Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel

Adrien Auclert, Matt Rognlie, Martin Souchier, and Ludwig Straub

Bank of Canada, November 2023

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Emerging literature: [Farhi-Werning, Cugat, De Ferra-Mitman-Romei, Giagheddu, Guo-Ottonello-Perez, Zhou, Oskolkov...]

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  - output boom, due to **expenditure switching channel**
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   $\rightarrow$ depends on χ: **HA** = **RA** when $\chi = 1$, **HA** < **RA** when $\chi < 1$ [similar for monetary policy]
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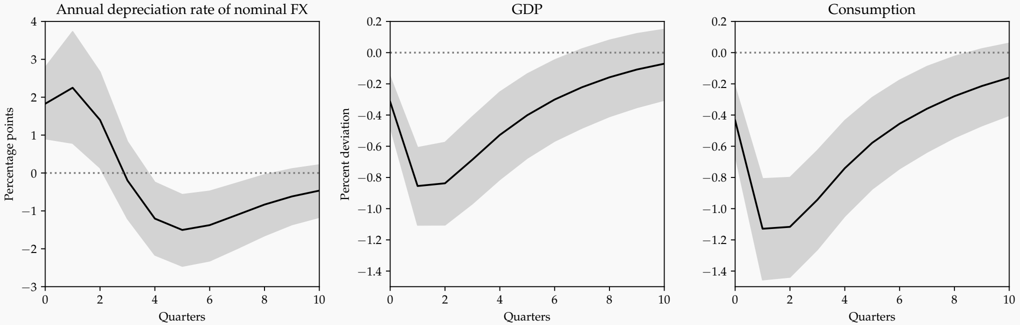
More in the paper: quantitative model, simple new way to get "J curve", het. cons. baskets, endog. UIP spreads

Empirical evidence on contractionary depreciations

- Extend Vicondoa (2019, JIE) to include consumption



(VAR on a panel of emerging market economies with 11 real and financial variables. 25 bps contractionary shock to the U.S. interest rate measured using Fed Funds futures contracts. 90% confidence bands.)

Roadmap

1. HANK meets Gali-Monacelli
2. Capital flows and exchange rates
3. Managing contractionary depreciations

HANK meets Gali-Monacelli

Model overview

- Discrete time, small open economy (SOE) model
    - No aggregate uncertainty + small shocks (first order perturb. wrt aggregates)
- Two goods
    - "Home": H, produced at home. Price P_{Ht} at home, P^*_{Ht} abroad
    - "Foreign": F, produced abroad. Price P_{Ft} at home, $P^*_{Ft} \equiv 1$ abroad
    - Consumed in bundles. Price P_t of bundle at home, $P^*_t \equiv 1$ abroad
    - Nominal rigidities in wages (for now), allow for two "pricing paradigms"
- Two classes of agents
    - large mass of foreign households
    - mass 1 of domestic households, **subject to idiosyncratic income risk**

Households' consumption behavior

▸ preferences

- Foreign households have fixed real C^*.

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$$\max_{\{c_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left\{ \frac{c_{it}^{1-\sigma}}{1-\sigma} - v(N_t) \right\}$$

$$c_{it} + a_{it+1} = (1 + r_t^p) a_{it} + e_{it} \frac{W_t}{P_t} N_t \qquad a_{it+1} \geq 0 \qquad C_t \equiv \int c_{it} di$$

  - a_{it} = position in domestic mutual fund

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- Both domestic & foreign have CES bundle, solve **intratemporal problem**

$$C_{Ht} = (1-\alpha) \left(\frac{P_{Ht}}{P_t} \right)^{-\eta} C_t \qquad C_{Ht}^* = \alpha \left(\frac{P_{Ht}^*}{P^*} \right)^{-\gamma} C^*$$

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- Domestic production and market clearing: $\quad Y_t = N_t = C_{Ht} + C_{Ht}^*$

Prices and nominal rigidities

- Exchange rates: nominal $\mathcal{E}_t$, real $Q_t \equiv \mathcal{E}_t / P_t$, $\uparrow$ is depreciation
- Standard nominal wage rigidity [Erceg-Henderson-Levin, Auclert-Rognlie-Straub]

$$\pi_{wt} = \kappa_w \left(\frac{v'(N_t) / u'(C_t)}{\mu_w W_t / P_t} - 1 \right) + \beta \pi_{wt+1}$$

- For now, flexible prices everywhere else: at home ...

$$P_{Ft} = \mathcal{E}_t \qquad P_{Ht} = \mu \cdot W_t$$

- ... and abroad (as in producer currency pricing, PCP)

$$P^*_{Ht} = \frac{P_{Ht}}{\mathcal{E}_t}$$

- Will consider dollar currency pricing (DCP) later

Monetary policy and assets

- Three types of assets
  - zero net supply: nominal home & foreign bonds
  - positive supply: shares in H firms $v_t = (v_{t+1} + \text{div}_{t+1})/(1 + r_t)$
  - asset market clearing $\qquad A_t = v_t + NFA_t$
- Domestic central bank sets nominal rate i_t on nominal home bonds
  - for now, it targets const CPI-based real interest rate, $i_t = r + \pi_{t+1}$
- Interest rate on foreign bonds is i_t^*, shocks to $i_t^* \equiv$ shocks to β abroad
- Mutual fund & foreigners invest freely in all assets
  - equalized $\mathbb{E}$ returns $\Rightarrow$ return on mutual fund is $r_{t+1}^p = r_t \; \forall t \geq 0$
  - UIP holds

$$1 + i_t = (1 + i_t^*) \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \qquad 1 + r = (1 + i_t^*) \frac{Q_{t+1}}{Q_t}$$

Benchmark model calibration

details

- Calibrate $\alpha = 0.40$ and balanced trade as in Gali-Monacelli
- Initial mutual fund portfolio invested 100% in domestic stocks
- **Allow for general substitution elasticities η, γ for now**
- Quarterly persistence of i_t^* and m.p. shocks ϵ_t of $\rho = 0.85$
- Standard calibration for HA part
  - EIS $\sigma^{-1} = 1$
  - target Peruvian data on MPCs and income risk [Hong 2020]
  - β heterogeneity to get reasonable average MPC & distribution
- Note: **HA model already stationary**, no need for debt-elastic interest rate [Schmitt-Grohe Uribe 2003]

Capital flows and exchange rates

Setup

- Consider a temporary shock $i_t^* \uparrow$

$\rightarrow$ Effect on path of real exchange rate: (long-run PPP)

$$dQ_t = \frac{1}{1+r} \sum_{s \geq 0} di_{t+s}^*$$

so $Q_t \uparrow$, $\frac{P_{Ht}}{P_t} \downarrow$, and $\frac{P_{Ht}}{\mathcal{E}_t} \downarrow$ (real depreciation)

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- **Next: RA**, then **HA**

Textbook RA complete markets model

- In **RA** : complete markets + r constant $\Rightarrow C_t = C$

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- Linearize around SS with $Y = C = C^* = 1$:

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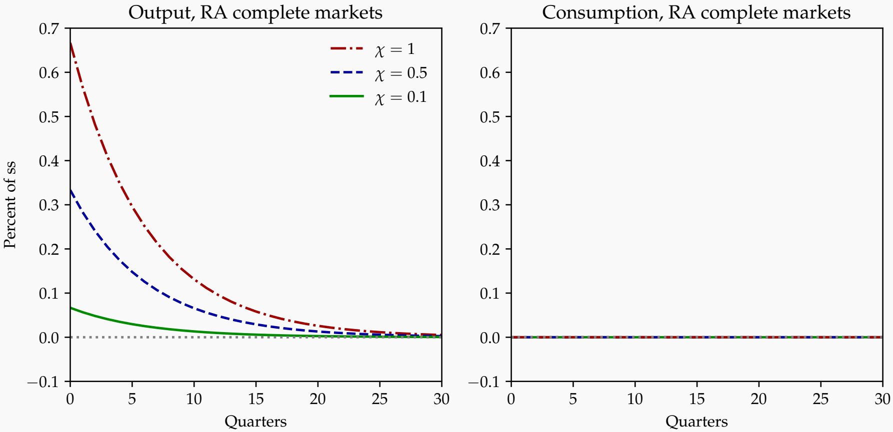
- Define **trade elasticity** $\chi \equiv \eta(1-\alpha) + \gamma$, use bold for time paths:

$$d\mathbf{Y} = \frac{\alpha}{1-\alpha}\chi d\mathbf{Q}$$

[sum of elasticities of imports and exports to P_F/P_H, cf Marshall-Lerner condition]

Representative agent: Exchange rate shock



(i_t^* shock of quarterly persistence $\rho = 0.85$ and impact effect of 1% on Q.)

What changes with heterogeneous agents?

- In **HA**, C_t is affected by $\frac{W_t}{P_t}N_t$ and r_t^p (through dividends):

$$\frac{W_t}{P_t}N_t = \frac{1}{\mu}\frac{P_{Ht}}{P_t}Y_t \qquad \text{div}_t = \left(1-\frac{1}{\mu}\right)\frac{P_{Ht}}{P_t}Y_t$$

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- Two effects of the exchange rate
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  - production Y_t changes $\rightarrow$ (Keynesian) **multiplier channel**
- To linearize, define derivatives $M_{t,s} \equiv \frac{\partial \mathcal{C}_t}{\partial Y_s}$ (Jacobian)
- These are "intertemporal MPCs" out of Y. Stack as $\mathbf{M}$. [Auclert Rognlie Straub 2018]

International Keynesian cross

Theorem

$d\mathbf{Y}$ solves an "international Keynesian cross"

$$d\mathbf{Y} = \underbrace{\frac{\alpha}{1-\alpha}\chi d\mathbf{Q}}_{\text{Expenditure switching}} - \underbrace{\alpha \mathbf{M} d\mathbf{Q}}_{\text{Real income}} + \underbrace{(1-\alpha)\mathbf{M} d\mathbf{Y}}_{\text{Multiplier}}$$

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- Use this to solve the model & decompose sources of effects on $d\mathbf{Y}$
- Entire role of heterogeneity encoded in $\mathbf{M}$ matrix, RA corresponds to $\mathbf{M} = 0$

General equilibrium neutrality result for $\chi = 1$

Theorem

$\chi = 1 \qquad \Rightarrow \qquad d\mathbf{Y}^{HA} = d\mathbf{Y}^{RA} = \frac{\alpha}{1-\alpha}\chi d\mathbf{Q}$

*Heterogeneity is **irrelevant** for output effect of exchange rate*

- **Multiplier channel** undoes **real income channel**, $\frac{P_{Ht}}{P_t} Y_t$ = const

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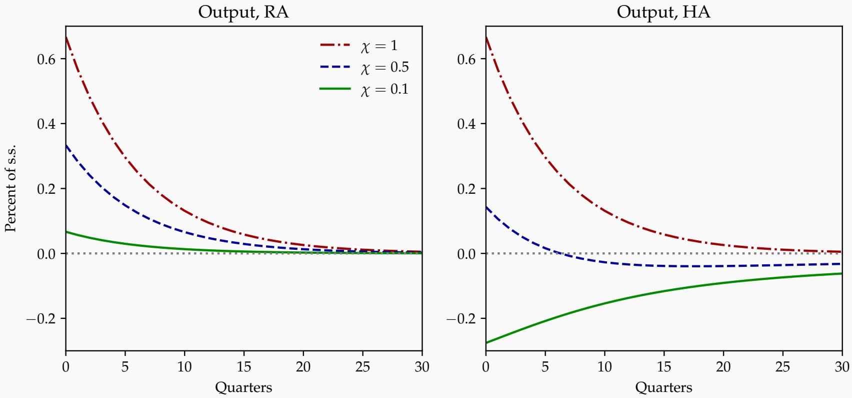
- Intuition: Marshall-Lerner condition, net exports unchanged if $\chi = 1$
- More generally, for $d\mathbf{Q} \geq 0$, can show $d\mathbf{Y}^{HA} < d\mathbf{Y}^{RA}$ if and only if $\chi < 1$.

Contractionary devaluations in output for low χ

RA

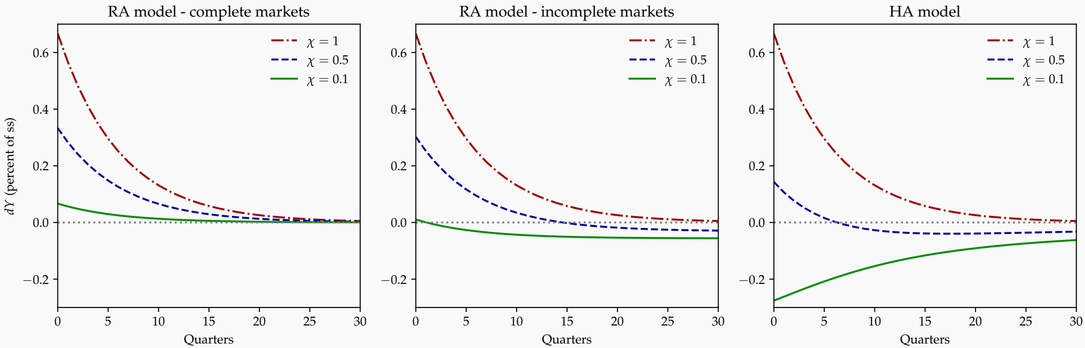
- When χ is small, the fall in consumption overwhelms expenditure switching:



→ Open economy **HA** model can generate **contractionary depreciations**!

HA vs incomplete markets: sizing up the real income channel

▸ TA model



(Incomplete market model is non-stationary, here assuming $Q_\infty = Q_{-1} = 1$.)

[For incomplete markets RA model, also see: Corsetti Pesenti 2001, Tille 2001, Corsetti Dedola Leduc 2008]

Dollar currency pricing (DCP)

- So far: **producer currency pricing (PCP)**
- Alternative: **dominant (or dollar) currency pricing (DCP)**
  - $\rightarrow$ export prices set in international currency P_{Ht}^{*} sticky

[Gopinath 2016, Gopinath Boz Casas Diez Gourinchas Plagborg-Moller 2020]

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  [Gopinath 2016, Gopinath Boz Casas Diez Gourinchas Plagborg-Moller 2020]

- Two effects in our HA model:
  1. **standard effect:** less expenditure switching by $F \Rightarrow d\mathbf{Y} \downarrow$
  2. **profit effect:** greater margins from exporting $\Rightarrow$ dividends rise, $d\mathbf{Y} \uparrow$

- Both can dominate, depends on magnitude of χ vs MPC out of dividends

Managing contractionary depreciations

How should monetary policy respond to capital flows?

- Consider situation with unexpected capital outflows, Q depreciates ($i_t^* \uparrow$)
- With low χ, the shock itself is initially contractionary

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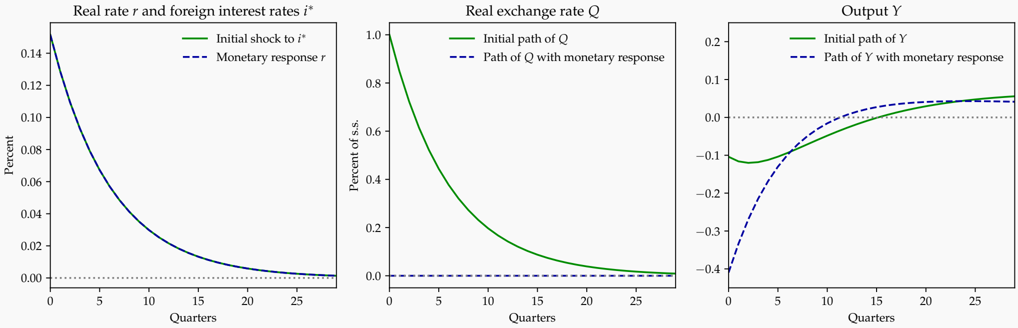
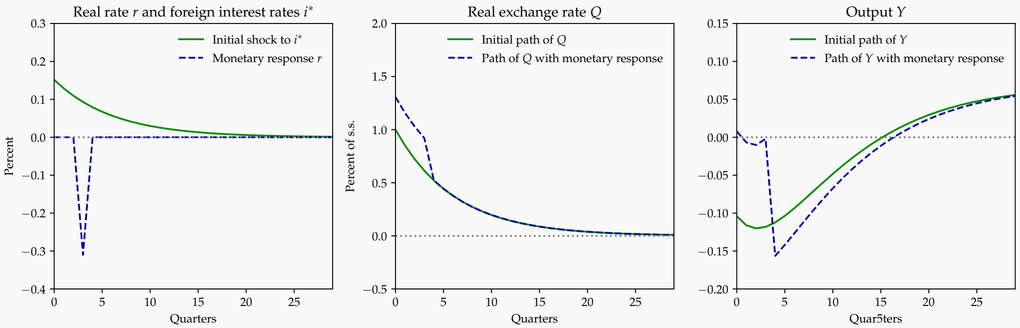
  2. Fight the **contraction** with monetary easing. Exacerbates depreciation?
- **Next:** Investigate both rationales
  + compare weak real income channel (AE?) vs strong (EM?)
  - by varying import price pass through

Fighting the depreciation: Effect of exchange rate stabilization



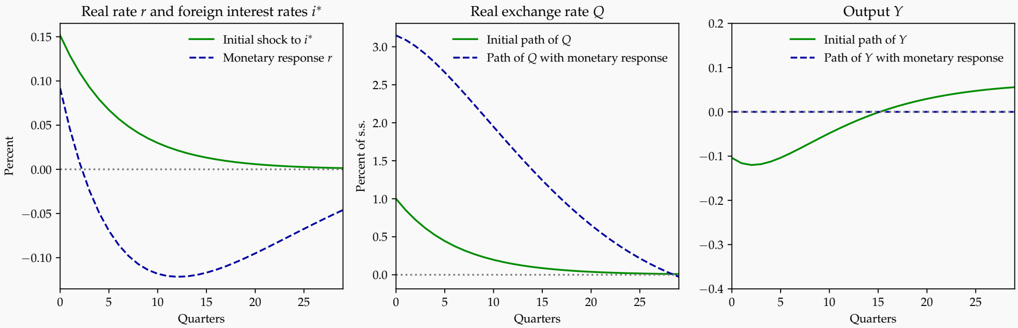
- Fighting the depreciation beneficial later, **contractionary** at first!
- Trading one evil (contractionary depreciation) for another (contractionary monetary policy) [Gourinchas 2018, Kalemli-Özcan 2019]

Fighting the contraction: Effect of monetary easing



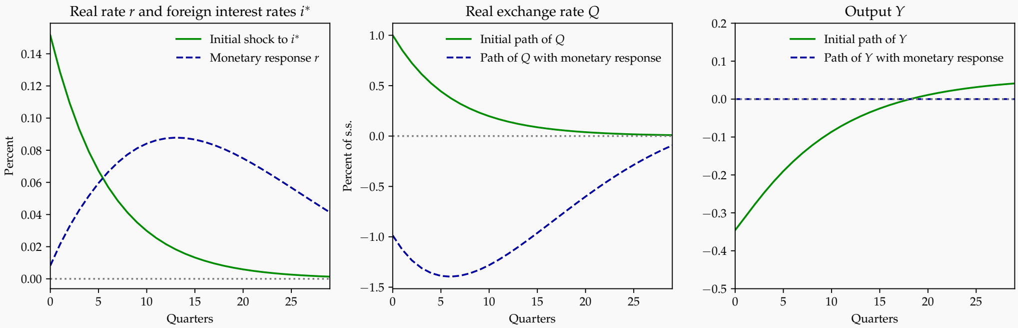
- Monetary easing helps in the short run... but worsens the long run!

What policy fully stabilizes output?



- **Monetary easing with weak real income channel!**

Very different for with strong real income channel



- **Monetary tightening with strong real income channel**!
- Stable (or even appreciating...) exchange rate
- Could explain why monetary policy typically less countercyclical in EMs

Conclusion

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HA + NK-SOE $\Rightarrow$

- real income channel
- contractionary depreciation for plausibly small short-run trade elasticity
- new perspectives on navigating contractionary depreciations

+ more results in the paper: monetary policy, *J* curve, het. cons baskets, UIP wedges, . . .

Preferences

back

- In baseline, consumption c_{it} aggregates H and F with elasticity η,

$$c_{it} = \left[(1-\alpha)^{\frac{1}{\eta}} \left(c_{iHt}\right)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(c_{iFt}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

  and preferences across goods j produced in countries k are

$$c_{iHt} = \left(\int_0^1 c_{iHt}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \quad c_{iFt} = \left(\int_0^1 c_{ikt}^{\frac{\gamma-1}{\gamma}} dk \right)^{\frac{\gamma}{\gamma-1}} \quad c_{ikt} = \left(\int_0^1 c_{ikt}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$$

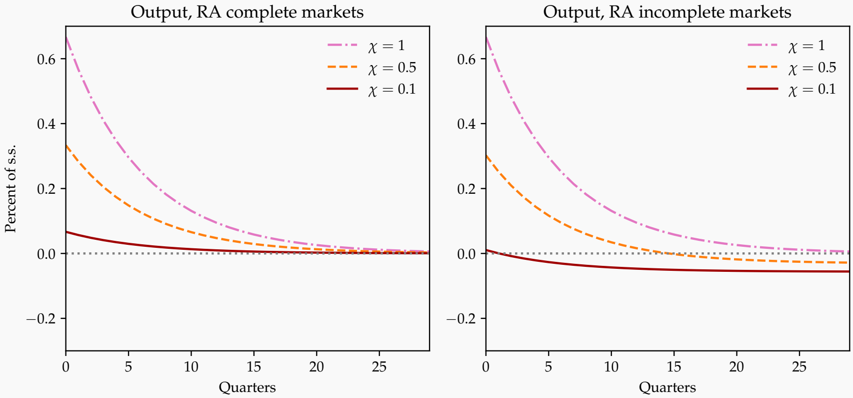
  with $\epsilon > 1$, $\gamma > 0$ and $\eta > 0$. Budget constraint:

$$\int_0^1 P_{Ht}(j)\, c_{iHt}(j)\, dj + \int_0^1 \int_0^1 P_{kt}(j)\, c_{ikt}(j)\, dj dk + a_{it+1} \leq \left(1 + r_t^p\right) a_{it} + e_{it} \frac{W_t}{P_t} N_t$$

- Demand for good j in country k by consumer i:

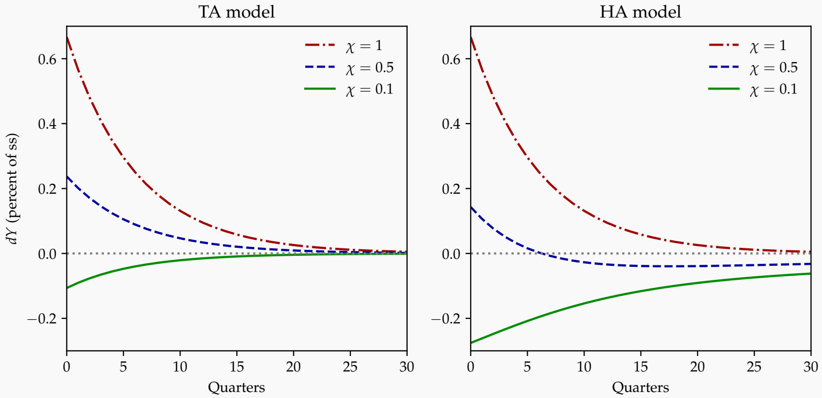
$$c_{ikt}(j) = \alpha \left(\frac{P_{kt}(j)}{P_{kt}} \right)^{-\epsilon} \left(\frac{P_{kt}}{P_{Ft}} \right)^{-\gamma} \left(\frac{P_{Ft}}{P_t} \right)^{-\eta} c_{it}$$

Contractionary devaluations in output for low χ



Two-agent model

back



The "stealing demand from the future" effect

◂ back

- The effect comes from a **current account deficit** after monetary easing:
    1. Real income effect: import prices rise
    2. Interest rate effect: agents front-load spending (intertemporal substitution!)

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... but one **big difference**: monetary easing here can have **negative NPV**

$$\text{Present value } (d\mathbf{Y}) < 0 \quad \Leftrightarrow \quad \chi < 1 - \alpha$$

Quantitative model: additional elements

back

1. Nonhomothetic Stone-Geary to capture heterogeneity in real income effect

$$C_t = \left((1-\alpha)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(C_{Ft} - \underline{c_F} \right)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

2. Realistic passthrough of exch. rate to domestic & foreign consumer prices
   - Add domestic price rigidities

$$\pi_{Ht} = \kappa_H \left(\frac{\mu_H W_t / Z_t}{P_{Ht}} - 1 \right) + \beta \pi_{Ht+1}$$

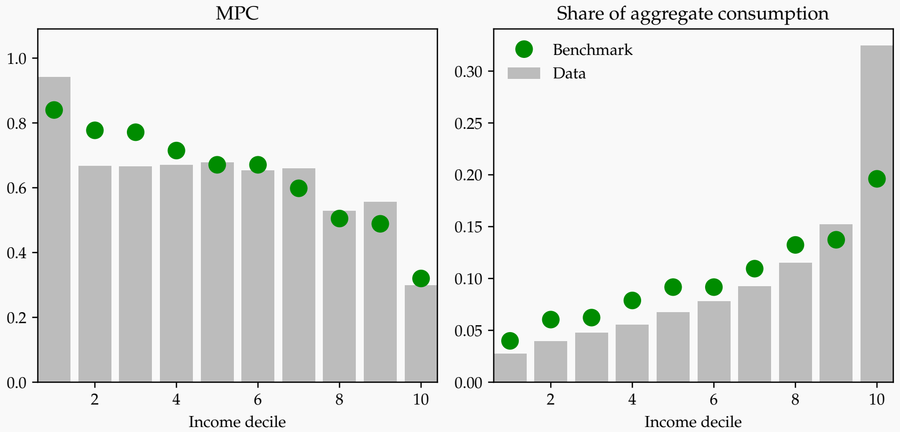
   - Add flexibility of dollar export prices

$$\pi^*_{Ht} = \kappa_X \left(\frac{P_{Ht} / \mathcal{E}_t}{P^*_{Ht}} - 1 \right) + \beta \pi^*_{Ht+1}$$

   - Allow foreign retailers to repatriate profits from dollar sales
3. Allow for currency mismatch in NFA ($f_Y \equiv$asset-liability mismatch/GDP)
   - Debt held by households via mutual fund, or by government and then rebated

Benchmark model fit

◂ back



Calibration

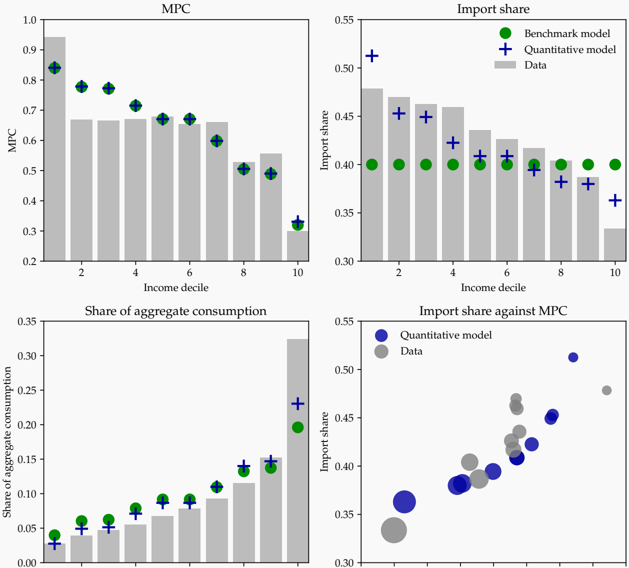
back to sec 1 back to sec 2

Parameter	Benchmark	Quantitative	Parameter	Benchmark	Quantitative
σ	1	1	μ	1.03	1.028
ψ	2	2	s.s. nfa	0	0
η	$\frac{\{0.1,0.5,1,2-\alpha\}}{2-\alpha}$	4	σ_e	0.6	0.6
γ	$=\eta$	$=\eta$	ρ_e	0.92	0.92
θ	n.a.	0.987	θ_w	0.95	0.95
β	0.954	0.953	θ_p	0	0.75
Δ	0.06	0.067	θ_X	n.a.	0.66
α	0.4	0.323	θ_I	0	0
$\underline{c}$	0	0.114	ϕ	n.a.	1.5

Calibration targets

back to sec 1 back to sec 2

Moment	Data	Benchmark model	Quantitative Model
Average MPC	0.632	0.636	0.637
Std of MPC	0.152	0.151	0.149
Average tradable share	0.400	0.400	0.400
Std of tradable share	0.042	n.a.	0.042


MPC
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
MPC
2
4
6
8
10
Income decile
Import share
0.55
0.50
0.45
0.40
0.35
0.30
Import share
Benchmark model
Quantitative model
Data
Income decile
Share of aggregate consumption
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Share of aggregate consumption
Import share against MPC
Quantitative model
Data
Import share

Delayed substitution model

- Ratio $x = \frac{C_H}{C_F}$ is a state variable, updated a la Calvo with parameter θ
- Static outcome ($\theta = 0$)

$$x_t = \frac{\alpha}{1-\alpha}\left(\frac{P_{Ht}}{P_{Ft}}\right)^{-\eta}$$

- Dynamic ($\theta > 0$) outcome with log utility [general case in paper]

$$d\log x_t^* = -\eta(1-\beta\theta)d\log\frac{P_{Ht}}{P_{Ft}} + \beta\theta d\log x_{t+1}^*$$
$$d\log x_t = (1-\theta)d\log x_t^* + \theta d\log x_{t-1}$$

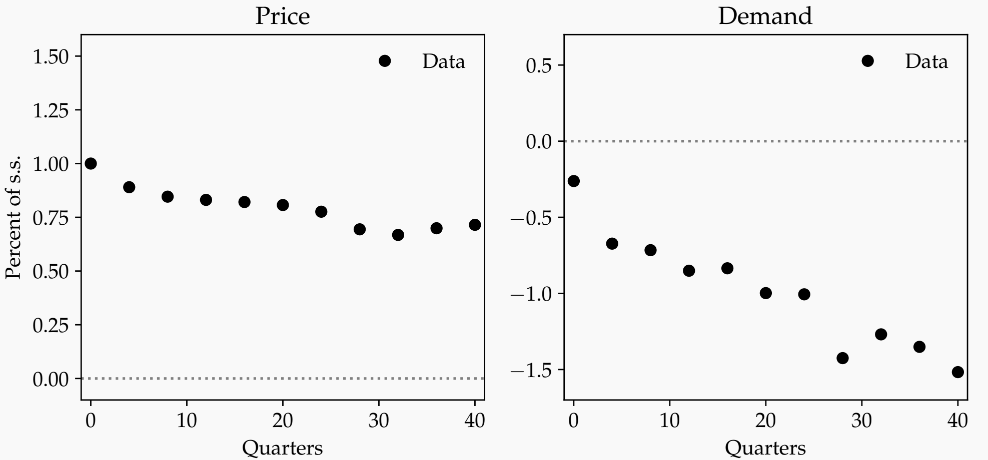
  Long-run elasticity is η, short-run is $< \eta$, depends on shock duration

- Same assumption for γ (exports slow to adjust)

Calibration of η, γ and θ

back

- Use tariff change evidence in Boehm, Levchenko, and Pandalai-Nayar



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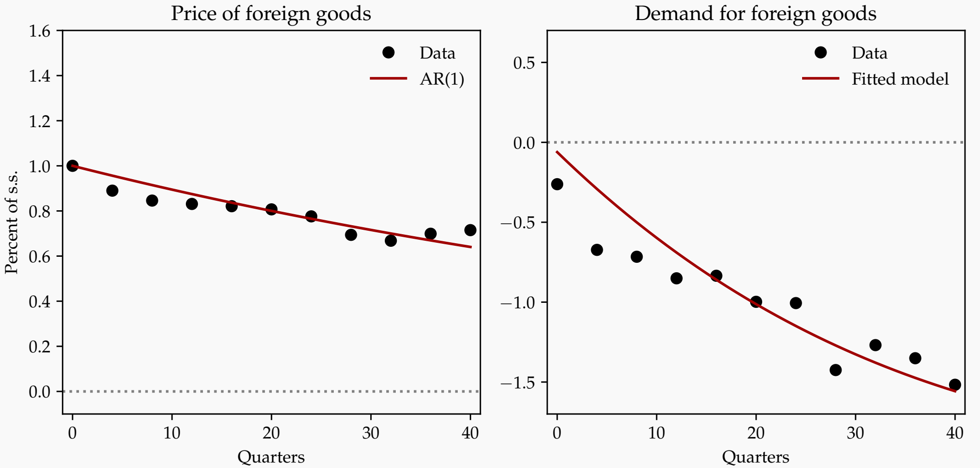
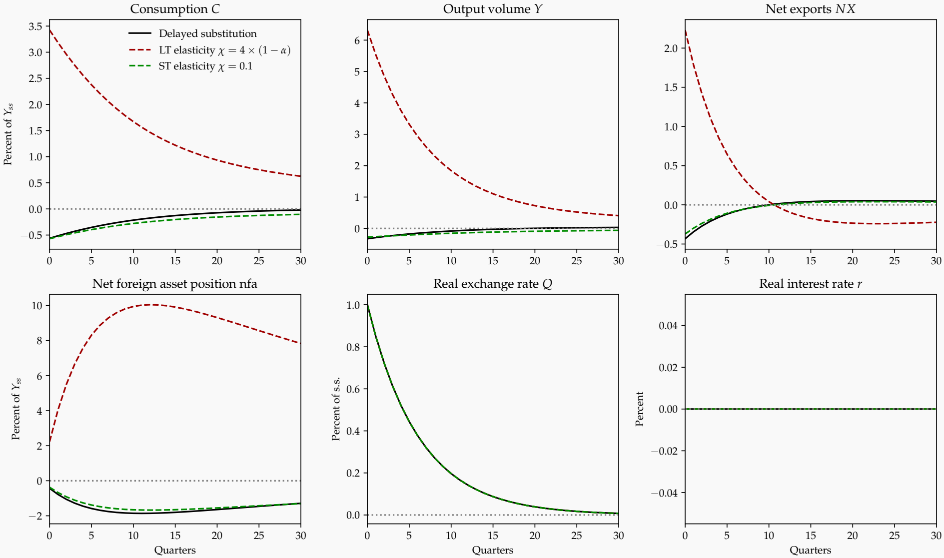


Quantitative model behaves like a low-elasticity model



Comparative statics

back

	Bench.	Low α	High *MPC*	Full DCP	Low passthru	Homothetic	High ST elast.
dY_0	- 0.36	- 0.27	- 0.40	- 0.31	- 0.09	- 0.32	- 0.30
PDV of dY	- 2.03	- 2.38	- 1.15	- 1.25	- 1.01	- 1.51	- 0.25

(Response to i_t^* shock of quarterly persistence $\rho = 0.8$ and impact effect of 1% on Q.)

Valuation effects

back

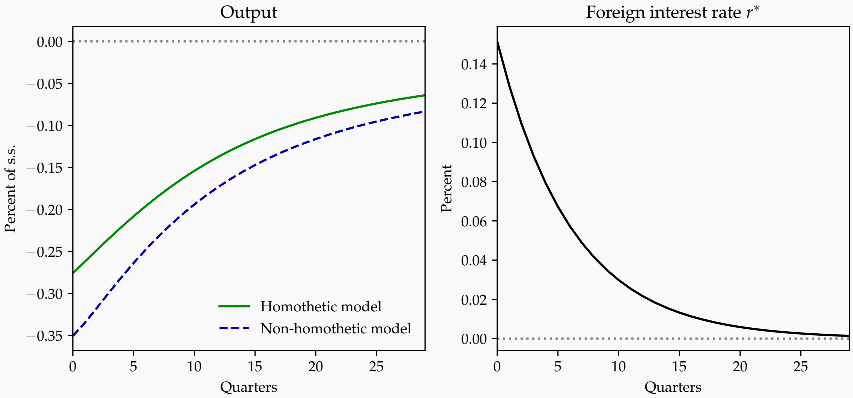
Assuming a gross currency debt position in the NFA of 50% of annual GDP:

			Government		
	Benchmark	Mutual fund	lump-sum	prop tax	+ deficit-fin.
dY_0	- 0.36	- 0.41	- 0.71	- 0.63	- 0.46
PDV of dY	- 2.03	- 2.86	- 3.18	- 3.17	- 3.21

(Response to i_t^* shock of quarterly persistence $\rho = 0.8$ and impact effect of 1% on Q.)

Amplification from non-homothetic demand

back



Amplification from currency mismatch on balance sheet

back