Spillovers: The Role of Prudential Regulation and Monetary Policy in Small Open Economies

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Closing Conference of the BIS CCA Research Network on “Incorporating financial stability considerations into central bank policy models”

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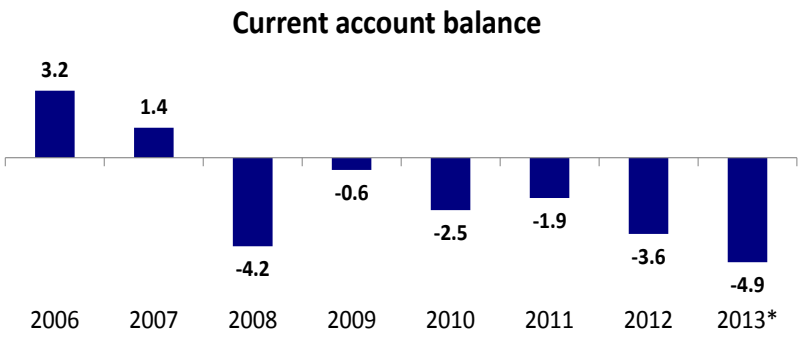
The opinions expressed in this paper are not necessarily shared by the institutions with which we are currently affiliated.

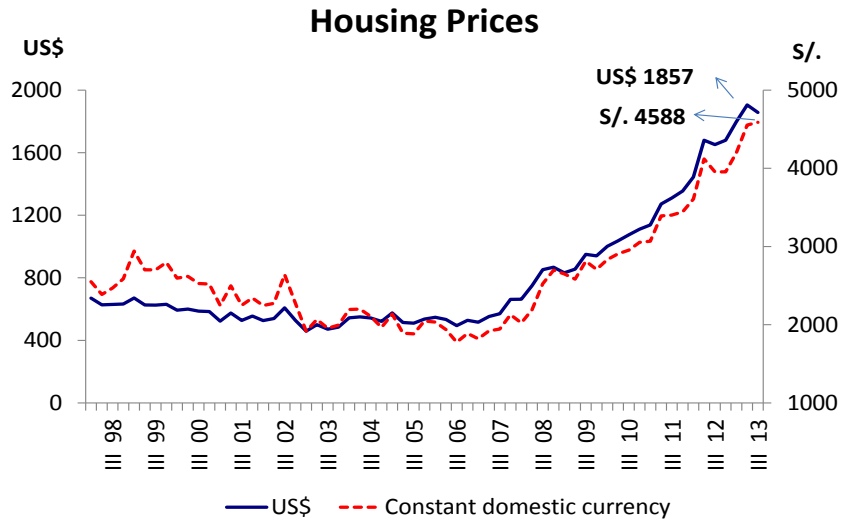
Contents

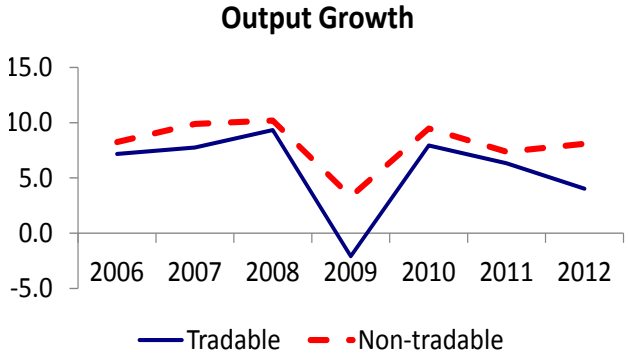
Motivation

Some stylized facts we attempt to replicate:

- Strong capital inflows in Latin-American region.
- Rapid output growth in both tradable and non-tradable sectors.
- Increase in indebtedness, asset prices booms, real appreciation, and current account deficit.
- Active policy response using macroprudential instruments.







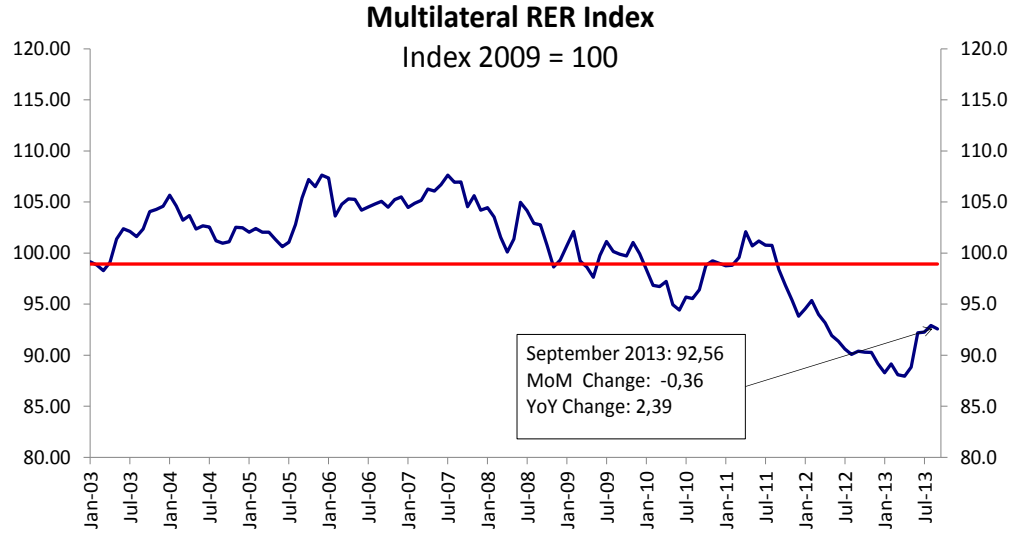


Figure : Peru - Key Macroeconomic Variables

Literature

- Kiyotaki & Moore (1997): credit limits and asset prices.
- Role of financial development in the amplification of capital flow externalities (Aghion et al. (2004), Aoki et al. (2009)).
- Caballero & Krishnamurthy (2001) study the interaction between domestic and foreign lending during periods of sudden stops, using collateral assumptions similar to ours.
- Paasche (2001): Two credit constrained SOEs who borrow and export commodities to a third large one. A negative productivity shock in one SOE generates an adverse terms of trade shock on the other, which is amplified.
- Sudden stop episodes associated with higher borrowing (Mendoza (2002), Jeanne & Korinek (2010), Bianchi (2011)).

What we do

- We build a stylized two sector real business cycle model incorporating borrowing constraints that generates the co-movements pointed out in the data, emphasizing spill over effects from the tradable to the non-tradable sector.
- We propose a countercyclical LTV rule that manages to reduce output volatility in this economy, generating redistributive welfare effects.
- We extend the model by introducing nominal rigidities *à la* Calvo in the non-tradable sector and incorporate monetary policy through a standard Taylor rule.

Some intuition

1. Borrowing constraints generate a link between entrepreneurs' credit limits and the price of assets used as collateral.
2. This link amplifies the co-movement between sectors in response to a productivity shock to the tradable sector.
3. When tradable productivity increases, factor demand pushes asset prices up, expanding the borrowing capacity of entrepreneurs in both sectors.
4. This yields output co-movement and increased borrowing in the non-tradable sector.

The Model

1. Extension of the model of Aoki et al. (2009) considering a 2 sector SOE in which entrepreneurs require collateral to borrow as in Iacoviello (2005).
2. Base model consisits of a real DSGE model without money or price rigidity.
3. Three agents: Workers (W) and entrepreneurs/producers of tradable (T) and non-tradable (NT) goods.

The Model (II)

4. Besides the markets for tradable and non-tradable goods, the model incorporates markets for labour, capital, housing and credit.
5. The credit market is segmented by collateral asset and production sector.
6. The tradable sector uses capital (k) as collateral to obtain foreign lending while the non-tradable sector uses housing (h) as collateral to borrow from domestic agents (the workers).
7. We assume a fixed aggregate supply for both capital and housing assets.

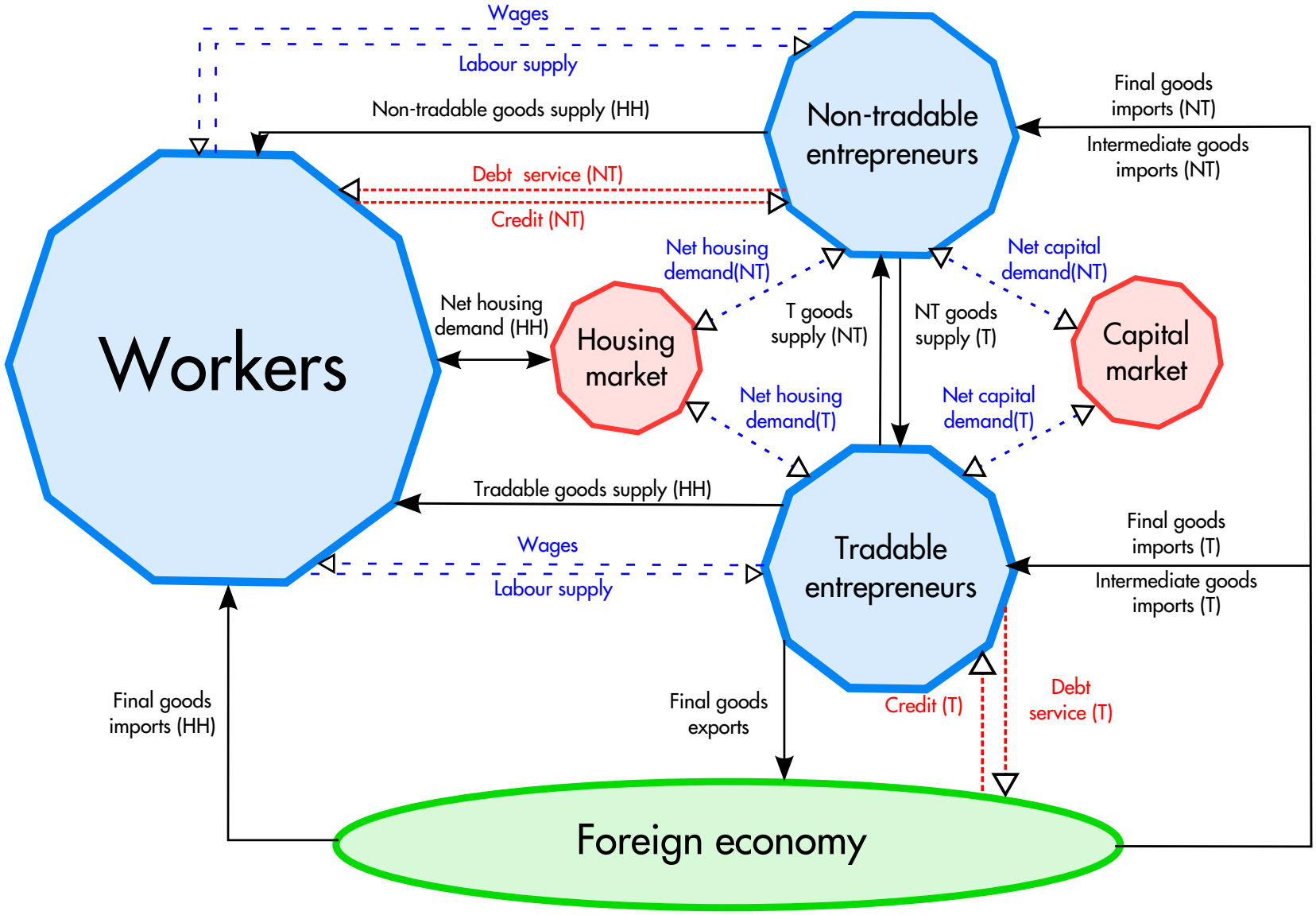


Figure : The Model

Workers

- Are the "patient" agents in the domestic economy.
- Lend to entrepreneurs producing non-tradable goods (b_s^{NT}) charging the domestic interest rate (R_s).
- Consume a basket ($C_{w,s}$) of tradable ($c_{w,s}^T$) and non-tradable ($c_{w,s}^{NT}$) goods; use housing services (h_s^W) and supply labour (l_s).

Worker Equations

Tradable Good Producers/Entrepreneurs

- Consume the same basket of goods ($C_{t,s}$) as workers.
- Combine housing services (h_s^T), capital (k_s^T), labour (l_s^T) and imported inputs (m_s^T) to produce (y_{s+1}^T).
- Given the lag in production, entrepreneurs need working capital loans (b_s^{T*}). These are subject to borrowing constraints:

$$R_s^* b_s^{T*} \leq \theta_s^{T*} E_s \left[q_{s+1}^k \right] k_s^T$$

where q_s^k is the price of capital, R_s^* is the foreign interest rate and θ_s^{T*} is the fraction of capital value accepted as collateral.

Tradable Entrepreneur Equations

Non-Tradable Good Producers/Entrepreneurs

- Consume the same basket of goods ($C_{nt,s}$) as workers.
- Use the same inputs ($h_s^{NT}, k_s^{NT}, l_s^{NT}, m_s^{NT}$) as tradable good producers to manufacture (y_{s+1}^{NT}).
- They are also subject to borrowing constraints in the domestic credit market that only admits housing as collateral.

$$R_s P_s^W b_s^{NT} \leq \theta_s^{NT} E_s \left[q_{s+1}^h \right] h_s^{NT}$$

- Producers of non-tradable goods sell at relative price p_s^{NT} which is expressed in units of tradable goods.

Non-Tradable Entrepreneur Equations

Results: A tradable productivity shock

- An increase in productivity in the tradable sector generates an expansion in the tradable and non-tradable sectors and boosts the price of both assets used as collateral.
- The positive wealth effect experienced by tradable entrepreneurs increases demand for non-tradable goods.
- This generates a real appreciation which leads to an expansion in the non-tradable sector. Given the increase in housing prices, the borrowing constraint of the non-tradable sector is relaxed.
- Non-tradable firms' demand for housing decreases. Such a decrease is not big enough to outweigh the effect of higher housing prices on their borrowing.

- During the adjustment process, collateral assets are exchanged between the non-tradable and the tradable sector.

  Non-tradable firms use less housing and the excess is absorbed by tradable firms. The latter liberate capital which is acquired by their non-tradable counterparts.

- Workers experience a positive wealth effect because of higher wages. This stimulates savings, reducing the domestic interest rate. As a result, the borrowing constraints of non-tradable firms relax even further and housing becomes less attractive.
- Higher demand for imported inputs in both sectors explains the current account deficit that follows the shock.

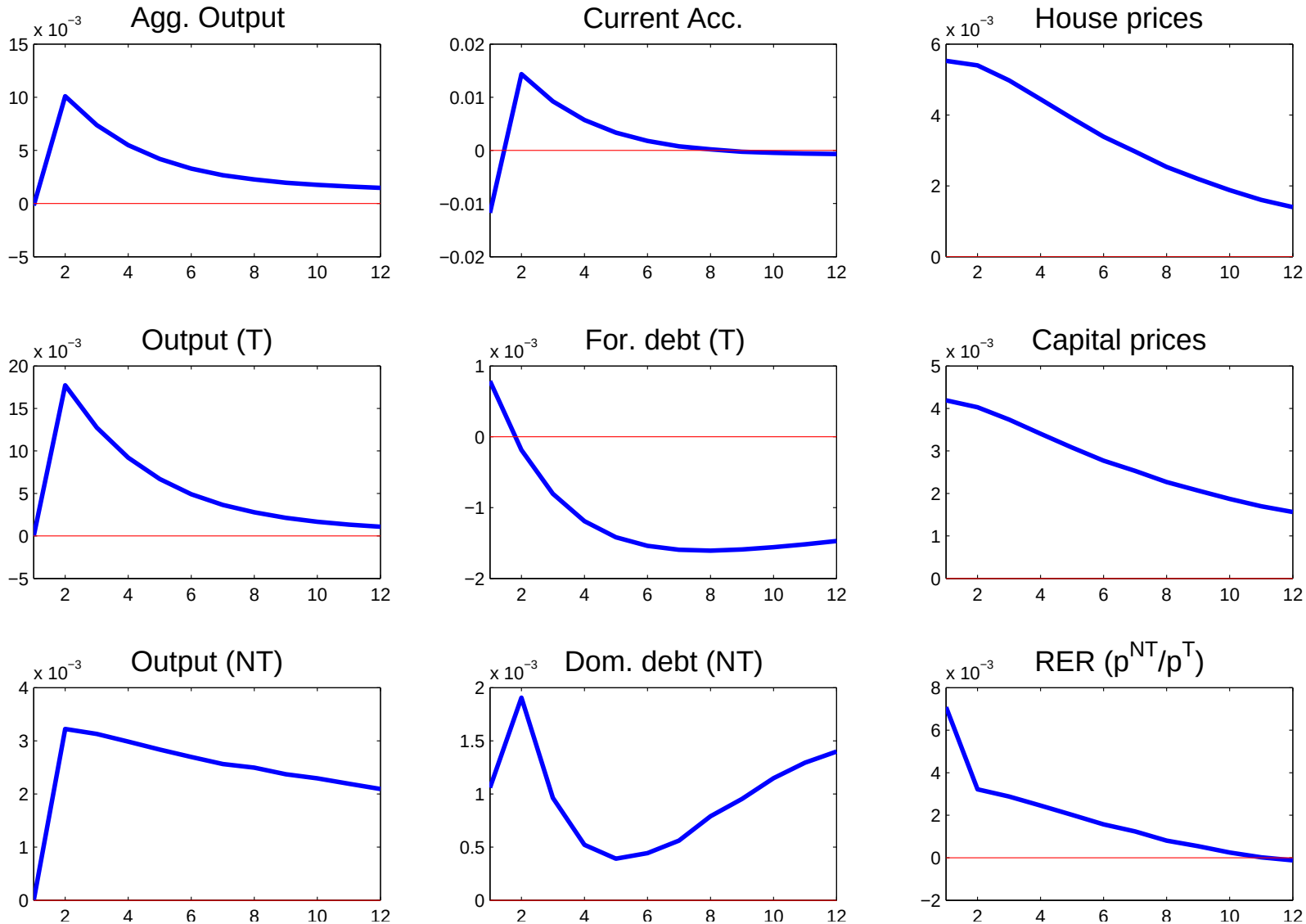


Figure : Tradable Productivity Shock ($\gamma = 0.98$, $R^* = 1.005$, $\theta = 0.6$)

More shocks

The Role of Borrowing Constraints

- The next figure shows the dynamics of the model considering different values of θ.
- A larger θ implies less restrictive borrowing constraints on entrepreneurs. Consequently, when θ is relative large, the model does not generate spillover effects.
- On the contrary, output in the non-tradable sector falls instead of rising in response to a positive productivity shock in the tradable sector.
- Debt of non-tradable entrepreneurs falls instead of rising and both houses and capital prices are muted.

- The real appreciation is much smaller in this case, which also is consistent with a milder current account deficit.
- But, tradable (and aggregate) output response is not very different.
- The opposite is observed when θ is relative low: the real exchange rate appreciates substantially, and the current account deficit is much higher, output in the non-tradable sector expands, and the debt of the non-tradable sector increases. Asset prices also increase, amplifying the initial impact of productivity shocks.

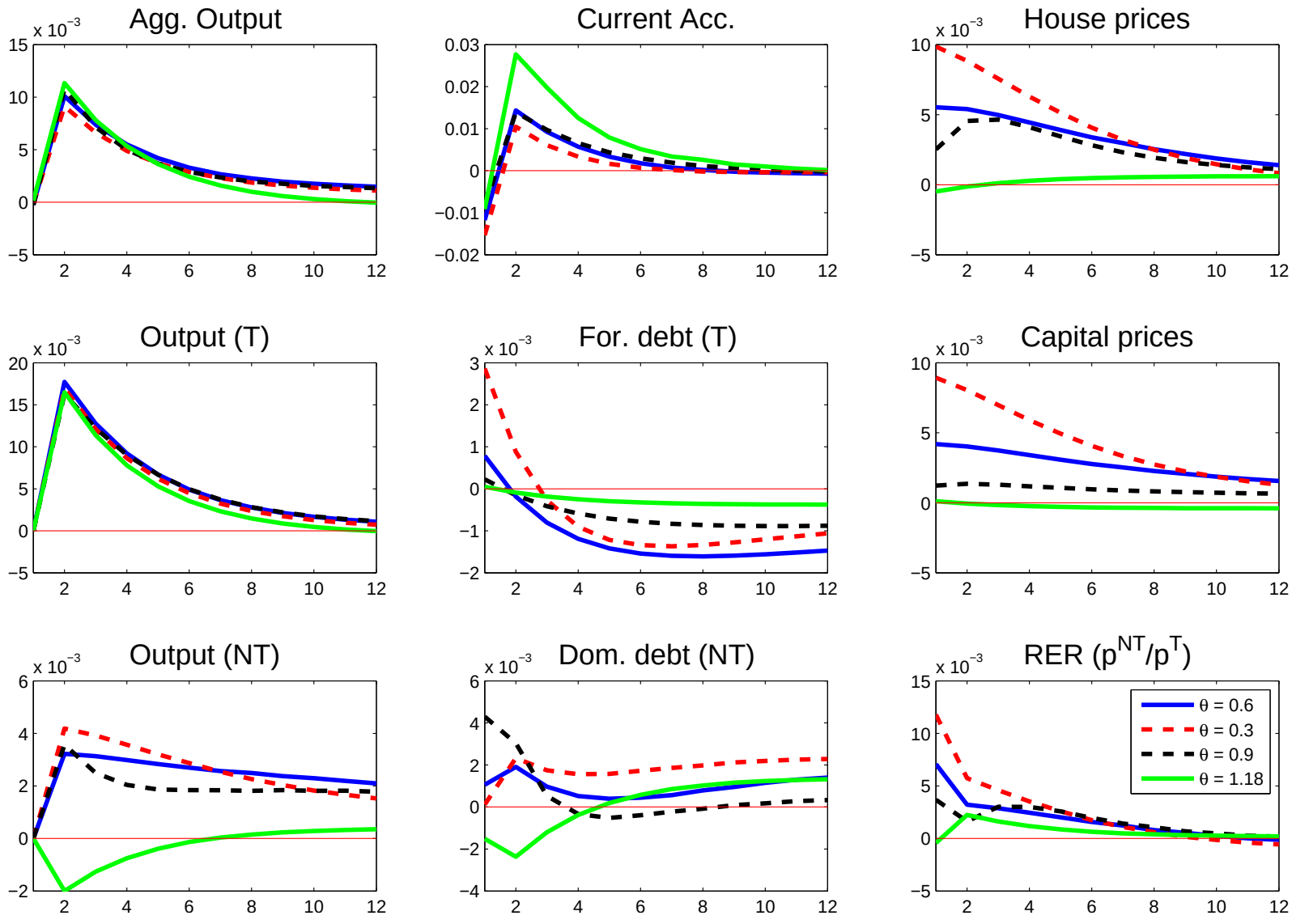


Figure : Tradable Productivity Shock: The role of borrowing constraints

Policy

- The analysis of the role of borrowing constraints suggests a role for policy: minimize spillover effects.
- But the presence of borrowing constraints in our model is a *structural* one. The values for θ^{T*} and θ^{NT} should be treated either as deep parameters or an endogenous response of agents to the frictions present in credit markets.
- For this reason, an authority that employs LTV ratios as a policy instrument faces an upper bound, as it is not possible to force lenders to accept less collateral than the one they privately deem adequate.
- We explore a (potentially) second best solution: time varying LTV rules in which the policy value of θ (θ^{int}) must be set below the private one (θ^{priv}).

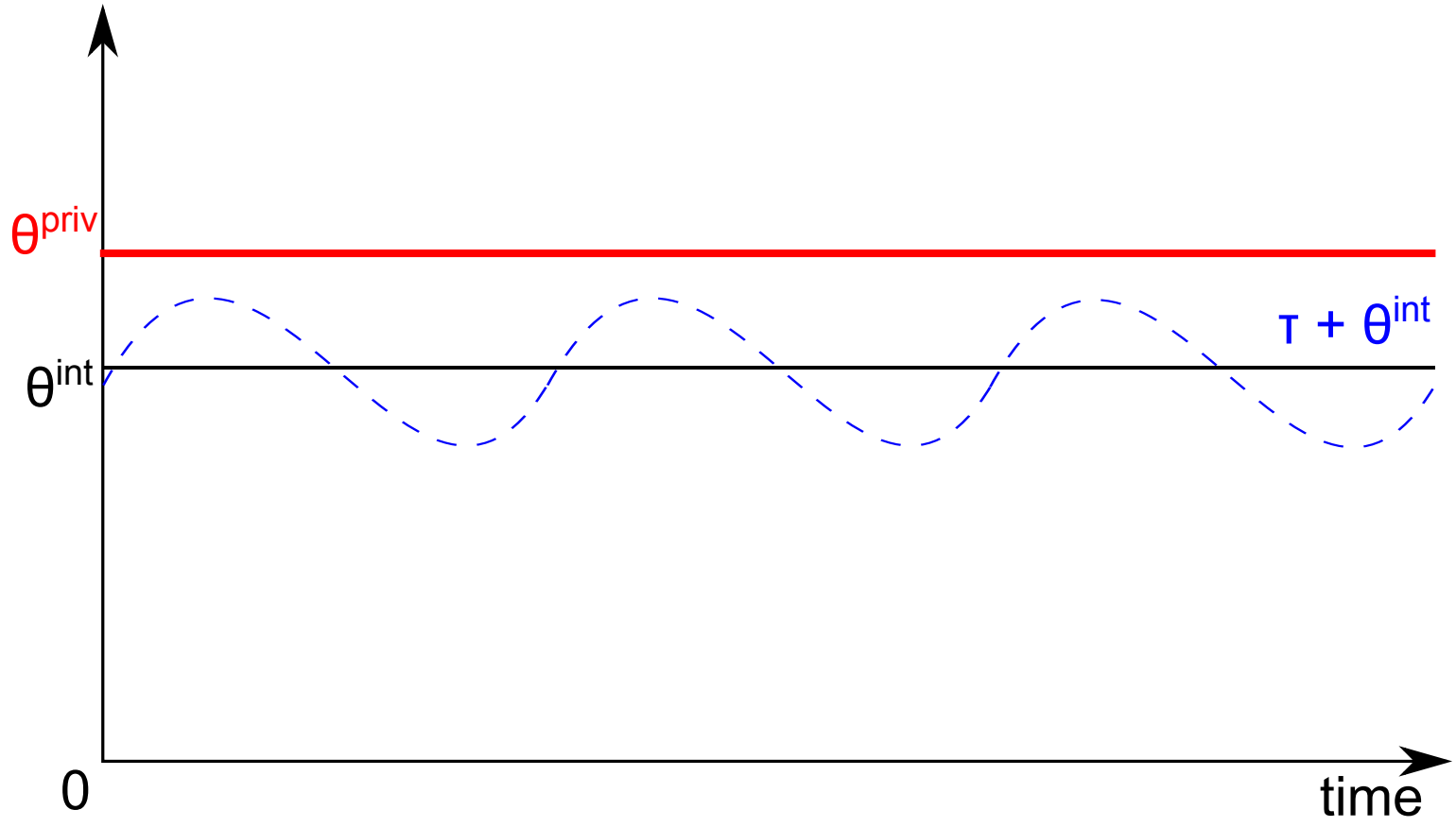


Figure : LTV Rules

Policy (II)

We propose a countercyclical rule that takes into account the position of the economy with respect to the business cycle.

$$\frac{\theta_s^{T*,int}}{\overline{\theta}^{T*,int}} = \frac{\theta_s^{NT,int}}{\overline{\theta}^{NT,int}} = E_s \left(\frac{Y_{s+1}}{\overline{Y}} \right)^{-\phi_\theta}$$

where Y denotes aggregate output (value added) defined as

$$Y_s = \left(y_s^T - p_{s-1}^M m_{s-1}^T + p_s^{NT} y_s^{NT} - p_{s-1}^M m_{s-1}^{NT} \right) / P_s^W$$

and $\phi_\theta > 0$.

Policy (III)

- An LTV rule targeting aggregate output does a good job dampening the spillover from the tradable to the non-tradable sector in the aftermath of a tradable productivity shock.
- Aggregate output is slightly affected, but there is a sizeable dampening on asset prices and the real exchange rate.
- Tighter LTV ratios imposed on the economy manage to curtail the expansion in debt in both sectors but the effect is bigger on non-tradable firms.
- Actually, borrowing taken by these firms diminishes, forcing non-tradable entrepreneurs to hold on to their houses. This reduces their demand for capital, explaining why tradable firms cannot exchange capital for housing.

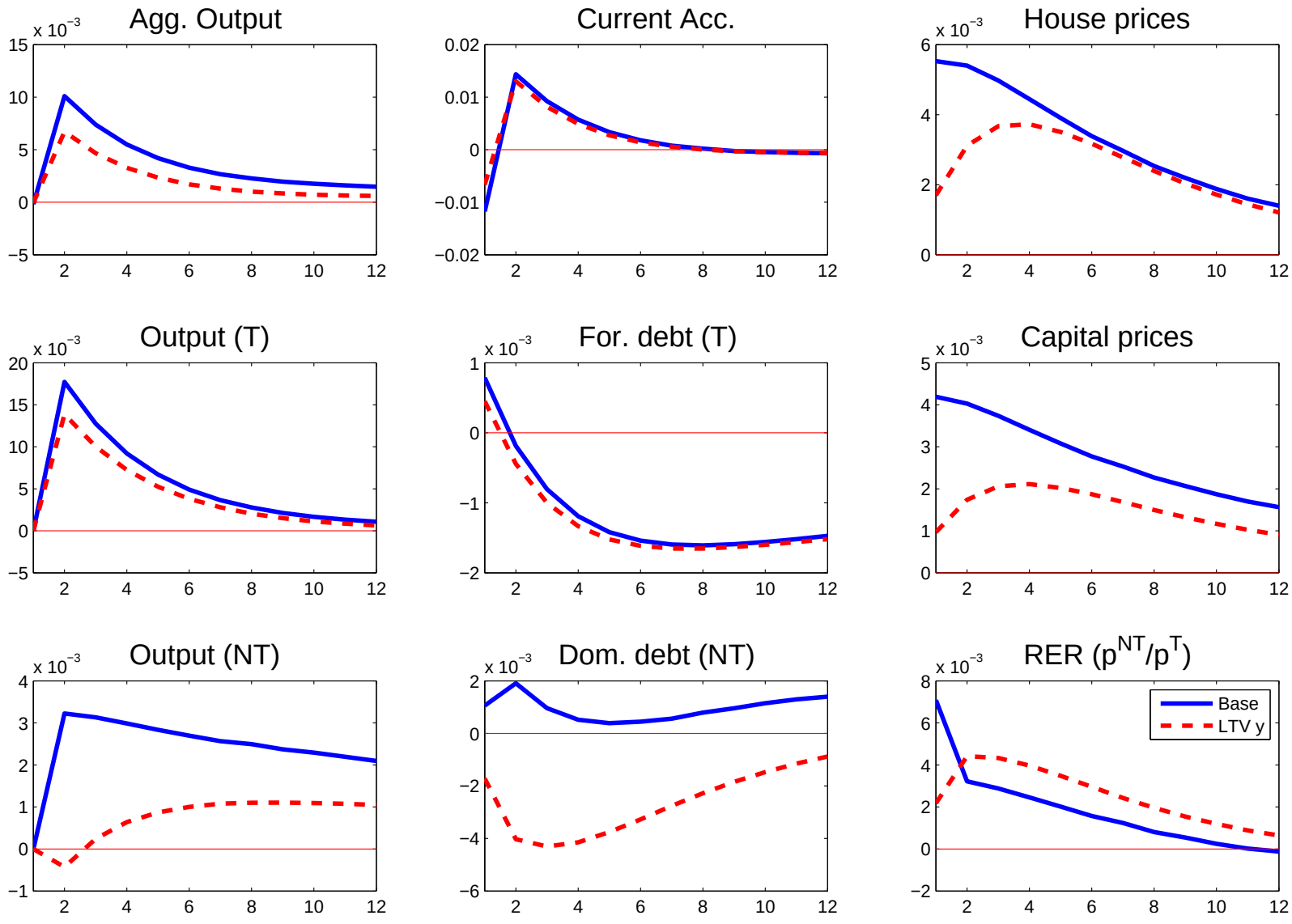


Figure : Tradable Productivity Shock: Countercyclical LTV Rule

Welfare and Volatility

- In order to further analyse the impact of LTV rules, we solve the model using a second order approximation around the non-stochastic steady state. We find that the countercyclical rule reduces the volatility of output. Table
- We also investigate the second order effects on welfare. This measure is the difference between the mean welfare measure and its non-stochastic steady-state value.
- Results show that the introduction of a countercyclical LTV policy rule generates strong redistribution effects. Namely, its use produces welfare increases for a subset of agents in the economy, while the rest suffer a reversal.

Welfare and Volatility (II)

- Which agents are favoured by the rule depends on the source of the shocks and how limiting the borrowing constraints are, captured by θ.
- For example, when all shocks are taken into account, imposing the countercyclical rule on an economy with low θ makes the entrepreneurs better off and the workers worse off. This outcome is reversed when θ is high. The intuition is that at low values of θ the entrepreneurs are very constrained and shocks generate high domestic interest rate fluctuations which disappear at high levels of θ.

Table

The Role of Nominal Rigidities

- We introduce nominal rigidities to the baseline setup to study the interaction between monetary and macroprudential policies.
- We add a non-tradable goods retailer sector, subject to imperfect competition, that sets prices à la Calvo.
- We impose a lump-sum tax on workers to subsidize the acquisition of "wholesale" non-tradable goods by the retailer, restoring the perfect competition allocation.

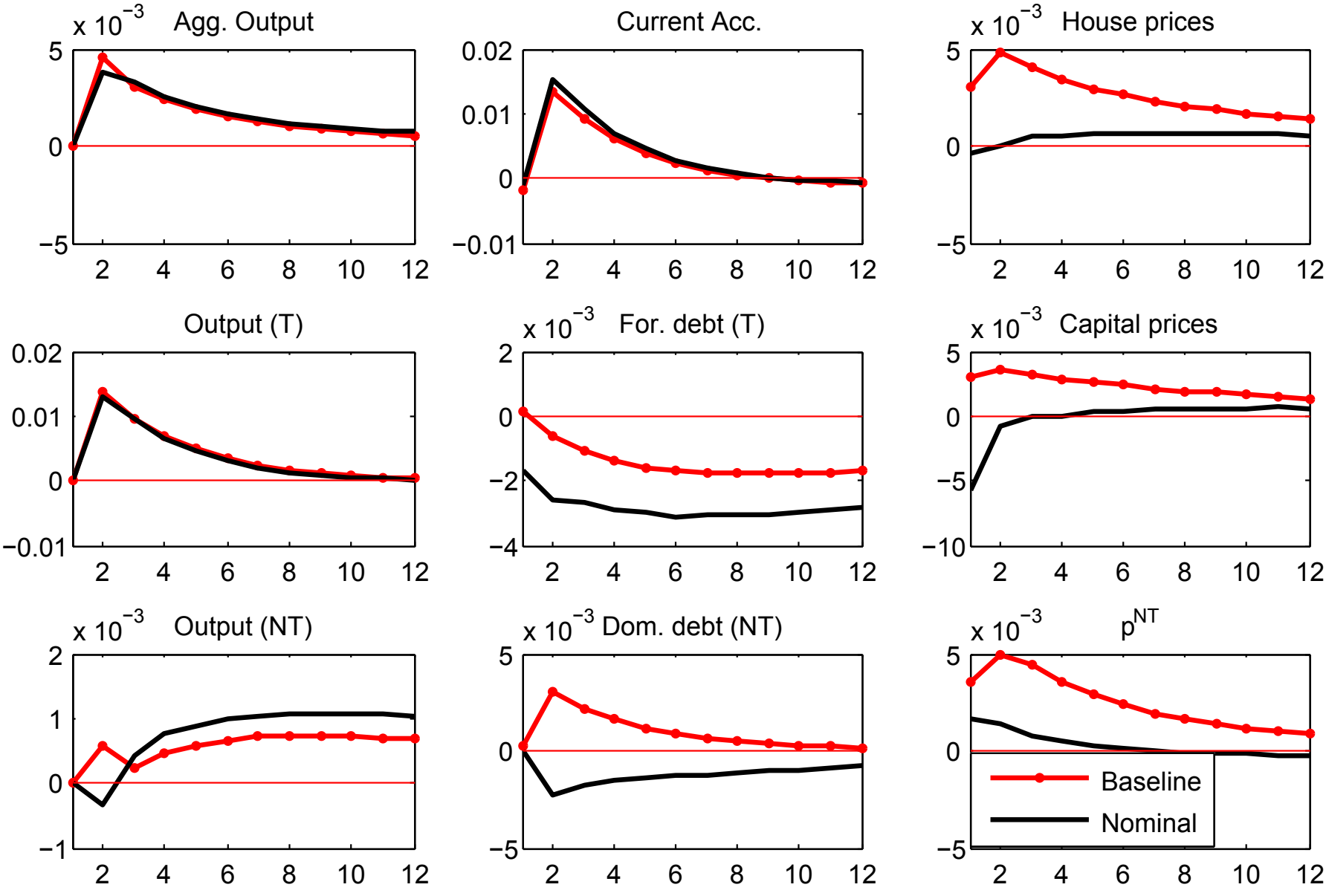


Figure : Tradable Productivity Shock: Role of Nominal Rigidities

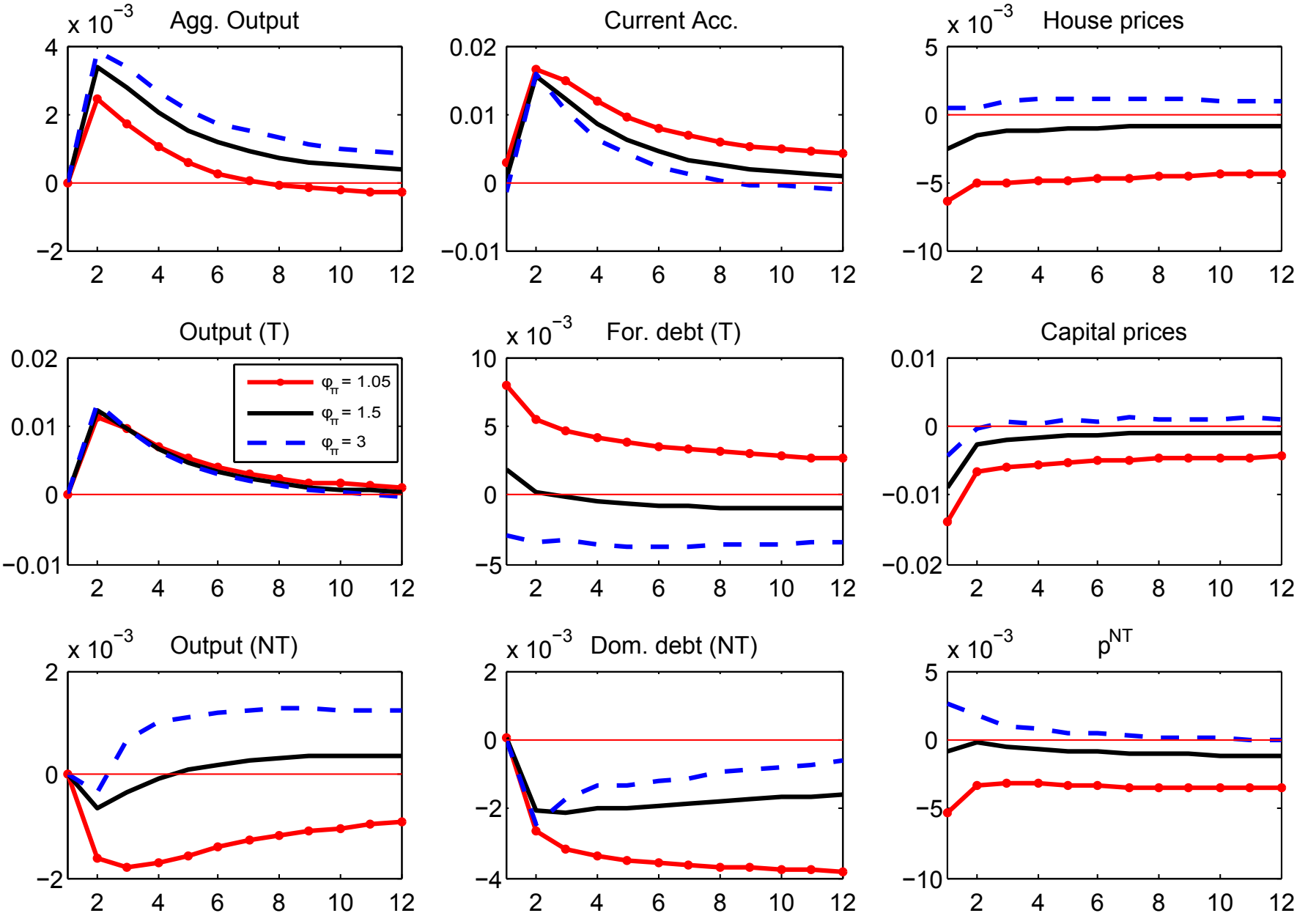


Figure : Tradable Productivity Shock: Role of Monetary Policy

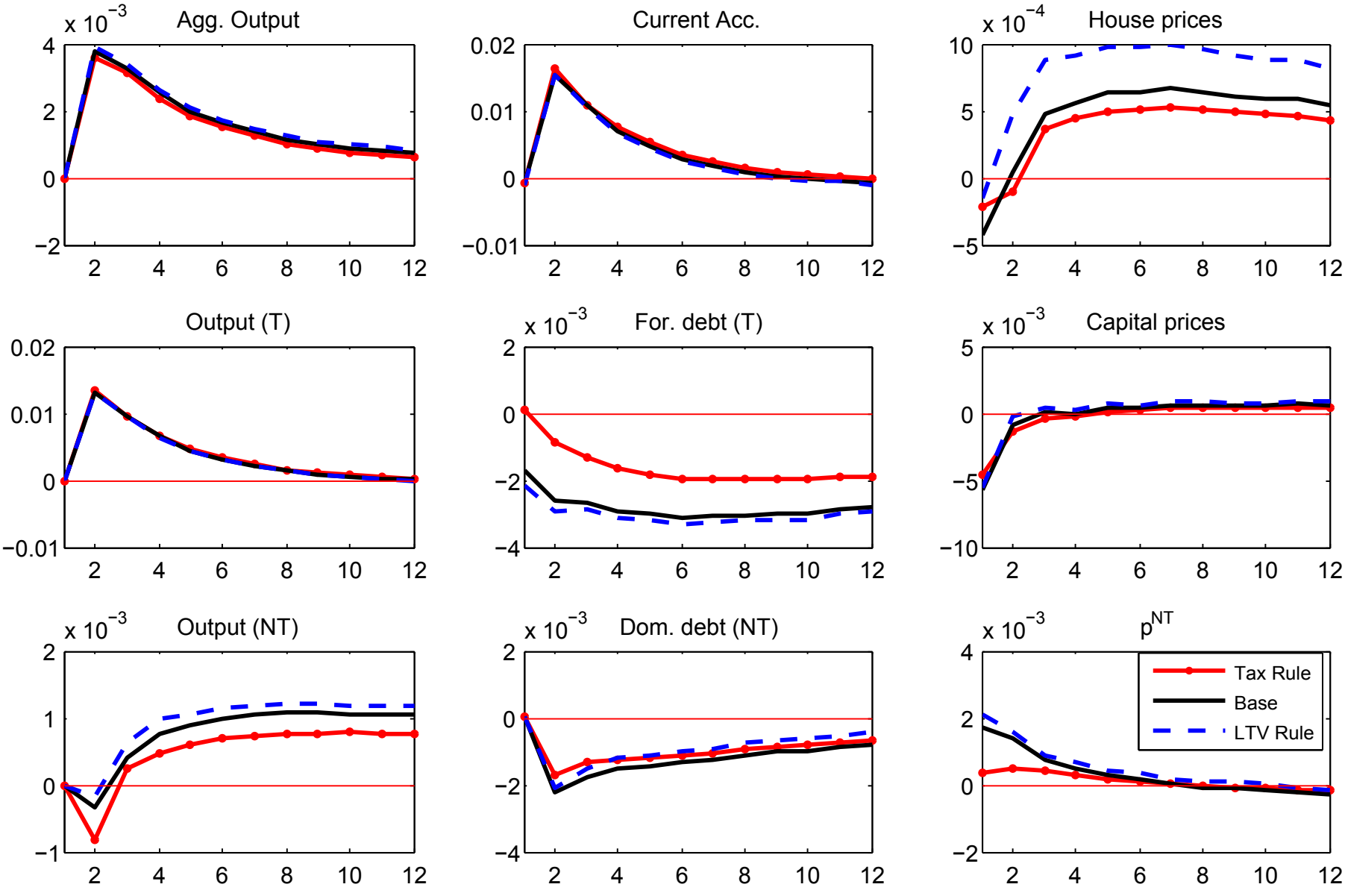


Figure : Tradable Productivity Shock: Monetary and Prudential Policy

Conclusions

1. A productivity shock in the tradable sector generates an increase in both asset prices and borrowing. Those effects spillover to the non-tradable sector and generate a real appreciation.
2. The appreciation and the increase in housing prices further reinforces this mechanism by increasing the ability of non-tradable firms to borrow.
3. As a result, non-tradable sector borrowing increases and a current account deficit appears.

Conclusions (II)

4. The model simulations can also be interpreted as showing a positive correlation between capital flows and terms of trade, a stylized fact observed in many commodity producer economies, such as Chile, Peru and Canada.
5. On the policy side, we show that countercyclical LTV rules can dampen the spillover effects of borrowing constraints.
6. Price rigidities matter for the transmission mechanism of tradable productivity shocks, as they affect the dynamics of collateral prices and credit.
7. Macroprudential instruments allow the central bank to pursue a stronger price stabilization policy by reducing the volatility of asset prices and, consequently, spillovers over the non-tradable sector.

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Worker Equations

Consumption basket:

$$C_{w,s} \equiv \left[\left(\gamma^T\right)^{\frac{1}{\varepsilon}} \left(c_{w,s}^T\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(1-\gamma^T\right)^{\frac{1}{\varepsilon}} \left(c_{w,s}^{NT}\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

Price index:

$$P_s^W = \left[\gamma^T + \left(1-\gamma^T\right) \left(p_s^{NT}\right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}$$

Euler equation:

$$\frac{1}{C_{w,s}} = \beta E_s \left[\frac{R_s}{C_{w,s+1}} \frac{P_s^W}{P_{s+1}^W} \right]$$

Workers Equations (II)

Labour supply:

$$\frac{w_s}{P_s^W} = C_{w,s}\lambda\left(l_s\right)^{\eta}$$

Housing demand:

$$q_s^h - E_s\left[\frac{q_{s+1}^h}{R_s}\right] = j\left(h_s^W\right)^{-\phi} P_s^W C_{w,s}$$

Back

Factor Demands (Tradable Goods Production)

$$q_s^h = \gamma E_s \left[F_s^T \left(q_{s+1}^h + \frac{\partial y_{s+1}^T}{\partial h_s^T} \right) \right]$$

$$q_s^k = \gamma E_s \left[F_s^T \left(q_{s+1}^k + \frac{\partial y_{s+1}^T}{\partial k_s^T} \right) \right] + \left(\frac{1}{R_s^*} - \gamma E_s F_s^T \right) \theta_s^{T*} E_s \left[q_{s+1}^k \right]$$

$$w_s = \gamma E_s \left[F_s^T \frac{\partial y_{s+1}^T}{\partial l_s^T} \right]$$

$$p_s^M = \gamma E_s \left[F_s^T \frac{\partial y_{s+1}^T}{\partial m_s^T} \right]$$

where p_s^M is the price of the imported input in tradable good units and:

$$F_s^T \equiv \frac{C_{t,s}}{C_{t,s+1}} \frac{P_s^W}{P_{s+1}^W}$$

Back

Factor Demands (Non-Tradable Goods Production)

$$q_s^h = \gamma E_s F_s^{NT} \left(q_{s+1}^h + p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial h_s^{NT}} \right) + \left(\frac{1}{R_s} - \gamma E_s F_s^{NT} \right) \theta_s^{NT} E_s q_{s+1}^h$$

$$q_s^k = \gamma E_s \left[F_s^{NT} \left(q_{s+1}^k + p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial k_s^{NT}} \right) \right]$$

$$w_s = \gamma E_s \left[F_s^{NT} \left(p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial l_s^{NT}} \right) \right]$$

$$p_s^M = \gamma E_s \left[F_s^{NT} \left(p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial m_s^{NT}} \right) \right]$$

where

$$F_s^{NT} \equiv \frac{C_{nt,s}}{C_{nt,s+1}} \frac{P_s^W}{P_{s+1}^W}$$

Back

Table : Parameter calibration

Preferences			
$\beta = 0.99$	$\gamma = 0.98$	$\lambda = 1$	$\eta = 1$
$\gamma^T = 0.3$	$\varepsilon = 0.5$	$j = 5$	$\phi = 3$
Technologies			
$\alpha = 0.3$	$\chi = 0.2$	$\kappa = 0.2$	
$\nu = 0.3$	$\varkappa = 0.2$	$\psi = 0.2$	
$\rho_A = 0.7$	$\rho_\zeta = 0.7$		
Collateral constraint			
$\theta^{T*} = 0.3$	$\theta^{NT} = 0.3$		
Open economy			
$R^* = 1.005$	$p^M = 0.8$		
Rules			
$\phi_\theta = -0.8$	$\phi_b = -5$		

Results: A non-tradable productivity shock

- Non-tradable output expands, coupled with a very mild increase in tradable output, a fall in asset prices and a short lived current account surplus consistent with a real depreciation.
- The key difference between the non-tradable productivity shock and the tradable productivity shock is that the price of tradable goods is fixed by arbitrage with the foreign sector while the price of non-tradable goods is determined domestically under perfect competition.

- Thus, the increase in productivity in the non-tradable sector is assimilated in the form of lower prices, generating a significant depreciation. As a result, asset and input prices are virtually unchanged and there is hardly any shift in factor allocation.
- The depreciation has the added benefit of relaxing the non-tradable sector's borrowing constraint. This is a balance-sheet effect: firms in the non-tradable sector contract debt in domestic (basket) units, therefore non-tradable debt in tradable good units expands.

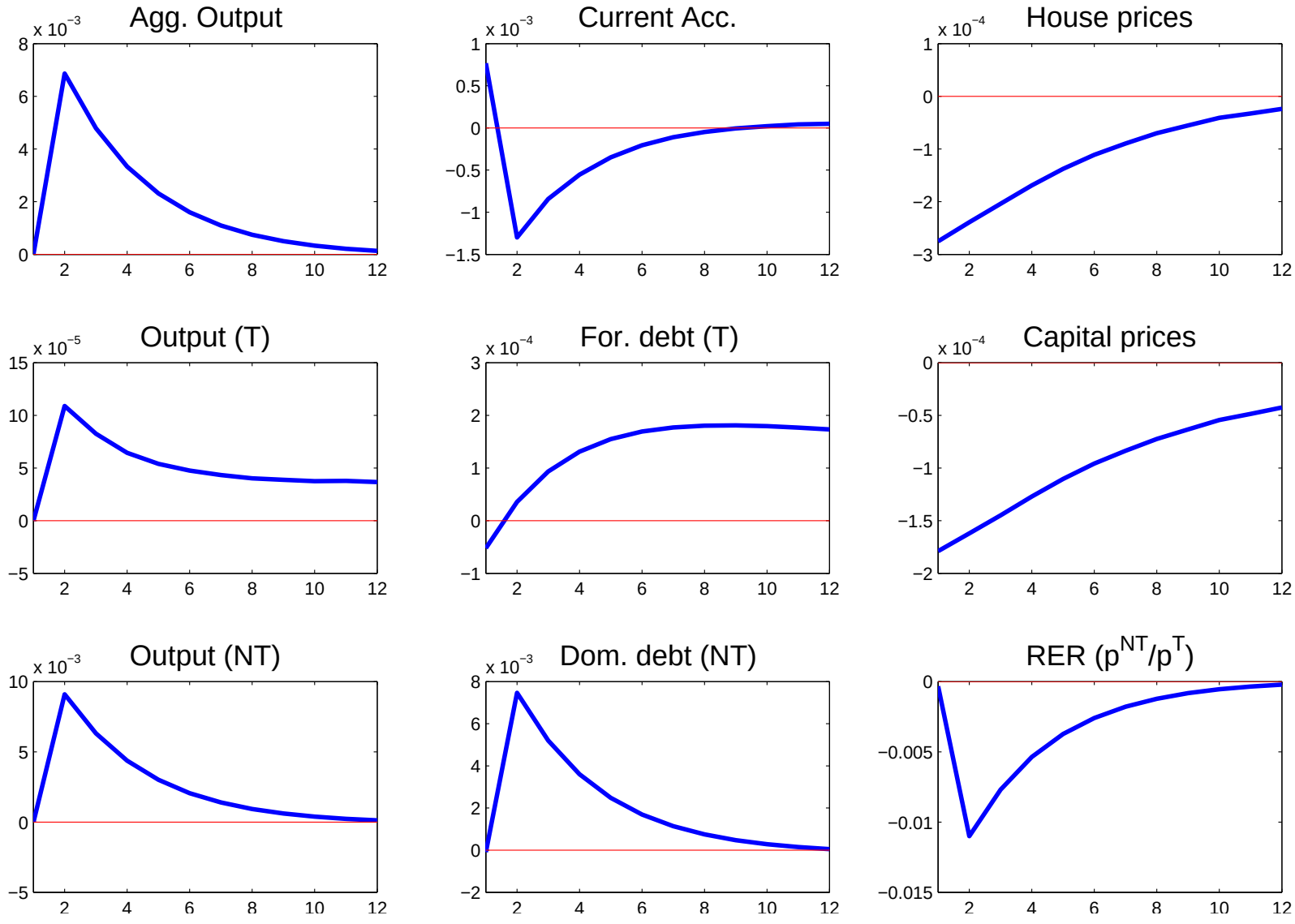

Figure : Non-Tradable Productivity Shock

Results: A foreign interest rate shock

- A higher foreign interest rate tightens the borrowing constraint of tradable firms, forcing a fall in tradable output.
- Lower input demand by tradable firms leads to a fall in the prices of houses and labour.
- The negative wealth effect on tradable entrepreneurs reduces demand for non-tradable goods, triggering a real depreciation.
- Output in the non-tradable sector falls as well, reducing demand for capital and labour further. The decline in wages prompts workers to borrow, pushing the domestic interest rate up, and discouraging borrowing by non-tradable firms.

- Given tighter borrowing constraints, housing is reallocated from the tradable to the non-tradable sector, and capital is reallocated from the non-tradable to the tradable sector, allowing the later to borrow more.
- The contraction in foreign debt and the depreciation that occurs when the shock hits is consistent with a current account surplus.
- This shock is basically the opposite of the tradable productivity shock. Thus, a fall in the foreign interest rate that generates capital inflows into this SOE would produce: higher asset prices, current account deficit, real depreciation and a boom in the non-tradable sector coupled with higher debt.

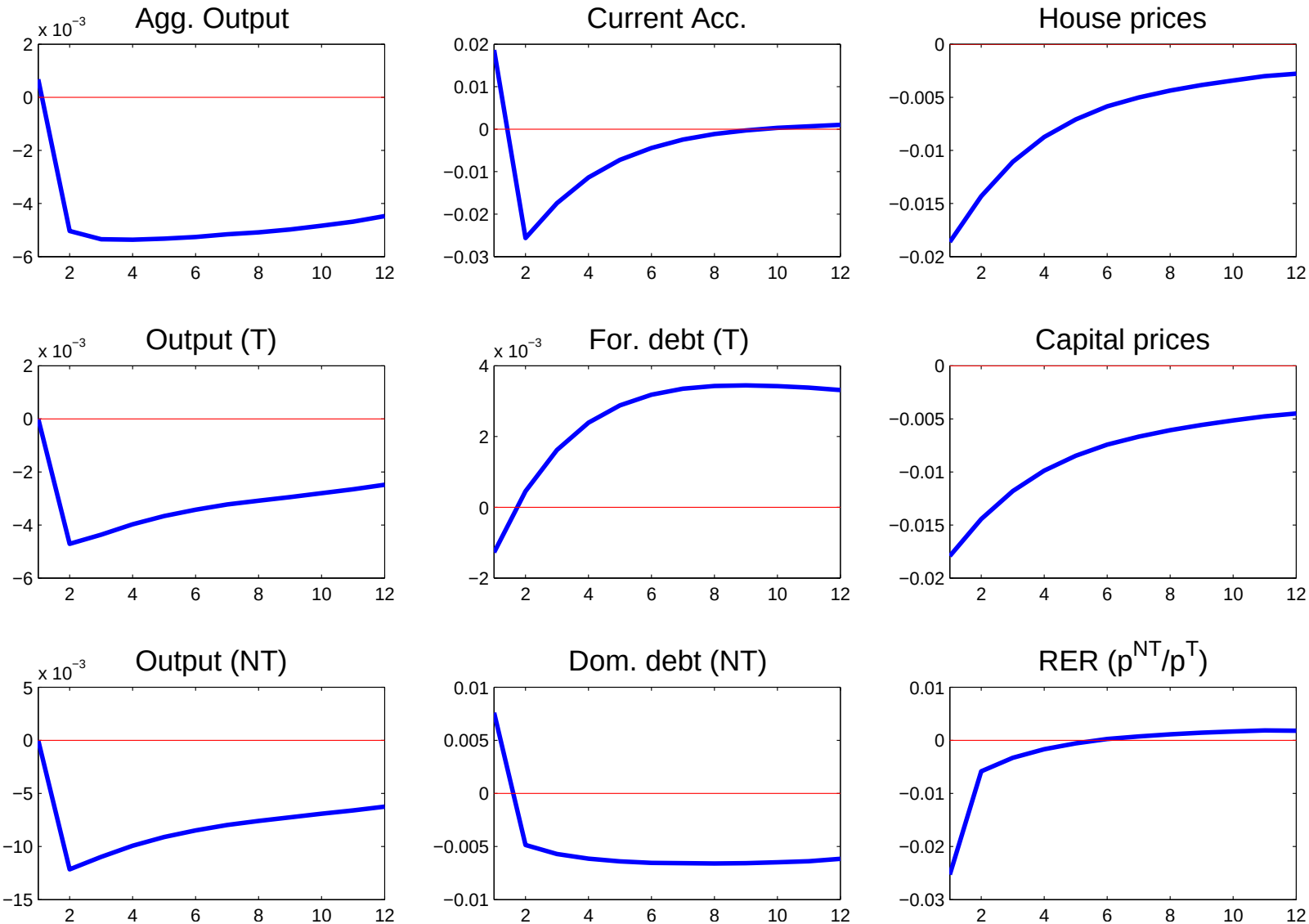

Figure : Foreign Interest Rate Shock

Back

Table : Coefficient of variability

$Variable$	$\theta = 0.3$		$\theta = 0.6$		$\theta = 0.9$	
	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$
All shocks						
Y	2.808	2.244	4.683	2.867	9.935	3.775
Y^{NT}	7.242	5.673	17.482	11.651	83.293	47.001
Y^T	7.247	6.335	8.747	6.538	12.829	5.447
Tradable productivity shock						
Y	2.149	1.69	2.59	1.588	2.931	1.259
Y^{NT}	3.645	2.281	5.101	2.394	12.926	4.166
Y^T	7.149	6.238	7.771	6.104	7.34	4.28
Non − tradable productivity shock						
Y	1.451	1.195	1.539	1.043	1.745	0.886
Y^{NT}	4.284	3.525	5.639	4.477	15.04	13.978
Y^T	0.116	0.591	0.1	0.979	0.094	2.103
Foreign interest rate shock						
Y	1.075	0.866	3.583	2.147	9.353	3.451
Y^{NT}	4.552	3.811	15.737	10.489	81.71	45.763
Y^T	1.161	0.915	4.003	2.132	10.604	2.626

Back

Table : Welfare

$Variable$	$\theta = 0.3$		$\theta = 0.6$		$\theta = 0.9$	
	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$
All shocks						
W^w	4.178	3.148	-3.204	0.607	-104.083	-1.429
W^{NT}	-3.827	-2.254	-2.139	-3.031	244.964	56.912
W^T	-4.036	-2.923	-9.366	-5.37	59.211	6.348
Tradable productivity shock						
W^w	1.102	0.639	-0.029	1.593	-0.712	20.101
W^{NT}	-0.541	0.246	1.04	1.187	4.055	12.979
W^T	-1.232	-0.419	-0.771	-0.873	0.251	-6.203
Non − tradable productivity shock						
W^w	-0.118	0.277	-0.124	0.52	-0.129	5.367
W^{NT}	-0.081	-0.104	-0.074	0.346	-0.068	5.991
W^T	-0.047	-0.684	-0.043	-0.749	-0.039	-1.506
Foreign interest rate shock						
W^w	3.193	2.233	-3.05	-1.506	-103.242	-26.896
W^{NT}	-3.205	-2.395	-3.106	-4.564	240.977	37.942
W^T	-2.757	-1.82	-8.552	-3.748	59	14.057

Back