Models

	(1) Het. Agents Benchmark EE	(2) Rep. Agent with lower κ Match Ave. Lev. Ratio	(3) Het. Agents Adv Eco. ($\sigma^d/2$)
Current Account / GDP p.p.	2.8	0.3	1.4
Consumption	-3.4%	-1.3%	-2.6%
Asset Price (q)	-1.7%	-3.0%	-1.3%

Sudden Stops in economies with different degrees of inequality



Notes: Triangle (circle) markers correspond to advanced (emerging) economies. Dates of Sudden Stop episodes come from Bianchi and Mendoza [2020]. Data Source: The World Bank.

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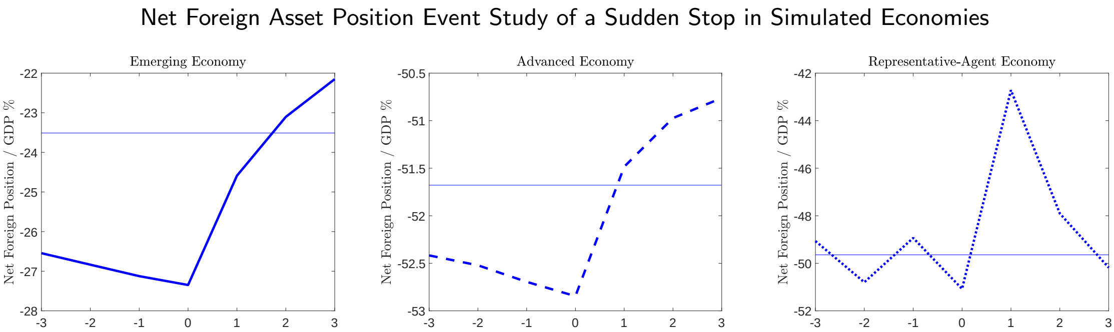
Sudden Stops in economies with different degrees of inequality



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Redistributive Dividend Income Tax: $\tau^d = 50\%$

Budget constraint with a dividend tax and lump-sum transfers (Balanced Budget) becomes:

$$c_t^i + R_t^{-1} b_{t+1}^i + q_t(a_{t+1}^i + \Phi(a_{t+1}^i, a_t^i)) = w_t^i + a_t^i(q_t + d_t^i(1 - \tau^d)) + b_t^i + T_t$$

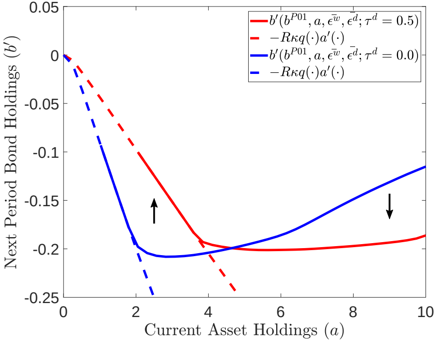
With lower idiosyncratic dividend risk the precautionary savings motive is less potent:

1. Less demand for bonds (more debt if negative holdings)
2. Less demand for domestic assets: on average the price is 11% smaller

$\Rightarrow$

Less agg. debt and more constrained HHs

Bond Policies with and without tax



Asset and Consumption Dynamics during a Crisis

Economy with tax (without tax)

- High-leveraged HHs still fire-sale assets

Cross-Sectional Effects

Median % Asset Change in a Crisis

	Non-Wealthy (I-IX)	Wealthy (X)
Low Leverage (I-VIII)	-0.3 (-0.1)	3.1 (3.8)
High Leverage (IX)	1.8 (1.7)	-0.8 (2.3)
Top Leverage (X)	1.2 (0.8)	-7.6 (-9.8)

- Less debt and redistribution makes consumption drop less

Consumption Dynamics

Median % Consumption Change in a Crisis

Non Leverage (I)	-1.3 (-1.5)
Moderate Leverage (II-IX)	-1.8 (-2.0)
Top Leverage (X)	-1.0 (-4.3)

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