# Sovereign Defaults and Domestic Debt

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# Research Question: Motivation

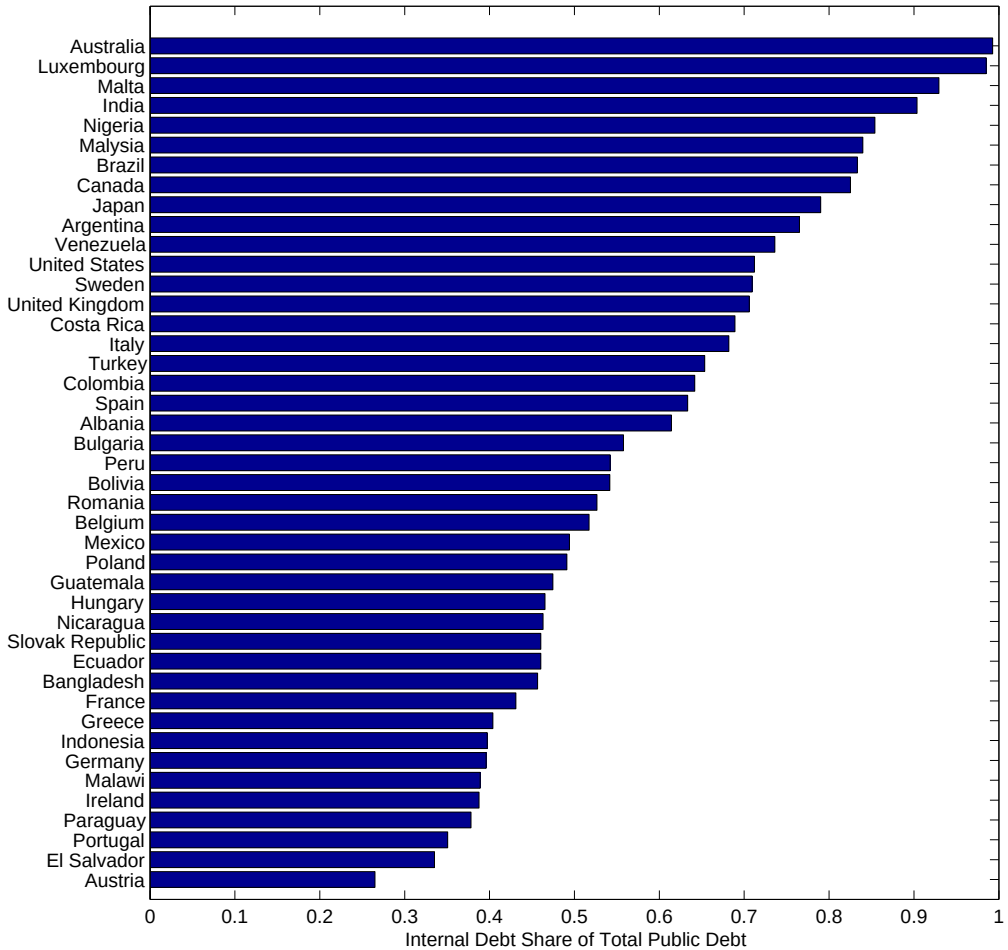
- Sovereign default literature concentrates on external sovereign debt
- Little about domestic holdings of government debt.
- Empirical works suggest domestic debt is relevant (R& R 2011)

This work:

- Extend quantitative model of sovereign default to include domestic and external debt
- Study positive and normative implications of such extension

# Stylized Facts - Domestic Debt

# Stylized Facts I: Domestic debt size




Time: 2013 Q4.

# Stylized Facts II: Domestic default Incidence

- Defaults on domestic debt happen
- 48% of default episodes since 1980 are (also) domestic defaults
- Argentina 1982 and 2001 defaults were on both domestic and external debt

# Stylized Facts III: Domestic debt and output contraction

Table: **Output dynamics around Default**

| | Domestic Defaults | | External Defaults | |
|---|---|---|---|---|
| Time | Output | Output Gap | Output | Output Gap |
| t-3 | 100 | 0.03 | 100 | 0.02 |
| t-2 | 98 | 0.04 | 111 | 0.03 |
| t-1 | 97 | 0.02 | 117 | 0.07 |
| t | 90 | -0.06 | 112 | -0.03 |
| t+1 | 88 | -0.11 | 116 | -0.03 |
| t+2 | 108 | -0.01 | 127 | 0.00 |
| t+3 | 125 | 0.02 | 135 | 0.02 |

# Stylized Facts IV: Determinants of output contraction

Theory:

- Default costs are external: exclusions from trade and foreign borrowing

Empirical Findings:

- Trade is not really diverted and exclusion time is short
- Output costs determined by credit contraction.
- Stronger credit contraction when domestic exposure is higher

# Stylized Facts IV: Determinants of output contraction

Table: **Credit Supply around Default**

| | Domestic Defaults | | External Defaults | |
|---|---|---|---|---|
| Time | *Credit* / *Y* | % Change | *Credit* / *Y* | % Change |
| t-3 | 100 | | 100 | |
| t-2 | 98 | −2.00% | 101 | 1.45% |
| t-1 | 98 | −1.57% | 106 | 6.30% |
| t | 96 | −3.60% | 110 | 10.64% |
| t+1 | 87 | −12.60% | 110 | 10.80% |
| t+2 | 87 | −12.63% | 108 | 8.23% |
| t+3 | 93 | −6.89% | 107 | 7.63% |

Source: FSD for 29 Default episodes

# Contributions

Positive Contribution:

- Describe a mechanism relating defaults and output contraction in a way which is consistent with empirics
- Match model to Argentina. Match default incidence and equilibrium debt levels better

Normative contribution:

- Debt composition matters to assess the default risk
- Externality: Policy intervention needed to achieve the efficient eq.

# Literature Review

- Quantitative sovereign default models with external debt
  - Arellano (2008) Aguiar & Gopinath (2006)
- Interaction between debt and credit:
  - Public debt as private liquidity (Holmstrom & Tirole 1997)
  - Sovereign Defaults and banking crises (Martin, Gennaioli & Rossi 2013; Brutti 2012)
- Secondary Markets and Domestic Debt
  - Existence of public debt (Bronner, Martin & Ventura 2012)

# Model

# Model overview

1. Firms
2. Households: Workers and Domestic Investors
3. Government
4. External Investors

# Firms

The profit maximization problem:

$$\max_{N} \left\{ zf\left(N\right) - wN - r^{L}\gamma wN \right\}$$

Firms are subject to a working capital constraint:

$$L = \gamma wN.$$

FOC relates the wage rate to the credit market

$$N: \; w = \frac{zf_{N}\left(N\right)}{1 + \gamma r^{L}}.$$

# Households

- Each Household $i$ is composed of Workers and Investors that pool consumption and income
- Workers choose labor supply and delegate the inter-temporal saving decision to Investors
- Investors manage the financial wealth of households: they purchase government bonds and provide credit to the economy

# Households: Workers

$$\max_{c,N} U(c, N);$$

$$s.t.\ c + T\left(z, B, B^H\right) = wN + \pi + \pi^I(z, B, B^H, b^H).$$

# Households: Investors

- Investors are subject to a capital adequacy ratio (CAR): credit supply cannot exceed a multiple of the equity value.
- Value of the equity is affected by holdings of government debt.
- Upon default equity contracts and credit supply falls leading to output contraction

# Households: Investors

$$\max_{b'^H} \Pi^I(z, B, B^H, b^H) = \pi^I(b'^H) + \beta EQ\left[(1 - P(def'))\,\Pi^I(z', B', B'^H, b'^H|z)\right]$$
$$+\beta EQ\left[P(def')\,\Pi^I(z', 0, 0, 0|z)\right];$$

$$s.t.\ Q = \frac{U_c(c', N')}{U_c(c, N)};$$

$$s.t.\ \pi^I = r^L l - q b'^H;$$

$$s.t.\ l = g\left(b^H\right).$$

Microfundation

In equilibrium: $L = \int_0^1 l\ di$ and $B^H = \int_0^1 b^H\ di$.

# Government

- Budget constraint:

$$T + qB' = B + g$$

- Internalizes the value function $V^H$ of Households
- Observes domestic exposure $B^H$
- Decides whether to default or not according to the rule:

$$Def = \begin{cases} 0 & if\ V(z, B, B^H) \geq (1-\lambda)V_{def}(z, 0, 0) + (\lambda)V_{red}(z, 0, 0) \\ 1 & if\ else \end{cases}$$

# International Investors

- Invest in government bonds and a risk-free technology.
- Price government bonds by arbitrage:

$$q(z, B', B'^H) = \frac{1 - P(def'|z)}{1 + r^f}.$$

- International investors have deep pockets and determine the price of government bonds

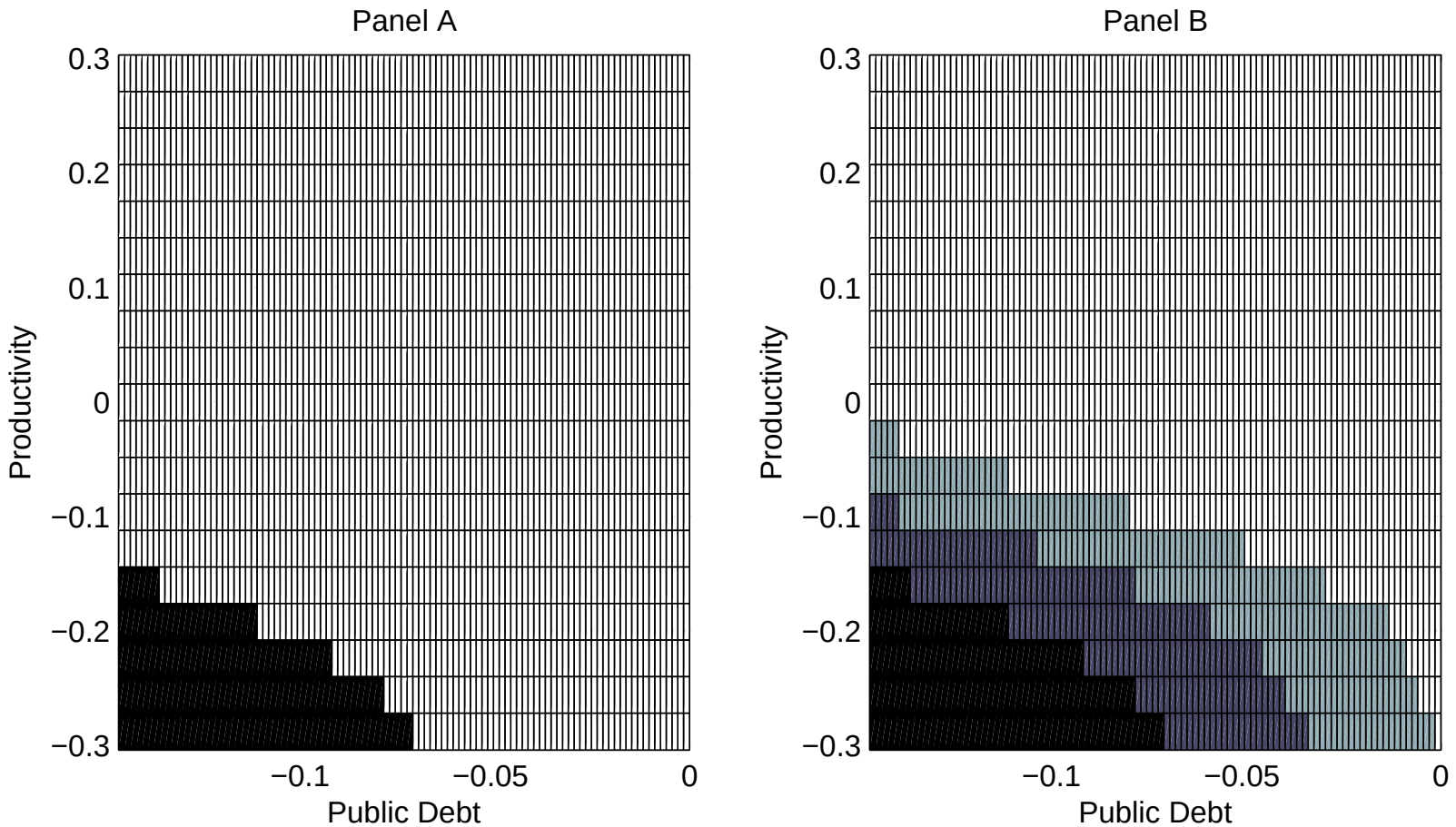
# Results - Positive Analysis

# Simulations: Calibration

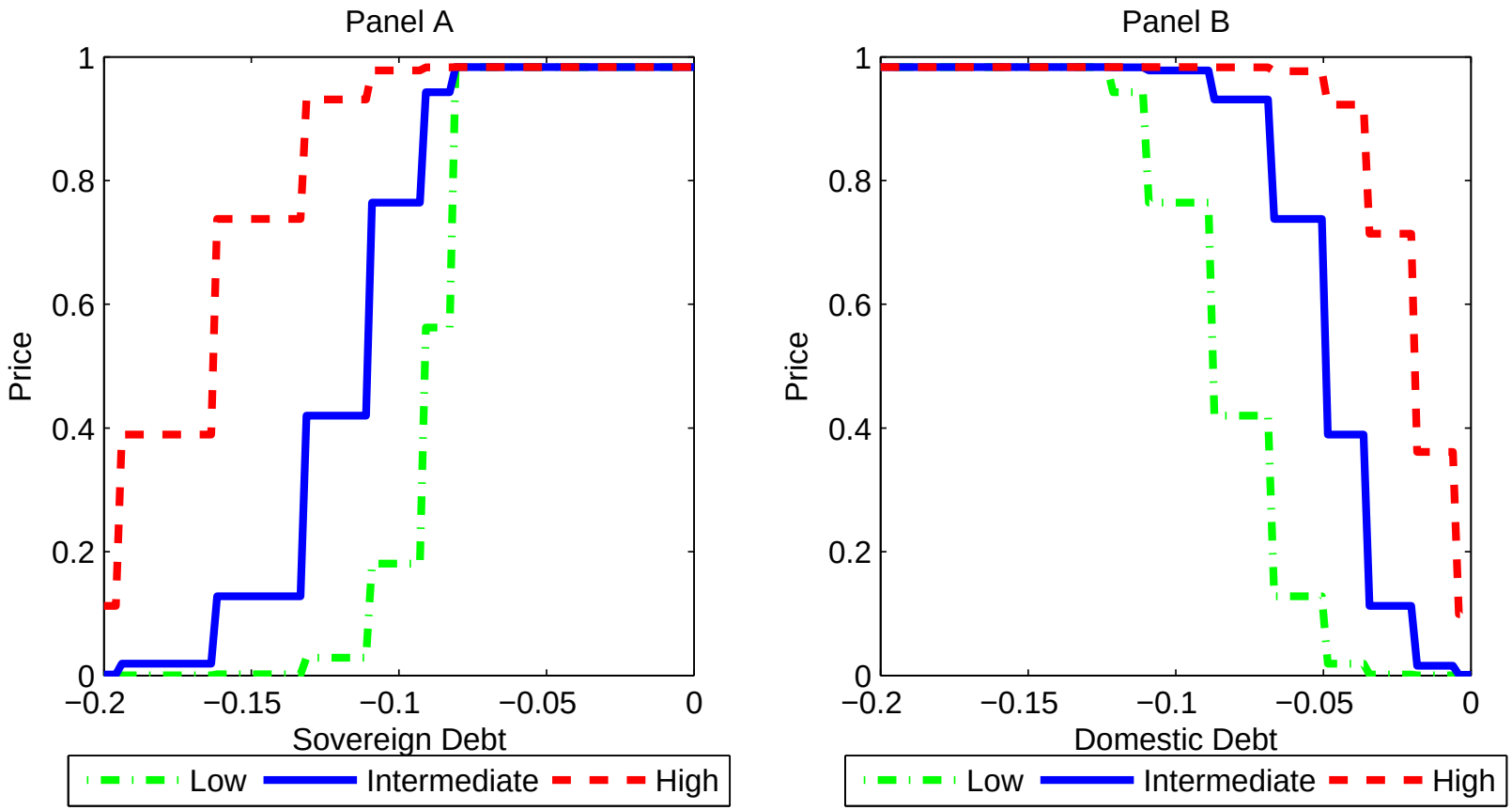
Table: **Calibration**

| Calibrated Parameter | | Value | Target Statistics/Source |
|---|---|---|---|
| Loan share final good production | $\alpha$ | 0.3 | Standard RBC |
| Discount factor | $\beta^B$ | 0.8 | Standard RBC |
| Re-entry probability | $\lambda$ | 0.185 | Exclusion length = 5.4 years |
| Autocorrelation of TFP shocks | $\rho$ | 0.96 | Standard RBC |
| Coefficient of relative risk aversion | $\sigma$ | 2 | Standard RBC |
| Frisch elasticity | $\omega$ | 1.455 | Standard RBC |
| Risk Free rate | $r^f$ | 0.017 | US 5 year bond return |
| Working capital parameter | $\gamma$ | 0.42 | Credit supply/GDP = 24.96% |
| Government spending | $G$ | 0.13 | Gov't spending/GDP = 0.2 |
| Investors' endowment | $\Gamma$ | 0.06 | Domestic Investors exposure = 0.41 |

# Default Set


Panel A
Panel B
Productivity
Public Debt
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.1
−0.05
0

# Domestic Debt Price



# Simulation Results

**Panel A: Non Targeted Moments**

| | Data | Model CE |
|---|---|---|
| Moments: | | |
| Default Rate | 2.5% | 2.9% |
| Debt/GDP ratio | 0.48 | 0.28 |
| Domestic Debt/GDP ratio | 0.28 | 0.16 |
| Internal/External Debt ratio | 0.58 | 0.56 |
| Spread | 1,016 | 636 |
| $\rho(spread, y)$ | -0.89 | -0.66 |
| $\rho(L, spread)$ | -0.28 | -0.30 |
| $\rho(B^H/B, spread)$ | -0.26 | -0.39 |
| Behavior around default: | | |
| Mean GDP loss | $-14\%$ | $-15\%$ |
| Mean Credit contraction | $-27\%$ | $-25\%$ |

**Panel B: Targeted Moments**

| | Data | Model CE |
|---|---|---|
| Moments: | | |
| Credit supply/GDP | 0.25 | 0.25 |
| Gov't spending/GDP | 0.20 | 0.21 |
| Domestic Investors Exposure | 0.28 | 0.28 |

# Results - Normative Analysis

# Equilibria

Competitive eq. and constrained efficient eq. do not coincide:

- Probability of default depends on domestic debt: $q\left(z, B', B'^{H}\right)$
- Domestic investors are too small to internalize the impact of purchases on $q$
- Government internalizes the effect of domestic bond purchases on $q$

$$B'^{H,CE} \neq B'^{H,PO}$$

# Pecuniary Externality

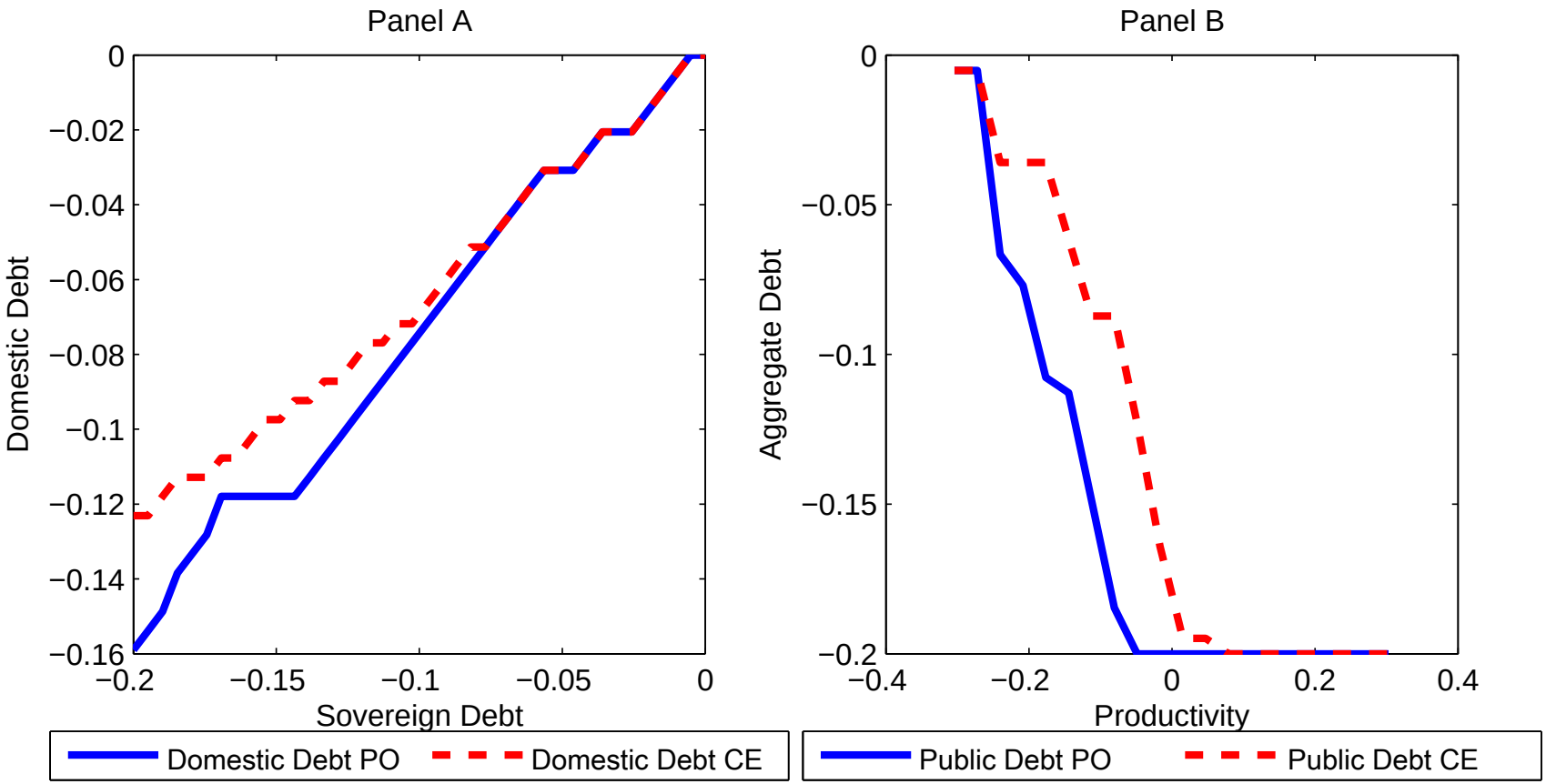
Distorted domestic debt allocation distorts debt price schedule:

$$B'^{H,CE} \neq B'^{H,PO} \Leftrightarrow q\left(z, B', B'^{H,CE}\right) \neq q\left(z, B', B'^{H,PO}\right)$$

As government debt price is distorted, so is government debt:

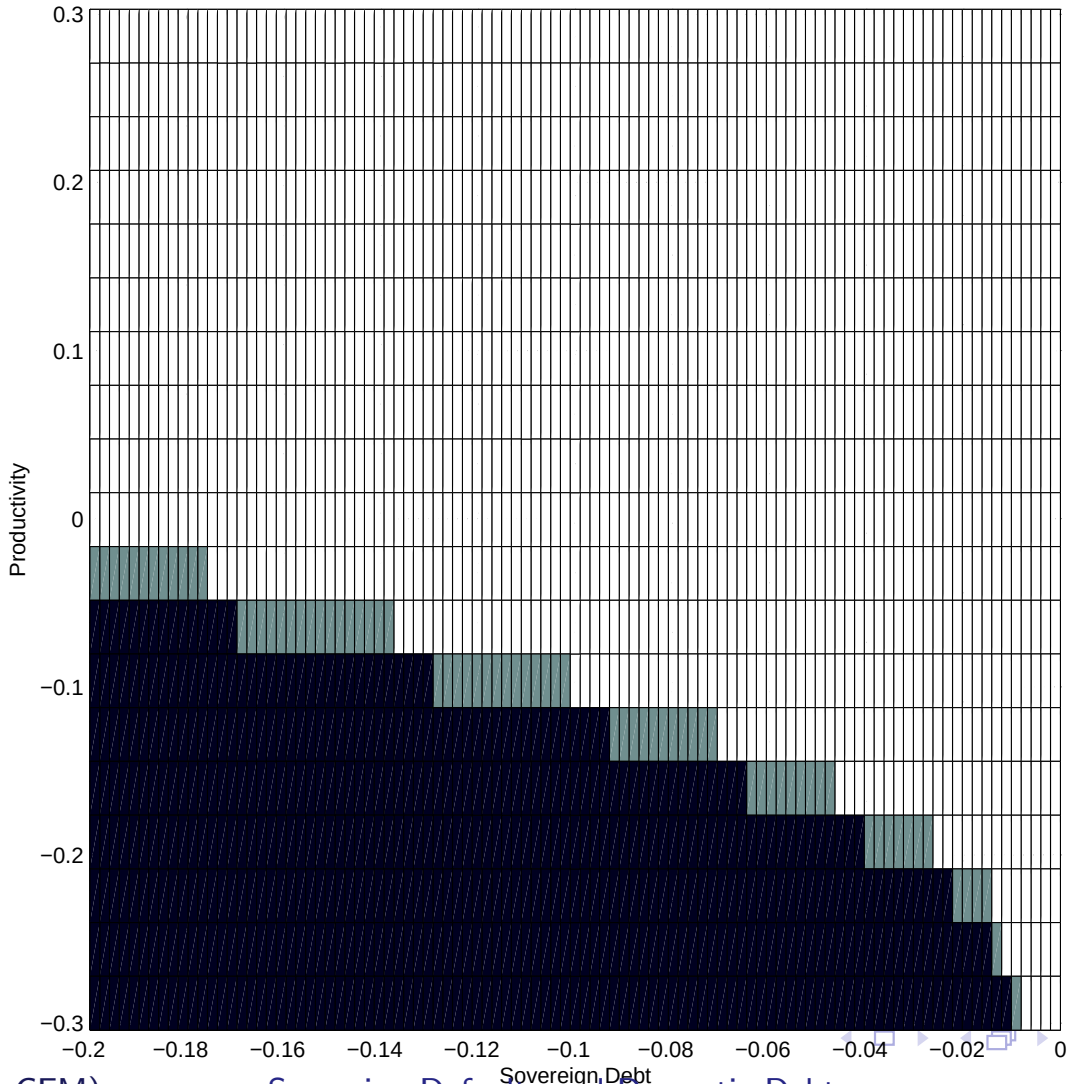
$$q\left(z, B', B'^{H,CE}\right) \neq q\left(z, B', B'^{H,PO}\right) \Leftrightarrow B'^{CE} \neq B'^{PO}$$

# PO and CE comparison



# Default Set

Distortion in debt composition increase the default risk



# Pigouvian Taxation

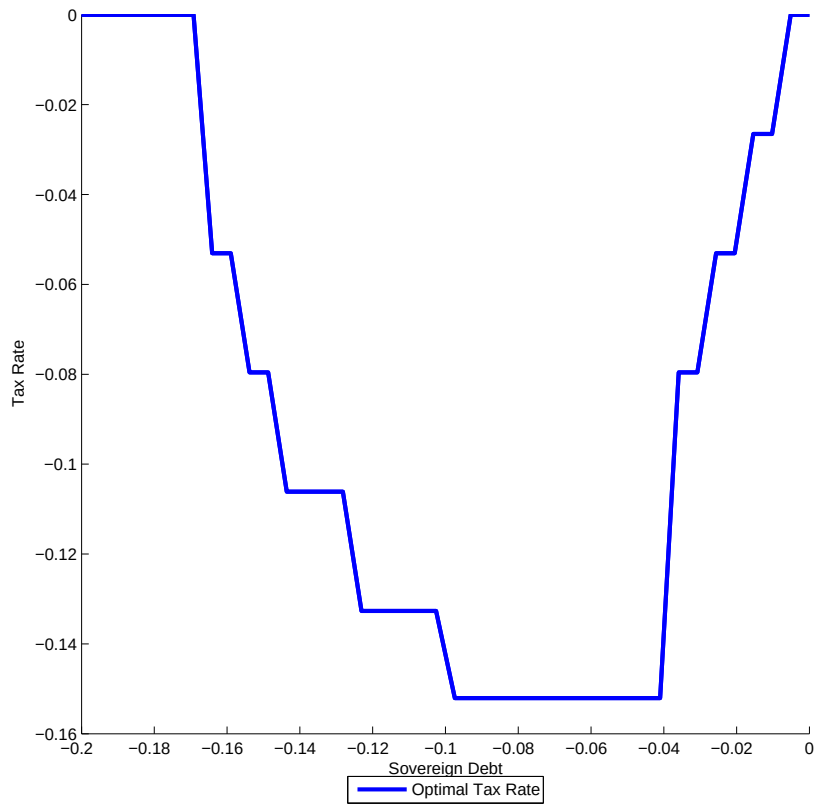
Domestic investors BC with Pigouvian tax

$$c + T^* + (q + \tau) B'^H = wN + \pi + B^H + r^L L.$$

Comparing with the PO:

$$\tau = -\frac{\partial q}{\partial B'^H} \left( B' - B'^H \right)$$

# Pigouvian Taxation: Optimal Prudential Schedule and Welfare



# Pigouvian Taxation: Optimal Prudential Schedule and Welfare

Table: **Optimal Pigovian Tax**

| | $mean(\tau)$ | $\sigma(\tau)$ | $\rho(\tau, y)$ | $\rho(\tau, spread)$ | W. Gain | max W. Gain |
|---|---|---|---|---|---|---|
| Model Simulations: | $-0.07$ | 0.39 | 0.28 | $-0.21$ | 1.6% | 46% |

# Conclusions

Positive Analysis:

- Introduce domestic debt: composition matters to determine default risk
- Endogenous default cost affecting output through the credit market
- Improve performance of sovereign default models

Normative Analysis:

- Policy measures should not only be limited to the management of debt size.
- Scope for policy intervention to achieve the optimal composition of debt

# Households

$$\max_{c,N,B'^H} V^H(z,B,B^H) = U^H(c,N) + \beta E\left(1 - def'\right) V'^H(z',B',B'^H|z)$$
$$+\beta E def' V'^H\left(z',0,0|z\right)$$

$$s.t.\ c + T\left(z,B,B^H\right) = wN + r^D D + \pi + \pi^B.$$

Solve Workers and Bankers problem separately.

# Household - Bankers: Morning Interim Time

- Bankers provide intra-temporal loans to firms
- Cash flow statement

$$D + B^H = L + qB'^H; \tag{1}$$

- Balance sheet identity

$$e \equiv L + qB'^H + M; \tag{2}$$

- Capital adequacy Requirement (CAR)

$$e \geq \frac{1}{\phi}\left(\nu_1 L + \mu B'^H\right); \tag{3}$$

# Household - Bankers: Morning Interim time

Combining (1), (2) and (3):

1. Equity equation

$$e = B^H +$$

2. Credit supply function:

$$L^B = \phi e - \frac{\mu}{\nu_1} B'^H$$

- Defaults reduce equity values
- Default cost depends on $B^H$ and are endogenous.

# Household - Bankers: Afternoon Interim time

Intra-temporal claims are settled:

- Cash flow statement

$$(1 + r^L)L = (1 + r^D)D;$$

# Household - Bankers Profits

Combining morning and afternoon cash-flows:

$$\pi^B(z, B, B^H) = \left(B^H - qB'^H\right) + r^L L - r^D D$$

$$s.t.\ e = B^H + M$$

$$s.t.\ L^B = \phi e - \frac{\mu}{\nu_1} B'^H$$

Back

# Sensitivity

Table: **Sensitivity Analysis**

| | Default Rate | $B/Y$ | $B^H/Y$ | $B^H/B$ | $L/Y$ | % GDP loss | % Credit fall |
|---|---|---|---|---|---|---|---|
| Data | 2.5% | 0.48 | 0.28 | 0.58 | 0.25 | $-14\%$ | $-27\%$ |
| Benchmark | 2.9% | 0.28 | 0.16 | 0.56 | 0.25 | $-14\%$ | $-25\%$ |
| W-K constraint. Benchmark value: $\gamma = 0.42$ | | | | | | | |
| $\gamma = 0.3$ | 6.74% | 0.20 | 0.09 | 0.47 | 0.19 | $-8\%$ | $-14\%$ |
| $\gamma = 0.5$ | 0.00% | 0.25 | 0.19 | 0.78 | 0.29 | - | - |
| Re-entry Prob. Benchmark value: $\lambda = 0.185$ | | | | | | | |
| $\lambda = 0.1$ | 1.9% | 0.28 | 0.15 | 0.54 | 0.25 | $-18\%$ | $-30\%$ |
| $\lambda = 0.25$ | 3.0% | 0.28 | 0.16 | 0.58 | 0.26 | $-11\%$ | $-20\%$ |
| Investors Endowment. Benchmark value: $\Gamma = 0.06$ | | | | | | | |
| $\Gamma = 0.03$ | 0.0% | 0.25 | 0.19 | 0.79 | 0.24 | - | - |
| $\Gamma = 0.1$ | 12% | 0.023 | 0.020 | 0.89 | 0.20 | $-1\%$ | $-2\%$ |

Back