Connected for Better or Worse? The Role of Production Networks in Financial Crises

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System Committee on International Economic Analysis
Federal Reserve Bank of San Francisco
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Frequency and Severity of Sudden Stops

- EMs are more volatile, more crisis-prone, and sustain less debt than AEs

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- **Question:**
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    - Yes, part of it

This Paper

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- **Policy:**
  - We evaluate *non-state contingent* debt and sectoral taxes
  - Policy gains depend on networks and financial depth: There is no one-size-fits-all
  - Planner may trade production efficiency for crisis resilience

Simple Perfect Foresight Model

A Perfect Foresight Economy

- Households:

$$\max_{\{c_t^N, c_t^T, b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma} \qquad \text{s.t.}$$

$$c_t = \left[\omega (c_t^T)^{-\eta} + (1-\omega)(c_t^N)^{-\eta}\right]^{-\frac{1}{\eta}},$$

$$c_t^T + p_t^N c_t^N + q b_{t+1} = \pi_t^N + \pi_t^T + b_t, \qquad q b_{t+1} \geq -\kappa(\pi_t^N + \pi_t^T).$$

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- Production: for each $i \in \{N, T\}$:

$$\pi_t^i = \max_{\{m_{jt}^i\}_{j \in \{N,T\}}} p_t^i A^i z_t^i \prod_{j \in \{N,T\}} (m_{jt}^i)^{\alpha_j^i} - \sum_{j \in \{N,T\}} p_t^j m_{jt}^i, \qquad \sum_{j \in N,T} \alpha_j^i \in (0,1)$$

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- Market clearing:

$$y_t^N = c_t^N + \sum_{i \in \{N,T\}} m_{Nt}^i, \qquad y_t^T = c_t^T + \sum_{i \in \{N,T\}} m_{Tt}^i + q b_{t+1} - b_t$$

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- **Production networks** shape both curves

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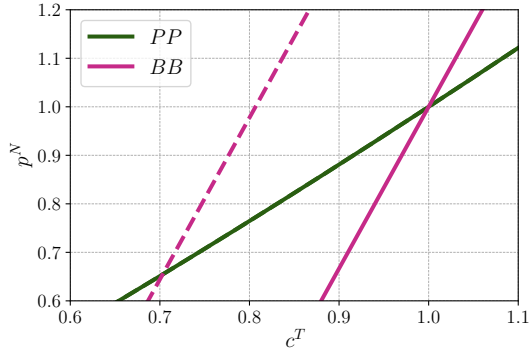
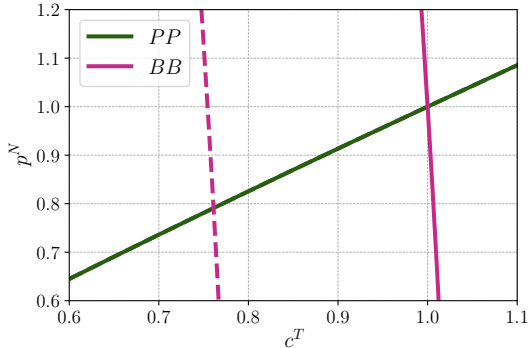
- Exercise:
  - Assume $\beta R = 1$
  - Sudden Stop: *wealth-neutral* tradable productivity shock z_t^T around steady state

Graphical Illustration of Main Proposition

(a) Diagonal Economy



(b) Non-Tradable buys from Tradable



- Experiment: 10% decline in tradable sector productivity
- Intersectoral linkages hedge adverse shocks
- Input prices buffer profits and support borrowing capacity

Sufficient Statistic

Cross-Country Production Structure

Data

- OECD 2021 input-output data Country Groups Sectoral Classification
  - 37-country network sample: 20 AEs, 17 EMs
  - 44 sectors grouped into commodity, tradable, and nontradable
  - Tradables: gross trade intensity above 20%; commodities split within tradables
- Baseline cross-country moments use 1995, the first year with IO data
- Focus on domestic linkages across sectors
  - Consistent with small open economy view
- Main takeaways: Details
  - **EMs** rely more on **commodities** for production
  - **AEs** rely more on **nontradable** inputs for production

Network Structure and Sudden Stops

- Estimate

$$y_{ct} = \alpha + \alpha_c + \alpha_t + \beta_0 \, \text{SS}_{ct} + \sum_{i \neq j} \beta_{ij} \, \text{SS}_{ct} \times \omega^i_{j,c} + \sum_k \beta_k \, \text{SS}_{ct} \times \text{Size}_{k,c} + \varepsilon_{ct},$$

  - y_{ct}: outcome variable for country c in year t
  - $\text{SS}_{ct} = 1$ during a sudden stop [Bianchi and Mendoza, 2020]
  - $\omega^i_{j,c}$: sector j's share in sector i's intermediate inputs
  - $\text{Size}_{k,c} = \text{Sales}_{k,c}/\text{nGDP}_c$: Domar weight of sector k
  - IO shares and sector sizes are fixed at 1995 values
  - Size variables are demeaned
  - Country and year fixed effects: α_c and α_t

Network Structure affects Sudden Stops Severity

	Consumption		GDP		CA/GDP	
	(1)	(2)	(3)	(4)	(5)	(6)
SS × EM	-0.0528***		-0.0654***		0.0069	
SS $\times\omega^{C}_{T,c}$		0.3020		0.3513		-0.1967
SS $\times\omega^{C}_{NT,c}$		1.0094***		0.2429		0.5918
SS $\times\omega^{T}_{C,c}$		0.1171		-0.0088		-0.0748
SS $\times\omega^{T}_{NT,c}$		-0.7235*		-0.4517		-0.9499***
SS $\times\omega^{NT}_{C,c}$		-1.6905***		-1.4465**		0.8668**
SS $\times\omega^{NT}_{T,c}$		1.0007***		0.7962***		-0.5752**
SS	-0.0112***	-0.2176***	-0.0026	-0.1477	0.0106	0.1836***
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared within	0.059	0.091	0.070	0.094	0.003	0.017
Observations	1463	1463	1517	1517	1434	1434

Note: 1979–2019 annual data. Two-way clustered standard errors at the country and year level. The panel is unbalanced and includes 37 countries: 17 EMs and 20 AEs.

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- Spain gets about 0.10 log points of GDP mitigation; Chile: 0.04

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- Spain gets about 0.10 log points of GDP mitigation; Chile: 0.04
- Chile's network overturns the baseline CA improvement; Spain's nearly cancels it.

Quantitative Model

Environment - New Features

- Extend to 3 sectors
  - Commodity c^C, tradable non-commodity c^X, and nontradable c^N
  - Capture better production asymmetries in the data.
    - Key: differentiated good

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Model Details Calibration Long-Run Moments Role of Networks

- Exercise:

  $\rightarrow$ Compare advanced economy with advanced economy + *EM network structure*

Production Networks affect long-run moments

Moment	EM	AE	AE + EM Network
$E(b/Y)$ %	**-30.77**	**-46.68**	-46.23
Pr(SS) %	**3.33**	**0.88**	1.47
$Pr(\mu_t > 0)$ %	**43.68**	**15.84**	29.64
ΔGDP_{SS} %	-12.23	-3.8	-4.94
$\Delta CA/GDP_{SS}$ %	3.9	1.91	2.44

- EM supports **less debt** and has a **higher probability of sudden stops** than AE

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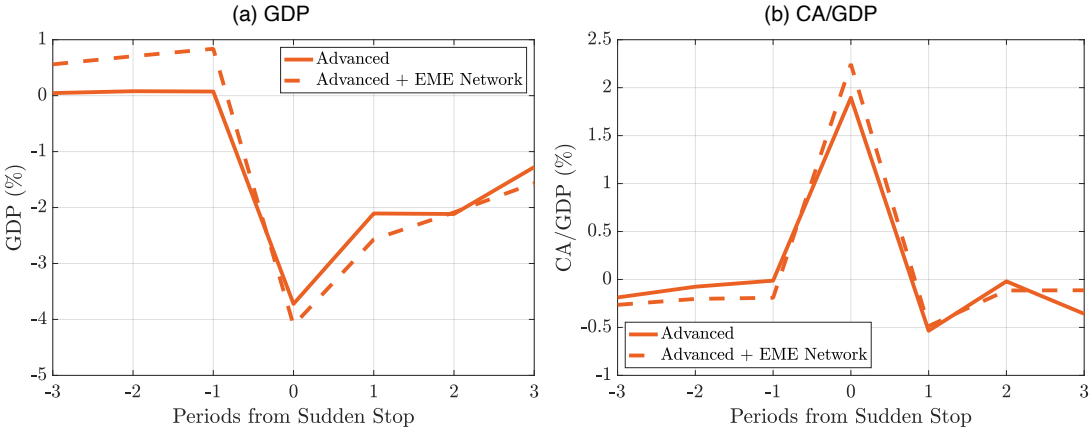
- EM supports **less debt** and has a **higher probability of sudden stops** than AE
- AE and AE + EM Network have:
  - **Similar debt**
  - **50% higher probability of experiencing a sudden stop** $[\approx 0.6\text{pp}]$

Role of Networks - Sudden Stops



- EM networks amplify GDP drops by 30% and CA reversals by 28%
- More diversified network structures provide a hedging mechanism
- Shock nature matters: not all Sudden Stops are created equal

Policy Exercises

Policy: Simple Instruments

- Pecuniary externalities create room for macroprudential and sectoral policy

Policy: Simple Instruments

- Pecuniary externalities create room for macroprudential and sectoral policy
- We study two kinds of policies:

Policy: Simple Instruments

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  - A flat non-state contingent tax on borrowing

Policy: Simple Instruments

- Pecuniary externalities create room for macroprudential and sectoral policy
- We study two kinds of policies:
  - A flat non-state contingent tax on borrowing
  - Flat non-state contingent taxes on inputs

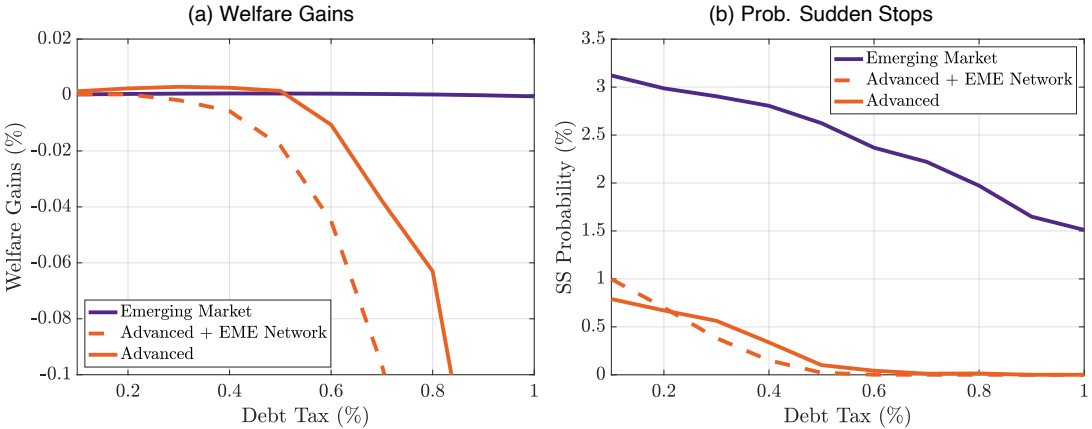
Planner Setup Planner FOCs

Policy: Simple Instruments

- Pecuniary externalities create room for macroprudential and sectoral policy
- We study two kinds of policies:
  - A flat non-state contingent tax on borrowing
  - Flat non-state contingent taxes on inputs
- Goal:
  - What are their welfare gains?
  - How does the probability of sudden stops change?

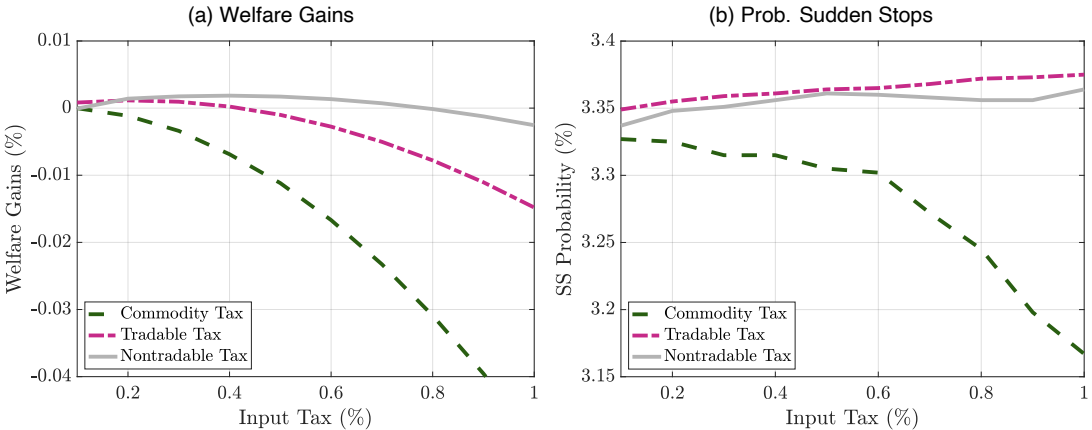
Planner Setup Planner FOCs

A simple debt tax policy is not one-size-fits-all



- Effect depends on financial development and network structure
- It can hurt financially developed economies with EM-style networks

Sectoral Input Taxes can help



- No welfare gains from commodity input tax
- Other sectoral taxes raise welfare but increase crisis risk slightly

Conclusion

- Sudden Stops differ in severity and frequency across EMs and AEs
- Potential explanations in the literature: fin. development and volatility of shocks
- Our paper emphasizes different **production network structures**
- **Takeaway:** production networks
  - account for 30% of the severity of Sudden Stops
  - increase the frequency of sudden stops by 50%
- Simple policies can generate welfare gains
  - but depend on financial development and production network structure

Conclusion

- Sudden Stops differ in severity and frequency across EMs and AEs
- Potential explanations in the literature: fin. development and volatility of shocks
- Our paper emphasizes different **production network structures**
- **Takeaway:** production networks
  - account for 30% of the severity of Sudden Stops
  - increase the frequency of sudden stops by 50%
- Simple policies can generate welfare gains
  - but depend on financial development and production network structure
- Ongoing: optimal policy + more data work + your comments!

Thank you!

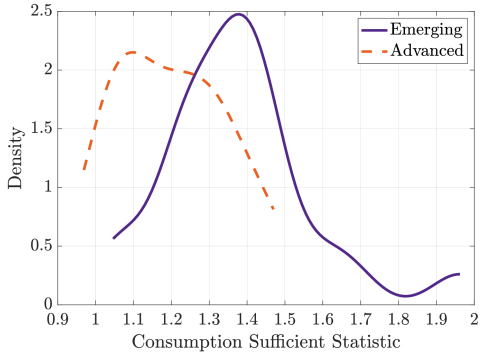
asilvub.github.io

Appendix

Sufficient Statistic in the Data

$$\frac{\mathrm{d}\log c_t}{\mathrm{d}\log z_t^T} = \mathcal{S}_c\big(\text{IO shares}, \text{profit shares}, \text{consumption shares}; \kappa, \eta\big)$$

- The plot shows the total-consumption response to a tradable shock
- Uses IO, profit, and consumption shares; fix $\kappa = 0.3$ and $1/(1+\eta) = 0.83$



Calibration - Summary

Parameter	Description	EM	AE
β	subjective discount factor	**0.90**	**0.95**
κ	collateral constraint parameter	**0.32**	**0.46**
ω_C^C	importance of commodity inputs in commodity production	0.5	0.5
ω_X^C	importance of tradable inputs in commodity production	0.37	0.35
ω_N^C	importance of nontradable inputs in commodity production	0.13	0.15
ω_C^X	importance of commodity inputs in tradable production	**0.20**	**0.13**
ω_X^X	importance of tradable inputs in tradable production	0.61	0.59
ω_N^X	importance of nontradable inputs in tradable production	**0.19**	**0.28**
ω_C^N	importance of commodity inputs in nontradable production	**0.18**	**0.06**
ω_X^N	importance of tradable inputs in nontradable production	0.35	0.34
ω_N^N	importance of nontradable inputs in nontradable production	**0.47**	**0.60**
$\{z_L^C, z_H^C\}$	Low-High productivity C	{1.9, 2.05}	{1.735, 1.745}
$\{z_L^X, z_H^X\}$	Low-High productivity X	{1.95, 2.05}	{1.71, 1.77}
$\{z_L^N, z_H^N\}$	Low-High productivity N	{1.98, 2.05}	{1.71, 1.77}

- Key differences: **impatience**, **finance**, and **production structure**

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Long-Run Moments

Moment	Emerging	Advanced
$E(b/Y)$ %	-30.77	-46.68
$\sigma(CA/Y)$ %	1.25	0.84
Share C Inputs to Total C Inputs %	48.06	45.39
Share N Inputs to Total C Inputs %	13.91	16.74
Share C Inputs to Total X Inputs %	18.78	11.1
Share N Inputs to Total X Inputs %	19.48	29.39
Share C Inputs to Total N Inputs %	16.59	5.00
Share N Inputs to Total N Inputs %	47.57	61.5
Pr(SS)	3.33	0.88
$Pr(\mu_t > 0)$	43.68	15.84
ΔGDP_{SS}	-12.23	-3.8
$\Delta CA/GDP_{SS}$	3.90	1.91

- EMs are more volatile and crisis-prone despite lower debt
- **Role of production structure?**

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Role of Networks

- Embed the EM network in the AE calibration; keep shocks fixed

Moment	EM	AE + EM Network	AE
$E(b/Y)$ %	-30.77	**-46.23**	**-46.68**
$\sigma(CA/Y)$ %	1.25	0.73	0.84
Share C Inputs to Total C Inputs %	48.06	47.81	45.39
Share N Inputs to Total C Inputs %	13.91	13.9	16.74
Share C Inputs to Total X Inputs %	18.78	18.7	11.1
Share N Inputs to Total X Inputs %	19.48	19.48	29.39
Share C Inputs to Total N Inputs %	16.59	16.52	5.00
Share N Inputs to Total N Inputs %	47.57	47.57	61.5
Pr(SS) %	3.33	**1.47**	**0.88**
$Pr(\mu_t > 0)$ %	43.68	29.64	15.84
ΔGDP_{SS} %	-12.23	**-4.94**	**-3.8**
$\Delta CA/GDP_{SS}$ %	3.9	**2.44**	**1.91**

- Similar debt, but about 50% more crisis-prone

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Policy: Social Planner's Problem

- Pecuniary externality: agents ignore price effects of their decisions

  [Mendoza (2005), Bianchi (2011), Benigno, Chen, Otrok, Rebucci & Young (2013)]

- This opens space for debt taxes, reserves, and sectoral policy

  [Arce et al. (2025), Benigno et al. (2023), Ottonello et al. (2024), Bianchi & Sosa-Padilla (2024)]

$$V(b, e) = \max_{\{\mathbf{c},\mathbf{m},b'\}} \quad U(c^C, c^X, c^N) + \beta E(V(b', e')),$$

subject to

$$c^C + m_C^C + m_C^X + m_C^N + qb' = y^C + p^X(\mathbf{c})\hat{c}^X(p^X(\mathbf{c})) + b \qquad (\lambda_1),$$

$$c^X + \hat{c}^X(p^X(\mathbf{c})) + m_X^C + m_X^X + m_X^N = y^X \qquad (\lambda_2),$$

$$c^N + m_N^C + m_N^X + m_N^N = y^N \qquad (\lambda_3),$$

$$qb' \geq -\kappa(\pi^C(p(\mathbf{c})) + \pi^X(p(\mathbf{c})) + \pi^N(p(\mathbf{c}))) \qquad (\mu).$$

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Social Planner's Problem

- Bonds Euler equation:

$$\lambda_1 = \beta R \mathbb{E}[\lambda_1'] + \mu,$$

$$\lambda_1 = U_C + \underbrace{\frac{\mu\kappa\left(\sum_{i\in C,T,N}\frac{\partial\pi^i}{\partial c^C}\right)}{1-\frac{\partial p^X}{\partial c^C}\hat{c}^X\frac{\eta_T}{1+\eta_T}}}_{\text{Pecuniary Externality}} + \underbrace{\frac{U_C\frac{\partial p^X}{\partial c^C}\hat{c}^X\frac{\eta_T}{1+\eta_T}-\lambda_2\frac{\partial\hat{c}^X}{\partial c^C}}{1-\frac{\partial p^X}{\partial c^C}\hat{c}^X\frac{\eta_T}{1+\eta_T}}}_{\text{Terms of Trade Manipulation}}$$

- Production FOC (commodity input in nontradable production)

$$p^N\frac{\partial y^N}{\partial m_C^N} = \frac{\lambda_1+\mu\kappa}{U_C+\mu\kappa\left(1+\sum_{i\in C,T,N}\frac{\partial\pi^i}{\partial c^N}\frac{1}{p^N}\right)}$$

- Production structure affects both distorted first-order conditions

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Country Groups

Emerging	Advanced
Argentina	Australia
Bulgaria	Austria
Brazil	Canada
Chile	Switzerland
China	Germany
Colombia	Denmark
Croatia	Spain
Hungary	Finland
Indonesia	France
Korea	United Kingdom
Morocco	Greece
Mexico	Iceland
Malaysia	Italy
Peru	Japan
Philippines	Netherlands
Poland	Norway
Russian Federation	New Zealand
Thailand	Portugal
Tunisia	Sweden

Sectoral Classification

Tradable and Commodity

Tradable: mining support services; food, beverages, tobacco; textiles; wood; paper and printing; refined petroleum; chemicals; pharmaceuticals; rubber and plastics; non-metallic minerals; fabricated metals; electronics; electrical equipment; machinery; motor vehicles; other transport equipment; manufacturing n.e.c.; wholesale/retail; land, water, and air transport; warehousing; IT and information services.

Commodity: agriculture; fishing and aquaculture; energy mining; non-energy mining; basic metals.

Tradable sectors are defined as those with exports share of revenues at least 20%.

Non-Tradable

Electricity and gas; water and waste; construction; postal and courier; accommodation and food; publishing and broadcasting; telecommunications; finance and insurance; real estate; professional services; administrative support; public administration; education; health and social work; arts and recreation; other services.

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Average expenditure share across sectors

- Average expenditure shares differ markedly across economies.

	Emerging	Advanced
ω_C^C	26.59	**29.48**
ω_X^C	19.87	**22.14**
ω_N^C	7.53	**11.18**
ω_C^X	**11.37**	6.66
ω_X^X	**34.68**	32.60
ω_N^X	11.36	**16.22**
ω_C^N	**4.61**	1.55
ω_X^N	**17.19**	13.51
ω_N^N	18.43	**24.72**

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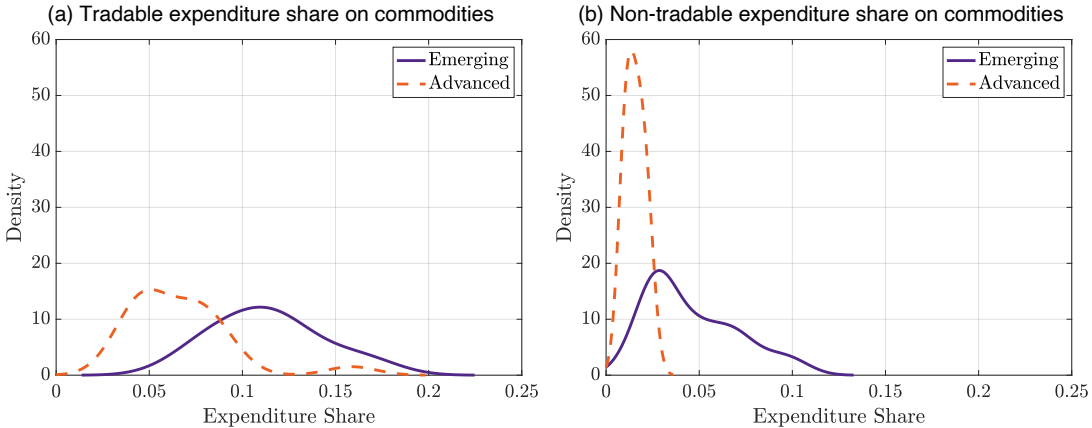
Emerging markets rely more on commodities for production



- Commodity expenditure shares by sector across countries.

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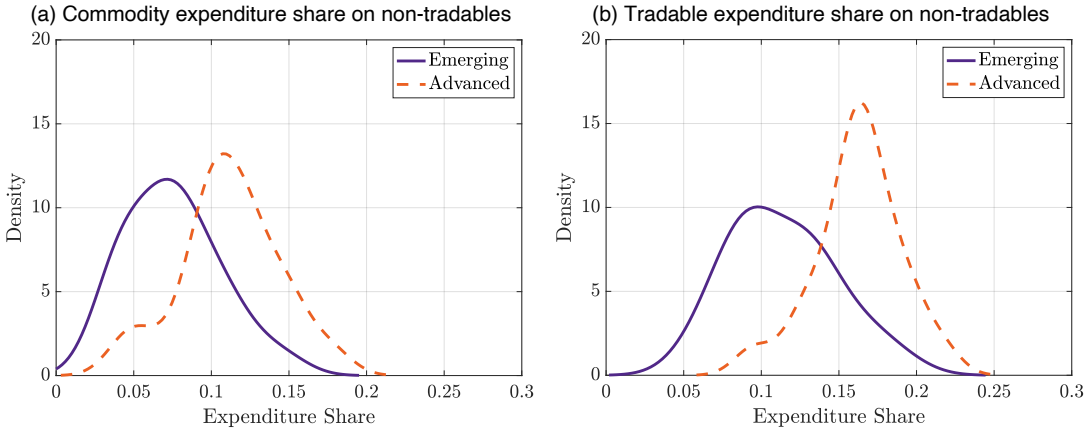
Advanced economies rely more on non-tradable inputs



- NT input use by commodity and tradable sectors; solid = EM, dashed = AE.

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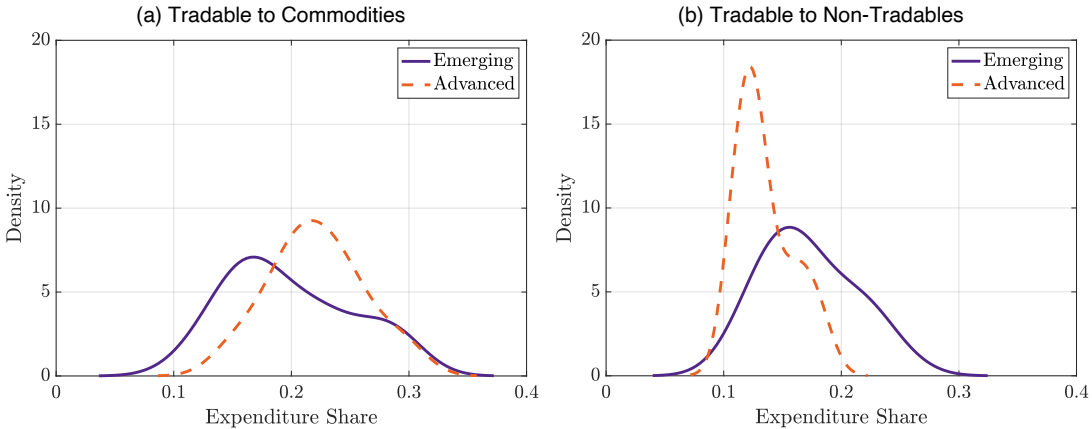
Tradable usage



- Tradable input use by commodity and nontradable sectors; solid = EM, dashed = AE.

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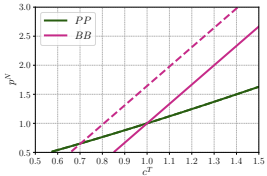
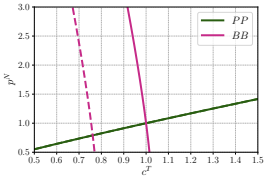
PP curve is always upward sloping

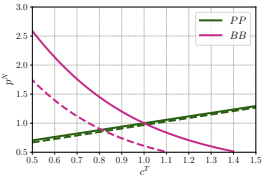
(a) Diagonal Economy



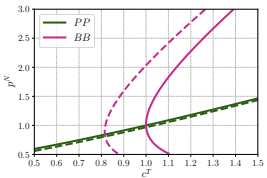
(b) NT buys from T



(c) Dense Economy



(d) T buys from NT



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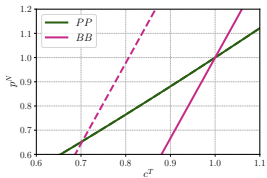
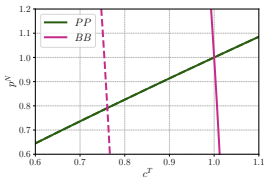
BB curve slope depends on the network structure

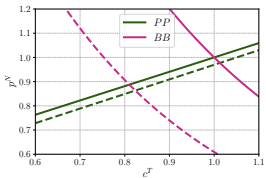
(a) Diagonal Economy



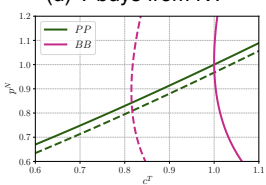
(b) NT buys from T



(c) Dense Economy



(d) T buys from NT



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Quantitative Model - Details

$$\max \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_t) \right], \qquad \text{where } \beta \in (0,1).$$

subject to

$$c_t^C + p_t^X c_t^X + p_t^N c_t^N + q b_{t+1} = b_t + \pi_t^C + \pi_t^X + \pi_t^N$$

$$q b_{t+1} \geq -\kappa(\pi_t^C + \pi_t^X + \pi_t^N)$$

$$c_t = \left((1-\omega)(c_t^N)^{-\eta} + \omega(c_t^T)^{-\eta} \right)^{-\frac{1}{\eta}}, \qquad c_t^T = \left[\omega_T (c_t^C)^{-\eta_T} + (1-\omega_T)(c_t^X)^{-\eta_T} \right]^{-\frac{1}{\eta_T}}.$$

Production:

$$y_t^i = z_t^i \left[\left(\sum_{j \in \{C,X,N\}} (\omega_j^i)^{\frac{1}{\chi^i}} (m_{jt}^i)^{\frac{\chi^i - 1}{\chi^i}} \right)^{\frac{\chi^i}{\chi^i - 1}} \right]^{\gamma^i}.$$

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Calibration - Additional Parameters

Parameter	Description	Value
σ	curvature of utility	2
ω	consumption weight of tradables	0.165
ω_T	weight of non-commodity tradables within tradables	0.20
γ	decreasing returns to scale	0.80
χ	elasticity of substitution among varieties	0.60
$1/(1+\eta) = 1/(1+\eta_T)$	trade elasticity	0.83
R^*	steady-state world interest rate	1.04
P_C	probability of remaining at low z^C	0.75
P_X	probability of remaining at low z^X	0.90
P_N	probability of remaining at low z^N	0.88

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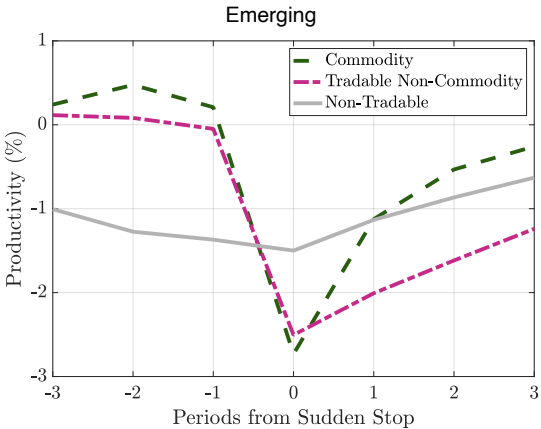
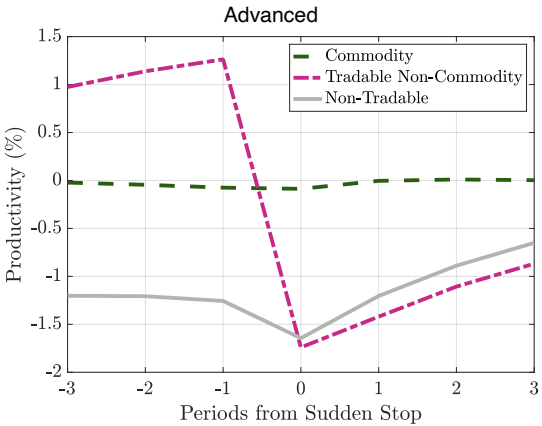
Sudden Stops - Shocks





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Network Structure and Sudden Stops (Full Table)

	Consumption		GDP		CA/GDP	
	(1)	(2)	(3)	(4)	(5)	(6)
SS × EM	-0.0528***		-0.0654***		0.0069	
SS $\times \omega^{C}_{T,c}$		0.3020		0.3513		-0.1967
SS $\times \omega^{C}_{NT,c}$		1.0094***		0.2429		0.5918
SS $\times \omega^{T}_{C,c}$		0.1171		-0.0088		-0.0748
SS $\times \omega^{T}_{NT,c}$		-0.7235*		-0.4517		-0.9499***
SS $\times \omega^{NT}_{C,c}$		-1.6905***		-1.4465**		0.8668**
SS $\times \omega^{NT}_{T,c}$		1.0007***		0.7962***		-0.5752**
SS × Tradable Size		-0.0087		0.0236		-0.0120
SS × Nontradable Size		-0.1656*		-0.0021		-0.0051
SS × Commodity Size		-0.1405*		-0.0602		-0.2499***
SS	-0.0112***	-0.2176***	-0.0026	-0.1477	0.0106	0.1836***
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared within	0.059	0.091	0.070	0.094	0.003	0.017
Observations	1463	1463	1517	1517	1434	1434

1979–2019 annual data. Two-way clustered standard errors at the country and year level. The panel is unbalanced and includes 37 countries: 17 EMs and 20 AEs.

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