Spillovers, capital flows and prudential regulation in small open economies*

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Abstract

This paper extends the model of Aoki et al. (2009) considering a two sector small open economy. We study the interaction of borrowing, asset prices, and spillovers between tradable and non-tradable sectors. Our results suggest that when it is difficult to enforce debtors to repay their debt unless it is secured by collateral, a productivity shock in the tradable sector generates an increase in asset prices and leverage that spills over to the non-tradable sector, generating an appreciation of the real exchange and a current account deficit. Macro-prudential instruments are introduced under the form of cyclical loan-to-value ratios that limit the amount of capital that entrepreneurs can pledge as collateral. Simulation results show that this type of instruments significantly lessen the amplifying effects of borrowing constraints on small open economies and consequently reduce output and asset price volatility.

Keywords: Collateral, productivity, small open economy.
JEL classification: E21, E23, E32, E44, G01, O11, O16

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1 Introduction

Capital flows constitute one of the main sources of volatility in small open economies.[1] As Calvo (1998) emphasized, a sudden stop of capital flows can trigger sharp reversals in the current account, a fall in domestic spending and a collapse of the real exchange rate and of asset prices, with long-lasting consequences for the health of the financial system and for the economy in general. Recent papers have addressed this issue by focusing on the phenomenon of over borrowing that typically characterizes sudden stop episodes (see Bianchi (2011), Mendoza (2002), Jeanne and Korinek (2010)). Another branch of the literature has focused on the role that financial development plays in amplifying the externalities that capital flows can generate (Aoki et al. (2009) and Aghion et al. (2004)).

An issue that has attracted less attention in the literature is the spillover effects between the tradable and non-tradable sector in the context of persistent capital inflows, and the impact of these spillovers in overborrowing, current account deficits and an increased vulnerability to sudden stops. In this paper, we address this issue presenting a small open economy model that generates overborrowing, altering the allocation of funding between tradable and non-tradable sectors. In particular, the model reproduces the positive correlation between capital flows, asset prices, firms' leverage in the non-tradable sector, the real exchange rate and current account deficits observed in developing countries.[2] Furthermore, we show that loan to value ratios can help mitigate the typical distortions observed during persistent periods of capital inflows and outflows.

The experience of Latin American economies previous to the global financial crisis, illustrates the relevance of spillover effects between the tradable and non-tradable sectors. As Table 1 shows, capital flows to the region increased substantially in 1997. Simultaneously, both the gross domestic product (GDP) and credit exhibited high growth rates. More importantly, the growth rates in the tradable and non-tradable sector showed a high degree of positive correlation. This pattern is particularly interesting in Chile and Peru, where GDP growth rates in the tradable sector reached two-digits in 2006 and a year after, in 2007, non-tradable sector growth accelerated. A similar pattern is observed for 2010 onwards, after the implementation of the quantitative easing policies by the FED. Over these years, the credit expansion was accompanied by positive growth rates in both sectors. While we would have expected the tradable sector to expand the most, the non-tradable sector registered important growth rates, even larger than the tradable sector ones in countries such as Colombia and Peru. Our model attempts to explain this stylized fact observed in Latin American countries.

Similar to Kiyotaki and Moore (1997), in our model, the dynamics between credit limits and asset prices become a transmission mechanism by which the effects of a shock persist and spill over other sectors. Unlike the existing literature, we explicitly study the interaction between over borrowing, housing prices, and spillovers between tradable and non-tradable sectors. Our results suggest that when it is difficult to enforce debtors to repay their debt unless it is secured by collateral, a productivity shock in the tradable sector generates an increase in asset prices and leverage that spills over to the non-

[1] See Converse (2013).

[2] Converse (2013) attributes these correlations to financial constraints and maturity mismatches which impact investment after negative shocks to capital flows. In his setup, this channel also links the volatility of capital flows to output and total factor productivity (TFP) volatility.

tradable sector, increasing the leverage in this sector and generating a real appreciation. The opposite is observed in response to a negative tradable productivity shock. These dynamics are consistent with the ones observed in emerging market economies during episodes of capital inflows and outflows.

We also introduce macro-prudential instruments in the form of cyclical loan-to-value ratios that limit the fraction of the value of assets that entrepreneurs can pledge as collateral. Simulation results show that this type of instruments significantly lessen the amplifying effects of borrowing constraints in small open economies and, consequently, reduce output and asset price volatility.

The paper extends the model of Aoki et al. (2009), considering a two sector small open economy where agents use housing as collateral to borrow in line with Iacoviello (2005). As in the aforementioned paper, our domestic agents find it difficult to enforce debtors to repay their obligations unless they are secured by collateral. This restriction generates a link between the entrepreneurs' debt limits and the price of collateral. Unlike the aforementioned papers, we consider both tradable and non-tradable sector specific shocks in our analysis. This link, given the collateral pledge by entrepreneurs in the tradable and non-tradable sectors, is the main mechanism that generates co-movements between these two sectors. The rise in the value of collateral triggered by an expected increase in productivity in one sector, also implies that constrained agents in the other sector can benefit from a larger borrowing capacity, which leads to co-movements amongst sectors.

The model economy consists of workers and entrepreneurs allocated in the tradable and non-tradable sectors of the economy. Entrepreneurs face borrowing constraints to finance both production and the acquisition of capital. Workers consume a basket of tradable and non-tradable goods and housing services; whereas entrepreneurs consume only final goods. We introduce two types of durable goods, houses (h) and capital (k). While both serve as collateral and as production factors, only houses will be part of a consumption basket. In both cases, due to limited commitment, agents have to pledge collateral in order to borrow. We also consider an asymmetry between domestic and foreign creditors. The foreign creditors will only lend to the tradable sector and take capital as pledgable collateral. In contrast, non-tradable entrepreneurs will obtain credit exclusively from domestic markets, which only accept houses as collateral.

Although our assumption of two types of collateral is not conventional, it is not new in the literature. Caballero and Krishnamurthy (2001) use a similar assumption to study the interaction between domestic and foreign lending during periods of sudden stops. However, a key difference between our assumption and that of Caballero and Krishnamurthy (2001) is that in our case, international collateral is used only for borrowing in the tradable sector, whereas domestic collateral is used only for borrowing in the non-tradable sector, which is plausible given the empirical evidence that shows that exports play a significant role in generating international collateral, whereas domestic agents prefer domestic collateral, such as real state. For example, as Caballero and Krishnamurthy (2001) highlight, during the 2004-2005 financial crisis Mexico used its oil revenues to back the liquidity package it received.

Our simulation results show that an increase in productivity in the tradable sector generates a rise in output both in the tradable and non-tradable sectors, boosting collateral prices, generating a real appreciation and increasing the leverage of entrepreneurs that operate in the non-tradable sector, which in turn generates a current account deficit. The real appreciation further reinforces this process by reducing the relative cost of importing production inputs in terms of non-tradable output. During the adjustment process, collateral is transferred from the tradable to the non-tradable sector and viceversa because, after a positive productivity shock, each type of entrepreneur uses relatively less of the collateralizable asset to finance production. In this way, the model can account for the typical stylized facts that precede periods of excess credit growth and capital flows in small open economy models, as periods of transitory increase in productivity in the tradable sector, that spillover to the non-tradable sector, generate exchange rate appreciations, overborrowing in the non-tradable sector, asset price booms, capital flows and current account deficits.

In the case of a rise in productivity in the non-tradable sector, the model generates an increase in non-tradable output, 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 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. Thus, non-tradable debt in tradable good units expands.

On the other hand, an increase in the 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.

As a result, output in the non-tradable sector also falls, reducing demand for capital and labour further. The fall 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. The fall in foreign debt and the depreciation that occurs when the shock hits is consistent with a current account surplus.

Our paper is related to a large body of literature that studies the macroeconomic role of financial frictions. Bianchi (2011) studies constrained efficient equilibria within a small open economy model with borrowing constraints. In contrast with his work, we study the spillover effects between tradable and non-tradable sectors, asset prices and capital flows in a model that does not rely on occasionally binding constraints.

Mendoza (2002) accounts for the abrupt economic collapses of sudden stops as an atypical phenomenon nested within the smoother co-movements of regular business cycles. In this setting, precautionary savings and state-contingent risk premiums play a key role in driving business cycle dynamics. In particular, he shows that sudden stops can be consistent with the optimal adjustment of a flexible-price economy in response to a suddenly binding credit constraint (occasionally binding credit constraint that limits borrowing). The liquidity constraint requires borrowers to finance a fraction of their current obligations out of their current income.[3]

[3] Aizenman (2002) questions the findings of Mendoza (2002) and argues that domestic tax policy uncertainty in the presence of exogenous liquidity constraints is a poor description of some countries in the East, such as Korea. Before the crisis, the global market viewed Korea as having a stable and responsible fiscal policy. An alternative interpretation is that an unanticipated tightening of the liquidity

Caballero and Krishnamurthy (2001) emphasize the interaction between domestic and international collateral constraints for financial crises by constructing a model where firms are subject to liquidity shocks. Since domestic collateral constraints lower the domestic rate of return on saving, agents tend to under-save: *"they hold too little spare international borrowing capacity, which makes the economy more vulnerable to adverse shocks."*

Aoki et al. (2009) provide a framework to analyse how the constraints in domestic finance and international finance interact with each other through assets prices. In their model, entrepreneurs combine a fixed asset (land) and working capital to produce output. With some probability, some entrepreneurs are productive while others are not. Here, the fixed asset is a factor of production as well as collateral for loans. The borrower's credit limit is affected by the price of the fixed asset, while the asset price is affected by credit limits. The interaction between credit limits and asset prices turns out to be a propagation mechanism that may generate large swings in aggregate economic activity. In addition to the fixed asset, some fraction of future output is allowed as collateral for domestic loans. The extent to which future output is usable as collateral depends upon both the technology and the quality of institutions, and proxies for the degree of development of the domestic financial system.

In a related paper, Paasche (2001) studies the spillover effects across countries. The authors extend the model of Kiyotaki and Moore (1997) to a setup of two credit constrained small open economies who borrow and export differentiated commodities to a third large one. These small countries are only connected through the elasticity of substitution in their exports to the large country. The authors show that spill over effects are present since a negative productivity shock in one of the small countries generates an adverse terms of trade shock on the other, which is amplified through the credit channel.

The rest of the paper is organized as follows. Section 2 presents our theoretical approach. Section 3 presents our results. Finally, section 4 concludes.

2 Model

In the model, the domestic economy is a small open economy inhabited by a continuum of two types of agents, entrepreneurs and workers. Workers consume a basket of tradable and non-tradable goods and housing services; whereas entrepreneurs consume only final goods. We introduce two types of durable goods, houses (h) and capital (k). While both serve as collateral and as production factors, only houses will be part of a consumption basket. In both cases, due to limited commitment, agents require to pledge collateral in order to borrow. Following Aoki et al. (2009) we consider an asymmetry between domestic and foreign creditors. The foreign creditors will only lend to the tradable sector

constraint would be associated with a very large welfare cost. In that regard, the Korean crisis should be modelled as an economy characterized by erratic access to the international capital market, stable domestic fiscal policies, and a high savings rate in which moral hazard provides the incentive for excessive borrowing. Aizenman (2002) suggests Dooley (2000) for this type of models. Aizenman (2002) also points out that the benchmark model does not consider the investment channel or allow for an endogenous long-run effect of uncertainty on growth. According to Aizenman (2002), sudden stops in Mendoza (2002) are not reflected in long-run business-cycle statistics; they are the outcome of the modelling strategy and may not hold in models in which long-run growth is systematically affected by policy uncertainty and economic volatility.

Table 1: Capital flows, credit, and output

		2006	2007	2008	2009	2010	2011	2012
International investment position, in percentages								
Bolivia		-14.0	-6.8	7.9	3.0	6.4	13.9	
Colombia		13.3	20.5	9.7	13.2	16.0	17.9	12.2
Chile		9.7	19.9	5.3	24.3	23.4	8.2	17.8
Mexico		16.5	10.7	-7.2	2.2	24.8	0.0	20.2
Peru		14.0	34.8	-0.4	13.8	28.7	8.5	
Credit to the private sector growth rates								
Bolivia	Tradable	-1.6	15.5	4.8	5.5	29.3	24.7	8.6
	Non-tradable	12.5	1.1	6.5	10.1	23.7	19.7	7.6
Colombia	Tradable	44.7	14.6	30.0	-7.4	27.5	9.2	2.6
	Non-tradable	50.7	27.8	35.4	0.4	33.0	31.5	-9.2
Chile	Tradable	14.2	18.3	34.9	-19.9	15.9	20.1	6.3
	Non-tradable	17.8	20.8	19.3	0.9	9.6	14.6	8.6
Mexico	Tradable						15.4	-4.7
	Non-tradable						11.7	7.7
Peru	Tradable	10.3	33.2	36.3	-7.2	-0.1	11.0	1.9
	Non-tradable	20.0	32.3	38.6	7.3	32.9	20.4	17.7
GDP, in percentages								
Bolivia	Tradable	5.6	4.1	7.5	3.2	3.1	4.5	4.2
	Non-tradable	3.3	4.8	3.8	5.2	4.5	4.2	4.8
Colombia	Tradable	6.1	6.6	2.8	-0.2	4.3	6.6	2.6
	Non-tradable	7.1	7.1	4.1	2.9	3.7	6.7	4.9
Chile	Tradable	28.5	7.0	-11.9	-1.5	22.7	6.3	1.9
	Non-tradable	11.9	13.1	16.6	5.4	10.7	11.4	10.8
Mexico	Tradable	5.4	2.5	-0.2	-8.6	8.0	4.1	4.3
	Non-tradable	5.0	3.8	2.2	-4.2	3.5	3.8	3.7
Peru	Tradable	7.2	7.8	9.3	-2.1	7.9	6.3	4.0
	Non-tradable	8.2	9.9	10.2	3.3	9.5	7.4	8.1

Note: The classification between tradable and non-tradable follows Stockman and Tesar (1995). Source: IFS and the institute of national statistics for each country.

and accept capital as pledgable collateral. In contrast, non-tradable entrepreneurs will obtain credit exclusively from domestic markets, which only accept houses as collateral.

We model workers to be more patient agents than entrepreneurs as in Iacoviello (2005). Workers supply labour to entrepreneurs and do not face borrowing constraints. We restrict the saving possibilities of the workers to the domestic economy. We further introduce macro-prudential instruments into the model by considering that the government can affect the amount entrepreneurs can pledge as collateral when they borrow both in domestic and foreign markets, using loan-to-value ratios as a policy tool.

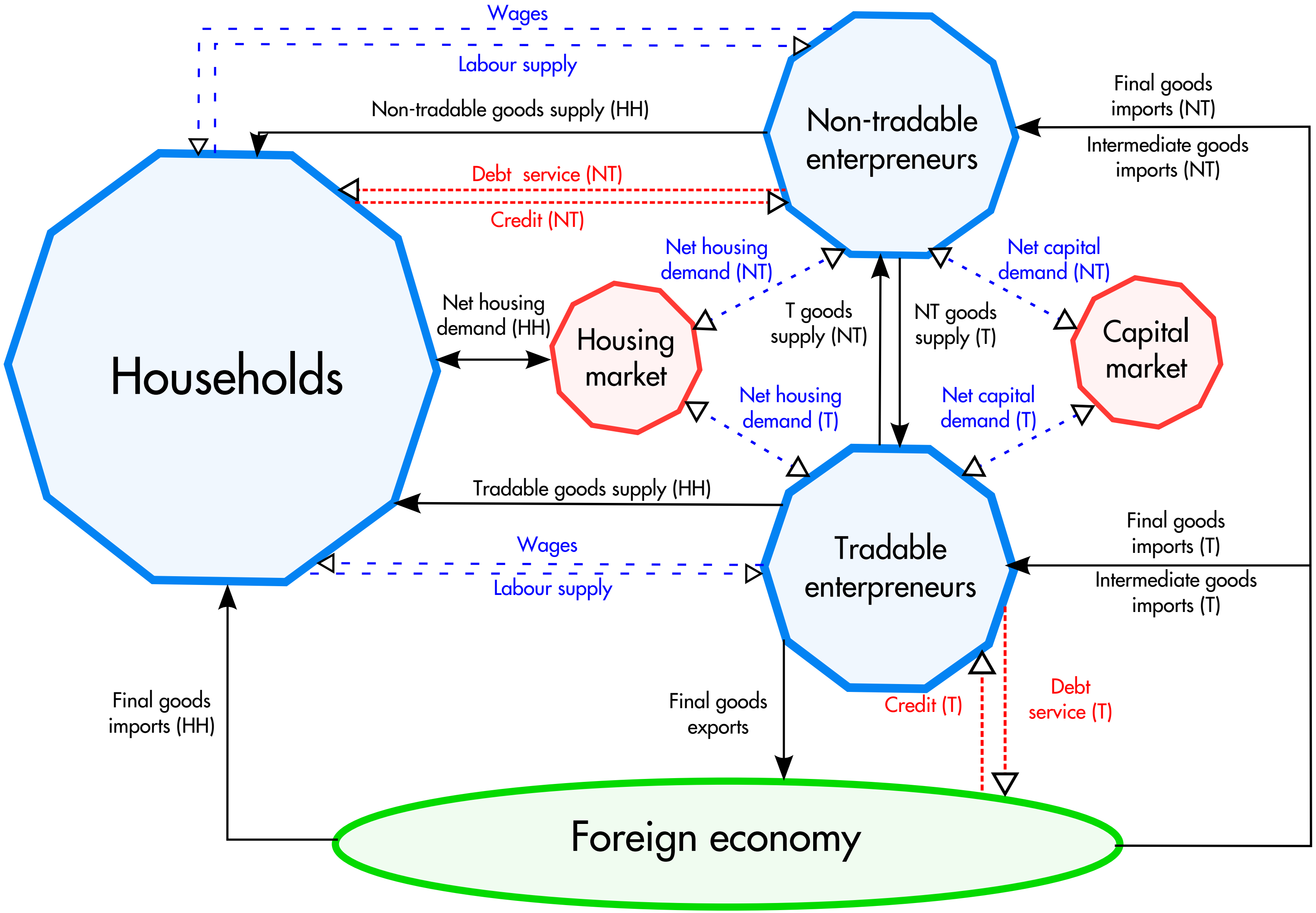

Figure 1: The model economy

2.1 Workers

Workers maximize a lifetime utility function given by:

$$E_0 \sum_{s=0}^{\infty} \beta^s \left[\log C_{w,s} + j \frac{(h_s^W)^{1-\phi}}{1-\phi} - \lambda \frac{(l_s)^{1+\eta}}{1+\eta} \right] \tag{1}$$

where $C_{w,s}$ and l_s represent the worker's consumption and labour, respectively. Their holdings of housing are represented by h_s^W and j controls the relative weight of housing services in the utility function, similar to the effect of parameter λ on the disutility from labour. Parameters ϕ and η pin down the elasticities of substitution between housing, labour and final goods consumption. E_s is the conditional expectation operator set at period s and β is the intertemporal discount factor, with $0 < \beta < 1$. Houses are a durable consumption good for workers and their total endowment is fixed over time.

The consumption basket of workers is a composite of tradable and non-tradable goods, aggregated using the following consumption index:

$$C_{w,s} \equiv \left[\left(\gamma^T\right)^{1/\varepsilon} \left(c_{w,s}^T\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(1-\gamma^T\right)^{1/\varepsilon} \left(c_{w,s}^{NT}\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2}$$

where $\varepsilon > 0$ is the elasticity of substitution between tradable ($c_{w,s}^T$) and non-tradable goods ($c_{w,s}^{NT}$), and γ^T is the share of tradable goods in the consumption basket of the domestic economy.

The worker's optimal demands for tradable and non-tradable consumption are given by:

$$c_{w,s}^T = \gamma^T \left(\frac{1}{P_s^W} \right)^{-\varepsilon} C_{w,s} \tag{3}$$

$$c_{w,s}^{NT} = \left(1-\gamma^T\right) \left(\frac{p_s^{NT}}{P_s^W} \right)^{-\varepsilon} C_{w,s} \tag{4}$$

This set of demand functions is obtained by minimizing the total expenditure in consumption $P_s^W C_{w,s}$ where P_s^W stands for the worker's consumer price index in terms of tradable goods. Notice that the consumption of each type of good is increasing in the total consumption level, and decreasing in their corresponding relative price. Also, it is easy to show that under these preference assumptions, the consumer price index is determined by the following condition:

$$P_s^W \equiv \left[\gamma^T + \left(1-\gamma^T\right) \left(p_s^{NT}\right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{5}$$

where p_s^{NT} denotes the relative price level of non-tradable goods.

We assume workers do not have access to the international financial market, therefore they can only save and lend in the domestic financial system. Their flow of funds is given by:

$$P_s^W C_{w,s} + q_s^h \Delta h_s^W + P_s^W b_s^{NT} = R_{s-1} P_{s-1}^W b_{s-1}^{NT} + w_s l_s \tag{6}$$

where w_s is the nominal wage and R_s the domestic interest factor (expressed in tradable units of account). b_s^{NT} represents the amount that workers lend to entrepreneurs in the non-tradable sector, Δh_s^W is the change in the workers' holding of houses and q_s^h stands for the house price.

Solving the first order conditions and assuming workers ignore the (potential) constraints on savings we get:[4]

$$\frac{1}{R_s} = \beta E_s \left[\frac{C_{w,s}}{C_{w,s+1}} \frac{P_s^W}{P_{s+1}^W} \right] \tag{7}$$

Equation (7) corresponds to the Euler equation that determines the optimal path of consumption for unconstrained households in the home economy, equalizing the marginal benefits of savings to its corresponding marginal costs.

Also from the first-order conditions, we obtain the labor supply function:

$$\frac{w_s}{P_s^W} = C_{w,s} \lambda \left(l_s \right)^{\eta} \tag{8}$$

where $\frac{w_s}{P_s^W}$ denotes real wages. In a competitive labour market, the marginal rate of substitution equals the real wage, as in equation (8).

Domestic agents also extract utility from housing services, hence an equilibrium condition between goods and housing consumption is required:

$$q_s^h = j \left(h_s^W \right)^{-\phi} P_s^W C_{w,s} + E_s \left[\frac{q_{s+1}^h}{R_s} \right] \tag{9}$$

this expression represents the demand of housing by workers and it establishes that workers' demand for housing depends on the marginal rate of substitution between housing services and consumption, as well as on the expected capital gains if housing prices rise over a period.

2.2 Entrepreneurs

There are two types of entrepreneurs in the economy, which differ in the goods they produce. The first type of entrepreneur produces tradable goods (which can be sold in the international markets) while the second produces non tradable goods, which can be traded only in the domestic market (non-tradable entrepreneur).

2.2.1 Non-tradable entrepreneurs

Non-tradable entrepreneurs produce the non-tradable good y_s^{NT} using housing h_{s-1}^{NT}, capital k_{s-1}^{NT}, labor l_{s-1}^{NT} and imported inputs m_{s-1}^{NT}. They can only obtain financing from the domestic market, where they face a credit constraint based on their housing asset. Since they hire factors in period t and receive output in period $t+1$, they will have to pay the factors in advance.

[4] Iacoviello (2005) does not introduce these constraints in the patient household problem either. This could be justified assuming the households are atomistic, while firms are not. Thus, households do not take into account their impact on the total funds available to lend. Still, it seems somewhat implausible that all households will be constrained in equilibrium and still don't incorporate these restrictions in their optimization programme.

This type of entrepreneur has access to the following production technology:

$$y_s^{NT} = \zeta_{s-1} \left(h_{s-1}^{NT}\right)^{\alpha} \left(k_{s-1}^{NT}\right)^{\chi} \left(l_{s-1}^{NT}\right)^{\kappa} \left(m_{s-1}^{NT}\right)^{1-\alpha-\kappa-\chi} \tag{10}$$

where ζ is the total factor productivity of the non-tradable sector. α, χ, and κ are the housing, capital and labour non-tradable output shares, respectively. We assume non-tradable entrepreneurs extract utility from the consumption good only. Their objective is to maximize the following utility function:

$$E_0 \sum_{s=0}^{\infty} \gamma^s \log C_{nt,s} \tag{11}$$

where γ is the time discount rate of the non-tradable entrepreneur. $\gamma < \beta$ is a necessary condition to guarantee that the borrowing constraint for these entrepreneurs is binding in the steady state. Hence, our entrepreneurs are relatively impatient with respect to workers, in line with Iacoviello (2005). This assumption helps us define the role of entrepreneurs as borrowers and workers as creditors in the domestic market. Their incomes and expenses (flow of funds) are captured in the following expression:

$$p_s^{NT} y_s^{NT} + P_s^W b_s^{NT} = P_s^W C_{nt,s} + q_s^h \Delta h_s^{NT} + q_s^k \Delta k_s^{NT} + R_{s-1} P_{s-1}^W b_{s-1}^{NT} + w_s l_s^{NT} + p_s^M m_s^{NT} \tag{12}$$

where $C_{nt,s}$ is a bundle of tradable and non-tradable goods.[5] Δh_s^{NT} and Δk_s^{NT} are the changes in the non-tradable entrepreneur's holding of houses and capital, respectively. q_s^k is the price of capital, while p^M is the price of imported inputs.

In the domestic financial market firms borrow from domestic agents using housing as collateral in line with Aoki et al. (2009). Domestic lenders accept this collateral, valued in units of the consumption basket, as they themselves make use of houses. The domestic credit restriction is given by:

$$R_s P_s^W b_s^{NT} \leq \theta_s^{NT} q_{s+1}^h h_s^{NT} \tag{13}$$

where θ_s^{NT} represents the fraction of the value of the collateral that the non-tradable entrepreneur can effectively pledge. We set the Lagrangian that summarizes the non-tradable entrepreneur's problem. The first order conditions set optimality in the choice of entrepreneurs regarding consumption, labor, imported inputs, housing, capital and debt. Out of these conditions we single out the demand for factors, given by the following expressions:

$$q_s^h = \gamma E_s \left[\frac{C_{nt,s}}{C_{nt,s+1}} \frac{P_s^W}{P_{s+1}^W} \left(q_{s+1}^h + p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial h_s^{NT}} \right) \right] + \left(\frac{1}{R_s} - \gamma E_s \left[\frac{C_{nt,s}}{C_{nt,s+1}} \frac{P_s^W}{P_{s+1}^W} \right] \right) \theta_s^{NT} E_s \left[q_{s+1}^h \right] \tag{14}$$

$$q_s^k = \gamma E_s \left[\frac{C_{nt,s}}{C_{nt,s+1}} \frac{P_s^W}{P_{s+1}^W} \left(q_{s+1}^k + p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial k_s^{NT}} \right) \right] \tag{15}$$

[5] This expression is constructed in exactly the same way as that of the worker and thus is valued at the same price index the workers face, P_s^W.

$$w_s = \gamma E_s \left[\frac{C_{nt,s}}{C_{nt,s+1}} \frac{P_s^W}{P_{s+1}^W} \left(p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial l_s^{NT}} \right) \right] \tag{16}$$

$$p_s^M = \gamma E_s \left[\frac{C_{nt,s}}{C_{nt,s+1}} \frac{P_s^W}{P_{s+1}^W} \left(p_{s+1}^{NT} \frac{\partial y_{s+1}^{NT}}{\partial m_s^{NT}} \right) \right] \tag{17}$$

Equations (14) and (15) represent the non-tradable entrepreneur's demand for housing and capital respectively, while equations (16) and (17) represents their demand for labor and intermediate imported goods. The optimal allocation of consumption between tradable and non-tradable goods is determined by equating the rate of substitution of these two types of goods to their corresponding relative price.

By comparing equations (14) with (15) we can notice that the first order condition for housing involves an additional term, given by the second expression of the left-hand side. This expression represents the gains that entrepreneurs obtain by holding an asset that allows them access to credit. This benefit is proportional to the difference between the interest rate and their stochastic discount factor, and plays a very important role in the model dynamics.

2.2.2 Tradable entrepreneurs

This case parallels the one of non-tradable entrepreneurs. The production technology is a Cobb-Douglas similar in structure to that of the tradable entrepreneur:

$$y_s^T = A_{s-1} \left(h_{s-1}^T\right)^{\nu} \left(k_{s-1}^T\right)^{\varkappa} \left(l_{s-1}^T\right)^{\psi} \left(m_{s-1}^T\right)^{1-\nu-\psi-\varkappa} \tag{18}$$

where A is the total factor productivity of the tradable sector. ν, $\varkappa$, and ψ are the housing, capital and labour tradable output shares, respectively. The tradable entrepreneurs extract utility only from consumption goods. They maximize the following utility function:

$$E_0 \sum_{s=0}^{\infty} \gamma^s \log C_{t,s} \tag{19}$$

where $\gamma < \beta$. As in the case of the typical non-tradable entrepreneur, it guarantees the borrowing constraint will be binding in equilibrium. The producer of tradable goods has the flow of funds:

$$y_s^T + b_s^{T*} = P_s^W C_{t,s} + q_s^h \Delta h_s^T + q_s^k \Delta k_s^T + R_{s-1}^* b_{s-1}^{T*} + w_s l_s^T + p_s^M m_s^T, \tag{20}$$

where $C_{t,s}$ is a bundle of tradable and non-tradable goods constructed in exactly the same way as that of the worker and thus is valued at the same price index the workers use, P_s^W. b_s^{T*} represents the debt of tradable entrepreneurs, while R_s^* is the foreign interest rate.

The tradable entrepreneur faces the following financial constraint,

$$R_s^* b_s^{T*} \leq \theta_s^{T*} q_{s+1}^k k_s^T \tag{21}$$

where θ_s^{T*} represents the fraction of collateral that can be used against a loan. We assume that tradable entrepreneurs only access foreign credit markets, where the only asset accepted as collateral is capital. In this case, the Lagrangian for the tradable entrepreneur mirrors the one of the non-tradable entrepreneur. Then, similar to the first order conditions of the non-tradable entrepreneur, tradable entrepreneur's demand for factors can be described as:

$$q_s^h = \gamma E_s \left[\frac{C_{t,s}}{C_{t,s+1}} \frac{P_s^W}{P_{s+1}^W} \left(q_{s+1}^h + \frac{\partial y_{s+1}^T}{\partial h_s^T} \right) \right] \tag{22}$$

$$q_s^k = \gamma E_s \left[\frac{C_{t,s}}{C_{t,s+1}} \frac{P_s^W}{P_{s+1}^W} \left(q_{s+1}^k + \frac{\partial y_{s+1}^T}{\partial k_s^T} \right) \right] + \left(\frac{1}{R_s^*} - \gamma E_s \left[\frac{C_{t,s}}{C_{t,s+1}} \frac{P_s^W}{P_{s+1}^W} \right] \right) \theta_s^{T*} E_s \left[q_{s+1}^k \right] \tag{23}$$

$$w_s = \gamma E_s \left[\frac{C_{t,s}}{C_{t,s+1}} \frac{P_s^W}{P_{s+1}^W} \frac{\partial y_{s+1}^T}{\partial l_s^T} \right] \tag{24}$$

$$p_s^M = \gamma E_s \left[\frac{C_{t,s}}{C_{t,s+1}} \frac{P_s^W}{P_{s+1}^W} \frac{\partial y_{s+1}^T}{\partial m_s^T} \right] \tag{25}$$

In this case, the term representing the benefit from accessing credit is present in the first order condition related to capital (23). Once again this will be a function of the difference between the loan rate and the stochastic discount factor of entrepreneurs.

2.3 Market equilibrium conditions

The model comprises five markets: (i) the labour market, (ii) the housing market, (iii) the capital market, and final goods markets, (iv) tradable and (v) non-tradable. Labour is homogeneous and it is used as a production factor by both the tradable and non-tradable sectors. Houses are demanded by the three main agents in the economy. Households demand them for consumption, whereas entrepreneurs use houses as a production factor. Non-tradable entrepreneurs use them as well as a collateral for borrowing. Capital is used by entrepreneurs as a production factor, and as a collateral only by the tradable sector entrepreneurs. In the economy there is no investment, which implies that the total supply of housing and capital is fixed at H, and K. The corresponding equilibrium conditions of the labour, housing and capital markets are given by the following three equations:

$$l_s = l_s^{NT} + l_s^T \tag{26}$$

$$H = h_s^W + h_s^{NT} + h_s^T \tag{27}$$

$$K = k_s^T + k_s^{NT} \tag{28}$$

Non-tradable goods are consumed by workers and entrepreneurs. Aggregate demand of non-tradable goods depends on its relative price and the total demand for consumption, as the following equation describes:

$$y_s^{NT} = \left(1 - \gamma^T\right) \left(\frac{p_s^{NT}}{p_s^W} \right)^{-\varepsilon} \left(C_{w,s} + C_{t,s} + C_{nt,s} \right) \tag{29}$$

Only entrepreneurs in the tradable sector have access to international capital markets. In contrast, non-tradable entrepreneurs and workers operate exclusively in the domestic financial system. Therefore, the debt of non-tradable entrepreneurs alone will affect the dynamics of the balance of payments.

$$y_s^T - \gamma^T \left(\frac{1}{p_s^W}\right)^{-\varepsilon} (C_{w,s} + C_{t,s} + C_{nt,s}) - p_s^M \left(m_s^T + m_s^{NT}\right) - (R_s^* - 1)\, b_s^{T*} = -\left(b_s^{T*} - b_{s-1}^{T*}\right) \tag{30}$$

2.4 Policy instruments

The presence of borrowing constraints in our model is a *structural* one. In other words, 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 instance, Kiyotaki and Moore (1997) base the use of collateral in the imperfect enforceability model of Hart and Moore (1994), in which human capital is *inalienable*. This pushes lenders to demand collateral as a way to protect themselves against the risk of default.[6] 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.

For this reason, the application of time varying LTV rules must involve two steps. First, the policy value of θ (θ^{int}) must be set below the private one (θ^{priv}). After that, it is possible to add an additional component (τ), which can be an effective instrument to reduce spill over patterns. Figure 2 displays these family of rules. In the present paper, we focus only on the *second-order effects* on welfare, which are associated with the aforementioned boom and bust patterns. Two different types of rules are considered. The first takes into account the position in the business cycle of the economy. The second, involves the debt position of entrepreneurs.

The countercyclical rule is given by:

$$\frac{\theta_s^{T*,int}}{\bar{\theta}^{T*,int}} = \frac{\theta_s^{NT,int}}{\bar{\theta}^{NT,int}} = E_s \left(\frac{Y_{s+1}}{\bar{Y}}\right)^{-\phi_\theta} \tag{31}$$

where Y denotes aggregate output (value added) defined as

$$Y_s = \left(y_s^T - p_{s-1}^M m_{s-1}^T + p_s^{NT} y_s^{NT} - p_{s-1}^M m_{s-1}^{NT}\right) / P_s^W \tag{32}$$

and $\phi_\theta > 0$.[7] In the case of debt position, we focus on the debt contracted by the non-tradable sector. In this case, the rule will be:

$$\frac{\theta_s^{NT,int}}{\bar{\theta}^{NT,int}} = \left(\frac{b_s^{NT}}{\bar{b}^{NT}}\right)^{-\phi_b} \tag{33}$$

[6] The literature presents several reasons for the use of collateral: moral hazard concerns (Holmstrom and Tirole (1997)), limited contract enforceability (Cooley et al. (2004), Kehoe and Levine (1993),Hart and Moore (1994); costly state verification (Townsend (1979)), and private information (Stiglitz and Weiss (1981), Wette (1983)), among others.

[7] Note that given our assumption of tradable entrepreneurs borrowing from abroad, adjusting θ_s^{T*} is akin to imposing capital controls.

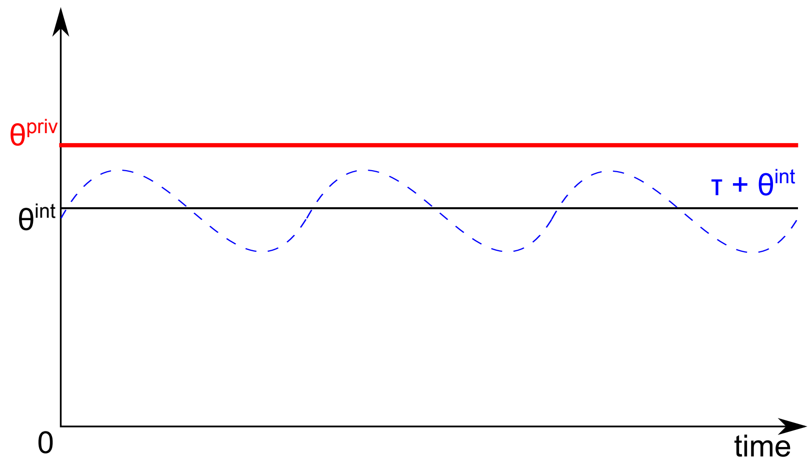

Figure 2: LTV rules

The diagram shows how loan to value rules should be designed. θ^{priv} stands for the *deep* parameter that acts as an upper bound for the macroprudential authority. LTV rules involve reducing the average LTV (θ^{int}), in effect making the constraint more binding. As a counterpart, the macroprudential authority will be able to introduce a time-varying component (τ) into its rule.

3 Results

3.1 Baseline calibration

In this section we describe the calibration of the model and assess its quantitative implications. The values assigned to all model's parameters are listed in Table 2. The discount factor for workers is set to 0.99 , which implies an annual interest rate of 4 percent, whereas for the case of entrepreneurs this parameter is set to 0.98, consistent with the assumption that entrepreneurs are more impatient agents than workers in the model. The inverse of the Frisch labour elasticity, $\frac{1}{\eta}$ is set to 1, in line with the microeconomic studies showing this parameter should be relatively small.[8]

The classification between tradables and non-tradables follows that of Stockman y Tesar (1995). We set $\gamma^T = 0.3$.

The share of labor factor is calibrated in 0.30 for the tradable and non-tradable sector. This value is consistent with those in Bernanke and Gurkaynak (2002) who document a range between 0.22 and 0.73 for different emerging economies. In order to estimate the remaining parameters for the production function, we consider the input-output table for the Peruvian economy, and we follow the approach of intermediate and final demand for both sectors.

We use the intermediate demand to estimate the use of input by origin in different sectors. In that sense, we identify the share of imported inputs in the production process. As for the share of housing, we use the participation of construction in the final demand for capital formation process. The remainder is assigned to the capital share.

Regarding the collateral constraints, legal limits impose a maximum that ranges from 65 to 90 percent of collaterized debt (this rate depends on the type of asset used as

[8]King and Rebelo (1999) assume a value of 4 for η.

Table 2: 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			
$\alpha = 0.3$	$\chi = 0.2$	$\kappa = 0.2$	
$\nu = 0.3$	$\varkappa = 0.2$	$\psi = 0.2$	
$\rho_A = 0.7$	$\rho_\varsigma = 0.7$		
Collateral constraint			
$\theta^{T*} = 0.3$	$\theta^{NT} = 0.3$		
Open economy			
$R^* = 1.005$	$p^M = 0.8$		
Rules			
$\phi_\theta = -0.8$	$\phi_b = -5$		

collateral). We set $\theta^T = 0.60$.

Productivity shocks in both sectors are assumed to follow first order autoregressive process, with relatively low persistence. Besides the productivity shocks, we consider a foreign interest rate shock which also follows an AR(1) process.

3.2 The dynamics of the model

Figures 3 to 6 show the impulse response functions of the main variables of the model to productivity shocks and a foreign interest rate shock.

In the model, an increase in productivity in the tradable sector (Figure 3) generates an expansion in output both in the tradable and non-tradable sectors and boosts the price of both assets used as collateral. The productivity shock increases the tradable sector's demand for inputs, increasing the price of housing and labour. Given our assumptions, the positive wealth effect experienced by tradable entrepreneurs increases demand for non-tradable goods, pushing up their price. This generates an appreciation of the real exchange rate.

The real appreciation generates an expansion in the non-tradable sector. This sector now demands more inputs as well, pushing up the price of capital and labour. Note that before the shock, the borrowing constraint implied that the tradable sector needed to hold more capital than necessary from a pure production perspective, because of its usefulness as collateral. When the price of capital increases, the tradable sector's borrowing constraint is relaxed and its demand for capital relative to housing decreases.

Given the increase in housing prices, the borrowing constraint of the non-tradable sector is relaxed as well and non-tradable firms' demand for housing decreases. However, this decrease in non-tradable firms' housing is not big enough to outweigh the increase in housing prices and borrowing by entrepreneurs that operate in the non-tradable sector expands. 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. Tradable firms liberate some of the capital they were using and it is acquired by their non-tradable counterparts.

Workers experience a positive wealth effect because of the temporary increase in 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.

The higher demand for imported inputs necessary to expand production in both sectors explains the current account deficit that follows the shock.

In the case of a rise in productivity in the non-tradable sector (Figure 5), the model generates an increase in non-tradable output, 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 shown earlier is that the price of tradable goods is fixed by arbitrage with the (not explicitly modelled) 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 a shift in factor allocation between sectors.

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. Thus, non-tradable debt in tradable good units expands.

An increase in the foreign interest rate (Figure 6) 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.

As a result, 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. The contraction in foreign debt and the depreciation that occurs when the shock hits is consistent with a current account surplus.

Note that this shock is basically the opposite of the tradable productivity shock. The implication is that a fall in the foreign interest rate that generates capital inflows into this small open economy would produce the same response as that shown in Figure 3: higher asset prices, current account deficit, real depreciation and a boom in the non-tradable sector coupled with higher debt.

3.3 The role of borrowing constraints

In order to illustrate the role that borrowing constraints play in the model, Figure 9 shows the dynamics of the model considering different values for θ. A larger θ implies that borrowing constraints are less restrictive for entrepreneurs decisions, consequently, spillover effects should be less important. As this figure shows, when θ is relative large ($\theta = 1.18$), the model does not generate spillover effects.[9] On the contrary, output in the non-tradable sector falls instead of rising in response to a positive productivity shock in

[9]Notice that in the case that $\theta > 1$ its effect on the collateral constraint ceases to be linear. The reason is that agents can pledge the additional funds more than once, obtaining a geometric increase in their funding.

the tradable sector. Similarly, debt of non-tradable entrepreneurs falls instead of rising and both houses and capital prices are muted.

Interestingly, real exchange rate appreciates much less in this case, which also is consistent with a milder current account deficit. However, output response is not very different. The opposite is observed when θ is relative low ($\theta = 0.1$), the real exchange rate appreciates substantially, and the current account deficit is much higher, output in the non-tradable sector expands as much as the output in the tradable sector, and the debt of the non-tradable sector increases substantially. Asset prices, housing and capital prices, also increase amplifying the initial impact of productivity shocks.

3.4 Robustness checks

Figures 10, 11 and 12 show robustness exercises to changes in three key parameter values, β, the degree of impatience of workers, γ the degree of impatience of entrepreneurs and ε, the elasticity of substitution between tradable and non-tradable goods.

For the first parameter we take as a low value, $\beta = 0.9885$, and as a high value, $\beta = 0.995$. A similar set of values is considered for γ, whereas for ε we consider as a low value, $\varepsilon = 0.5$ and as a high value, $\varepsilon = 1.2$. The simulation results shows that the spillover effect is robust to the changes of these three key parameters. It tends to be lower, when tradable and non-tradable goods are more substitutes, however the spillover effects prevail.

The other two parameters do not affect significantly the magnitude of the spillover effects, they only change the relatively response of the demand for houses and capital of entrepreneurs across the tradable and non-tradable sectors.

3.5 The role of macro-prudential policies

Figures 7 and 8 show the effect that the loan-to-value policy rules defined in equations (31) and (33) would have on the dynamics that our model generates in response to a tradable productivity shock.

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 (Figure 7). Aggregate output is barely 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 8 shows the impact of a LTV rule that targets domestic debt incurred by non-tradable firms directly. Note that the rule manages to dampen the impact of the tradable productivity shock on non-tradable debt, containing its expansion, but has virtually no effect on other variables. The reason is that our entrepreneurs can obtain funds selling their assets. When the LTV rule tightens the borrowing constraint of non-tradable entrepreneurs in the aftermath of a productivity expansion, these agents respond by selling more houses and using the proceedings to finance the growth of non-tradable output. House prices are high in this economy and the shock pushes them up even more, a small fraction of assets being sold generates enough funds to sustain production for quite a while.

For further examination of the model under LTV rules, we solve the model using a second order approximation around the non-stochastic steady state. We simulate the paths for a series of key variables. Focusing on output, the countercyclical rule reduces its volatility. Table 3 reports model generated coefficients of variation for aggregate, tradable and non-tradable output under different assumptions regarding which shocks hit the economy. Except for the case of an economy subject to only non-tradable shocks, the introduction of rules reduce volatility for all indicators. In the case of the tradable output under non-tradable shocks, the former is barely affected by non-tradable shocks.

Table 4 shows the second order effects on welfare. This measure is the difference between the mean welfare measure and its non-stochastic steady-state value. We use this measure since we are interested in the effects that policy has through the reduction of spillover effects. Results show that the introduction of a countercyclical macroprudential 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. 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.

4 Conclusions

This paper investigates the interaction between over borrowing, housing prices, and spillovers between tradable and non-tradable sectors within a general equilibrium framework. The key contribution of the paper is to show that when it is difficult to enforce debtors to repay their debt unless it is secured by collateral, a productivity shock in the tradable sector generates an increase in asset prices and leverage that spillover to the non-tradable sector and appreciates the real exchange rate. The appreciation of the exchange rate and the increase in housing prices further reinforces this mechanism by increasing the ability of non-tradable firms to increase their leverage. As a result, the economy experiences a large increase in leverage and credit in the non-tradable sector and a current account deficit. All these effects are consistent with the empirical evidence.

In the model, the aforementioned dynamic response of the economy to a positive productivity shock in the tradable sector is similar to the response that an increase in commodity prices would generate for economies where the tradable sector production is mostly commodities. Therefore, 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.

In the case of a rise in productivity in the non-tradable sector, the model generates an increase in non-tradable output, which spills over to the tradable sector, a fall in asset prices and a short lived current account surplus consistent with a real depreciation. The depreciation of the real exchange rate generates lower wealth for non-tradable sector, firms and workers, which in turn generates a fall in savings and consequently an increase in the domestic interest rate.

On the other hand, an increase in the 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 price of houses and labour. The negative wealth effect on tradable entrepreneurs reduces demand for non-tradable goods, triggering a real depreciation.

On the policy side, we show that macro-prudential instruments under the form of cyclical loan-to-value ratios that limit the amount of capital that entrepreneurs can pledge as collateral can dampen the effects of borrowing constraints. Interestingly we find that LTV ratios work better in reducing output volatility when these ratios change according to the business cycle and not necessarily according to the level of domestic lending.

Within our framework we can incorporate a larger set of policy instruments to diminish the effects of capital flows on the over borrowing externality, such us reserve requirements to the use of external funding or taxes to the non-tradable sector. We plan to incorporate these in a future version of the paper.

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A Model Equations

In this appendix we present a compiled list of all the equations in the model in non-linear form.

A.1 Worker problem

$$\max \mathcal{L}^W = E_0 \sum_{s=0}^{\infty} \beta^s \left[\begin{array}{c} \left(\ln C_{w,s} + j \frac{\left(h_s^W\right)^{1-\phi}}{1-\phi} - \lambda \frac{(l_s)^{1+\eta}}{1+\eta} \right) \\ +\lambda_s^W \left(-C_{w,s} - \frac{q_s^h}{P_s^W} \Delta h_s^W - b_s^{NT} + R_{s-1} \frac{P_{s-1}^W}{P_s^W} b_{s-1}^{NT} + \frac{w_s}{P_s^W} l_s \right) \end{array} \right]$$

where λ_s^W is the current value lagrangian multiplier associated to the worker's budget constraint. The first order conditions of this problem are:

$$C_{w,s} + \frac{q_s^h}{P_s^W} \Delta h_s^W + b_s^{NT} = R_{s-1} \frac{P_{s-1}^W}{P_s^W} b_{s-1}^{NT} + \frac{w_s}{P_s^W} l_s \tag{A.1}$$

$$\lambda_s^W = \frac{1}{C_{w,s}} \tag{A.2}$$

$$\frac{w_s}{P_s^W} \frac{1}{C_{w,s}} = \lambda \left(l_s\right)^{\eta} \tag{A.3}$$

$$\frac{q_s^h}{P_s^W} = j \left(h_s^W\right)^{-\phi} C_{w,s} + \beta E_s \left[\frac{\lambda_{s+1}^W}{\lambda_s^W} \frac{q_{s+1}^h}{P_{s+1}^W} \right] \tag{A.4}$$

$$\frac{1}{R_s} = \beta E_s \left[\frac{\lambda_{s+1}^W}{\lambda_s^W} \frac{P_s^W}{P_{s+1}^W} \right] \tag{A.5}$$

Where the price level, P_s^W, is defined as:

$$P_s^W \equiv \left[\gamma^T + \left(1 - \gamma^T\right) \left(p_s^{NT}\right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{A.6}$$

A.2 Non-tradable entrepreneur's problem

$$\max \mathcal{L}^{NT} = E_0 \sum_{s=0}^{\infty} \gamma^s \left[\begin{array}{c} \ln C_{nt,s} \\ +\lambda_s^{NT} \left(\begin{array}{c} -C_{nt,s} - \frac{q_s^h}{P_s^W} \Delta h_s^{NT} - \frac{q_s^k}{P_s^W} \Delta k_s^{NT} - R_{s-1} \frac{P_{s-1}^W}{P_s^W} b_{s-1}^{NT} \\ - \frac{w_s}{P_s^W} l_s^{NT} - \frac{p_s^M}{P_s^W} m_s^{NT} + \frac{p_s^{NT}}{P_s^W} y_s^{NT} + b_s^{NT} \end{array} \right) \\ +\mu_s^{NT} \left(-R_s \frac{P_s^W}{P_{s+1}^W} b_s^{NT} + \theta_s^{NT} \frac{q_{s+1}^h}{P_{s+1}^W} h_s^{NT} \right) \end{array} \right]$$

where λ_s^{NT} and μ_s^{NT} are the current value lagrangian multipliers associated to the non-tradable entrepreneur's budget and borrowing constraint, respectively. The first order conditions of this problem are:

$$\frac{p_s^{NT}}{P_s^W} y_s^{NT} + b_s^{NT} = C_{nt,s} + \frac{q_s^h}{P_s^W} \Delta h_s^{NT} + \frac{q_s^k}{P_s^W} \Delta k_s^{NT} + R_{s-1} \frac{P_{s-1}^W}{P_s^W} b_{s-1}^{NT} + \frac{w_s}{P_s^W} l_s^{NT} + \frac{p_s^M}{P_s^W} m_s^{NT} \tag{A.7}$$

$$R_s E_s \left[\frac{P^W_s}{P^W_{s+1}} \right] b^{NT}_s = \theta^{NT}_s E_s \left[\frac{q^h_{s+1}}{P^W_{s+1}} \right] h^{NT}_s \tag{A.8}$$

$$\lambda^{NT}_s = \frac{1}{C_{nt,s}} \tag{A.9}$$

$$\frac{q^h_s}{P^W_s} = \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{q^h_{s+1}}{P^W_{s+1}} \right] + \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{p^{NT}_{s+1}}{P^W_{s+1}} \frac{\partial y^{NT}_{s+1}}{\partial h^{NT}_s} \right] + \frac{\mu^{NT}_s}{\lambda^{NT}_s} \theta^{NT}_s E_s \left[\frac{q^h_{s+1}}{P^W_{s+1}} \right] \tag{A.10}$$

$$\frac{q^k_s}{P^W_s} = \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{q^k_{s+1}}{P^W_{s+1}} \right] + \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{p^{NT}_{s+1}}{P^W_{s+1}} \frac{\partial y^{NT}_{s+1}}{\partial k^{NT}_s} \right] \tag{A.11}$$

$$\frac{w_s}{P^W_s} = \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{p^{NT}_{s+1}}{P^W_{s+1}} \frac{\partial y^{NT}_{s+1}}{\partial l^{NT}_s} \right] \tag{A.12}$$

$$\frac{p^M_s}{P^W_s} = \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{p^{NT}_{s+1}}{P^W_{s+1}} \frac{\partial y^{NT}_{s+1}}{\partial m^{NT}_s} \right] \tag{A.13}$$

$$\frac{1}{R_s} = \gamma E_s \left[\frac{\lambda^{NT}_{s+1}}{\lambda^{NT}_s} \frac{P^W_s}{P^W_{s+1}} \right] + \frac{\mu^{NT}_s}{\lambda^{NT}_s} E_s \left[\frac{P^W_s}{P^W_{s+1}} \right] \tag{A.14}$$

The non-tradable entrepreneur's production function is:

$$y^{NT}_s = \zeta_{s-1} \left(h^{NT}_{s-1} \right)^{\alpha} \left(k^{NT}_{s-1} \right)^{\chi} \left(l^{NT}_{s-1} \right)^{\kappa} \left(m^{NT}_{s-1} \right)^{1-\alpha-\kappa-\chi} \tag{A.15}$$

A.3 Tradable entrepreneur's problem

$$\max \mathcal{L}^T = E_0 \sum_{s=0}^{\infty} \gamma^s \left[\begin{array}{c} \ln C_{t,s} \\ +\lambda^T_s \left(\begin{array}{c} -C_{t,s} - \frac{q^h_s}{P^W_s} \Delta h^T_s - \frac{q^k_s}{P^W_s} \Delta k^T_s - R^*_{s-1} \frac{1}{P^W_s} b^{T*}_{s-1} \\ -\frac{w_s}{P^W_s} l^T_s - \frac{p^M_s}{P^W_s} m^T_s + \frac{1}{P^W_s} y^T_s + \frac{1}{P^W_s} b^{T*}_s \end{array} \right) \\ +\mu^{T*}_s \left(-R^*_s \frac{1}{P^W_{s+1}} b^{T*}_s + \theta^{T*}_s \frac{q^k_{s+1}}{P^W_{s+1}} k^T_s \right) \end{array} \right]$$

where λ^T_s and μ^{T*}_s are the current value lagrangian multipliers associated to the tradable entrepreneur's budget and borrowing constraint, respectively. The first order conditions of this problem are:

$$\frac{1}{P^W_s} y^T_s + \frac{1}{P^W_s} b^{T*}_s = C_{t,s} + \frac{q^h_s}{P^W_s} \Delta h^T_s + \frac{q^k_s}{P^W_s} \Delta k^T_s + R^*_{s-1} \frac{1}{P^W_s} b^{T*}_{s-1} + \frac{w_s}{P^W_s} l^T_s + \frac{p^M_s}{P^W_s} m^T_s \tag{A.16}$$

$$R^*_s E_s \left[\frac{1}{P^W_{s+1}} \right] b^{T*}_s = \theta^{T*}_s E_s \left[\frac{q^k_{s+1}}{P^W_{s+1}} \right] k^T_s \tag{A.17}$$

$$\lambda^T_s = \frac{1}{C_{t,s}} \tag{A.18}$$

$$\frac{q^h_s}{P^W_s} = \gamma E_s \left[\frac{\lambda^T_{s+1}}{\lambda^T_s} \frac{q^h_{s+1}}{P^W_{s+1}} \right] + \gamma E_s \left[\frac{\lambda^T_{s+1}}{\lambda^T_s} \frac{1}{P^W_{s+1}} \frac{\partial y^T_{s+1}}{\partial h^T_s} \right] \tag{A.19}$$

$$\frac{q^k_s}{P^W_s} = \gamma E_s \left[\frac{\lambda^T_{s+1}}{\lambda^T_s} \frac{q^k_{s+1}}{P^W_{s+1}} \right] + \gamma E_s \left[\frac{\lambda^T_{s+1}}{\lambda^T_s} \frac{1}{P^W_{s+1}} \frac{\partial y^T_{s+1}}{\partial k^T_s} \right] + \frac{\mu^{T*}_s}{\lambda^T_s} \theta^{T*}_s E_s \left[\frac{q^k_{s+1}}{P^W_{s+1}} \right] \tag{A.20}$$

$$\frac{w_s}{P_s^W} = \gamma E_s \left[\frac{\lambda_{s+1}^T}{\lambda_s^T} \frac{1}{P_{s+1}^W} \frac{\partial y_{s+1}^T}{\partial l_s^T} \right] \tag{A.21}$$

$$\frac{p_s^M}{P_s^W} = \gamma E_s \left[\frac{\lambda_{s+1}^T}{\lambda_s^T} \frac{1}{P_{s+1}^W} \frac{\partial y_{s+1}^T}{\partial m_s^T} \right] \tag{A.22}$$

$$\frac{1}{R_s^*} = \gamma E_s \left[\frac{\lambda_{s+1}^T}{\lambda_s^T} \frac{P_s^W}{P_{s+1}^W} \right] + \frac{\mu_s^{T*}}{\lambda_s^T} E_s \left[\frac{P_s^W}{P_{s+1}^W} \right] \tag{A.23}$$

The tradable entrepreneur's production function is:

$$y_s^T = A_{s-1} \left(h_{s-1}^T \right)^{\nu} \left(k_{s-1}^T \right)^{\varkappa} \left(l_{s-1}^T \right)^{\psi} \left(m_{s-1}^T \right)^{1-\nu-\psi-\varkappa} \tag{A.24}$$

A.4 Market equilibrium

$$l_s = l_s^{NT} + l_s^T \tag{A.25}$$

$$y_s^{NT} = \left(1 - \gamma^T\right) \left(\frac{p_s^{NT}}{P_s^W} \right)^{-\varepsilon} \left(C_{w,s} + C_{t,s} + C_{nt,s} \right) \tag{A.26}$$

$$H = h_s^W + h_s^{NT} + h_s^T \tag{A.27}$$

$$K = k_s^T + k_s^{NT} \tag{A.28}$$

Equations (A.1) to (A.28) describe a system in 28 endogenous variables[10]. Additionally, we consider 6 exogenous processes:

$$R_s^* = \overline{R}^* + \rho_R \left(R_{s-1}^* - \overline{R}^* \right) + \epsilon_s^R \tag{A.29}$$

$$\log \zeta_s = \rho_\zeta \left(\log \zeta_{s-1} \right) + \epsilon_s^\zeta \tag{A.30}$$

$$\log A_s = \rho_A \left(\log A_{s-1} \right) + \epsilon_s^A \tag{A.31}$$

$$\log p_s^M - \log \overline{p}^M = \rho_p \left(\log p_{s-1}^M - \log \overline{p}^M \right) + \epsilon_s^p \tag{A.32}$$

For θ^{NT} and θ^{T*}, AR(1) processes and several different rules are considered.

[10] These are: P^W, C_w, y^T, p^{NT}, w, l, q^k, q^h, h^W, y^{NT}, C_{nt}, h^{NT}, l^{NT}, l^T, h^T, k^T, k^{NT}, m^T, m^{NT}, C_t, R, b^{NT}, b^{T*}, λ^W, λ^T, λ^{NT}, μ^{NT} and μ^{T*}.

B Figures and Tables

Table 3: *Coef. of variability*

	$\theta = 0.3$		$\theta = 0.6$		$\theta = 0.9$	
$Variable$	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$
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

Table reports the coefficients of variability calculated from simulations of the model under different values for fraction of asset value accepted as collateral (θ) and the intensity of the countercyclical rule (ϕ_θ), under different assumptions regarding the shocks hitting the economy. Y,Y^{NT},Y^T stand for aggregate, non-tradable and tradable output, respectively. Values were scaled-up by 100.

Table 4: $Welfare$

$Variable$	$\theta = 0.3$		$\theta = 0.6$		$\theta = 0.9$	
	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$	$\phi_\theta = 0$	$\phi_\theta = 0.8$
			$All\ shocks$			
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

Table shows the difference between the mean and the non-stochastic steady-state value for welfare for each agent, under different values for fraction of asset value accepted as collateral (θ) and the intensity of the countercyclical rule (ϕ_θ), under different assumptions regarding the shocks hitting the economy. W^w,W^{NT},W^T stand for welfare measures for the worker, non-tradable and tradable sector entrepreneurs, respectively. Values were scaled-up by 100.

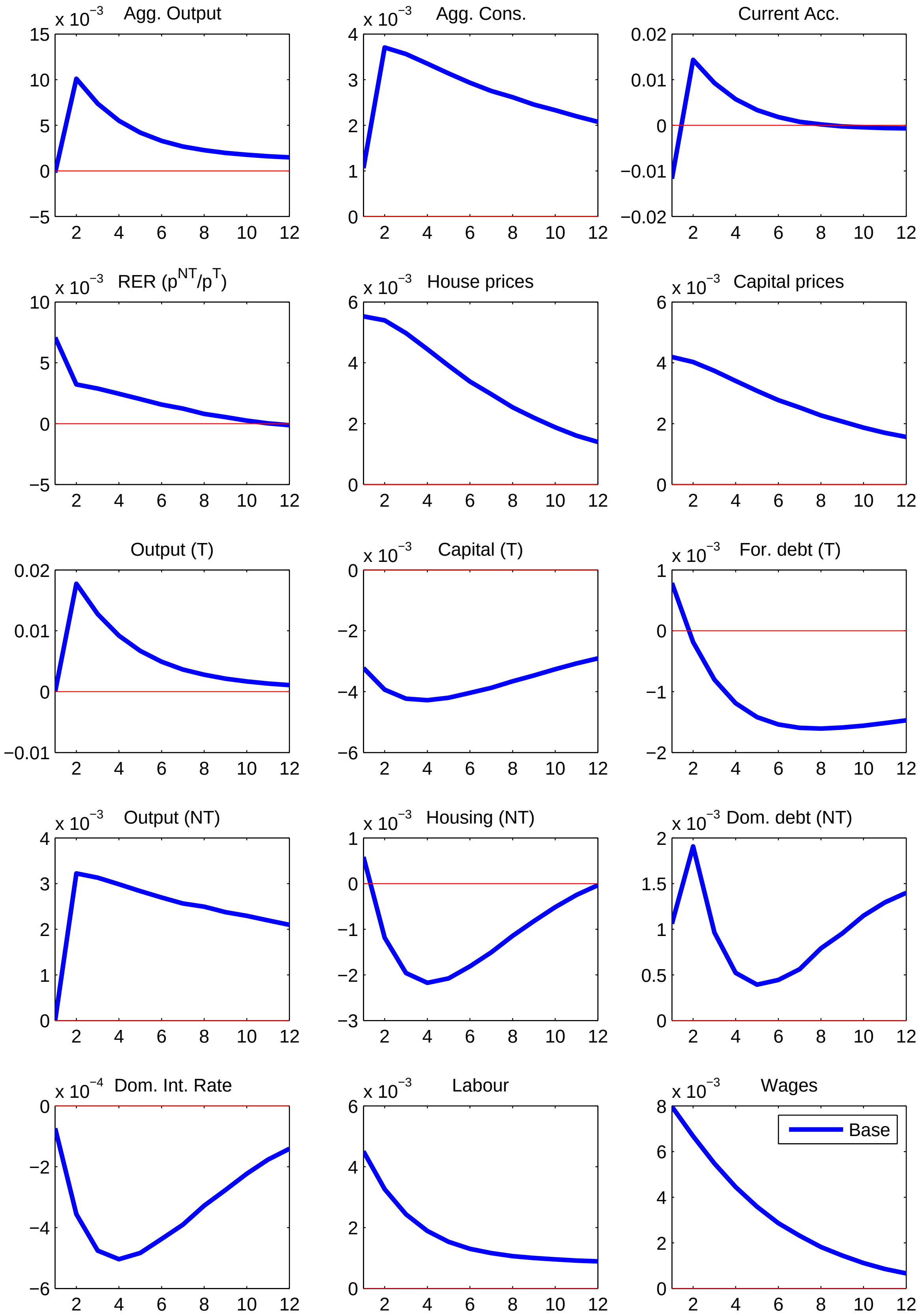

Figure 3: Tradable Productivity shock (I)

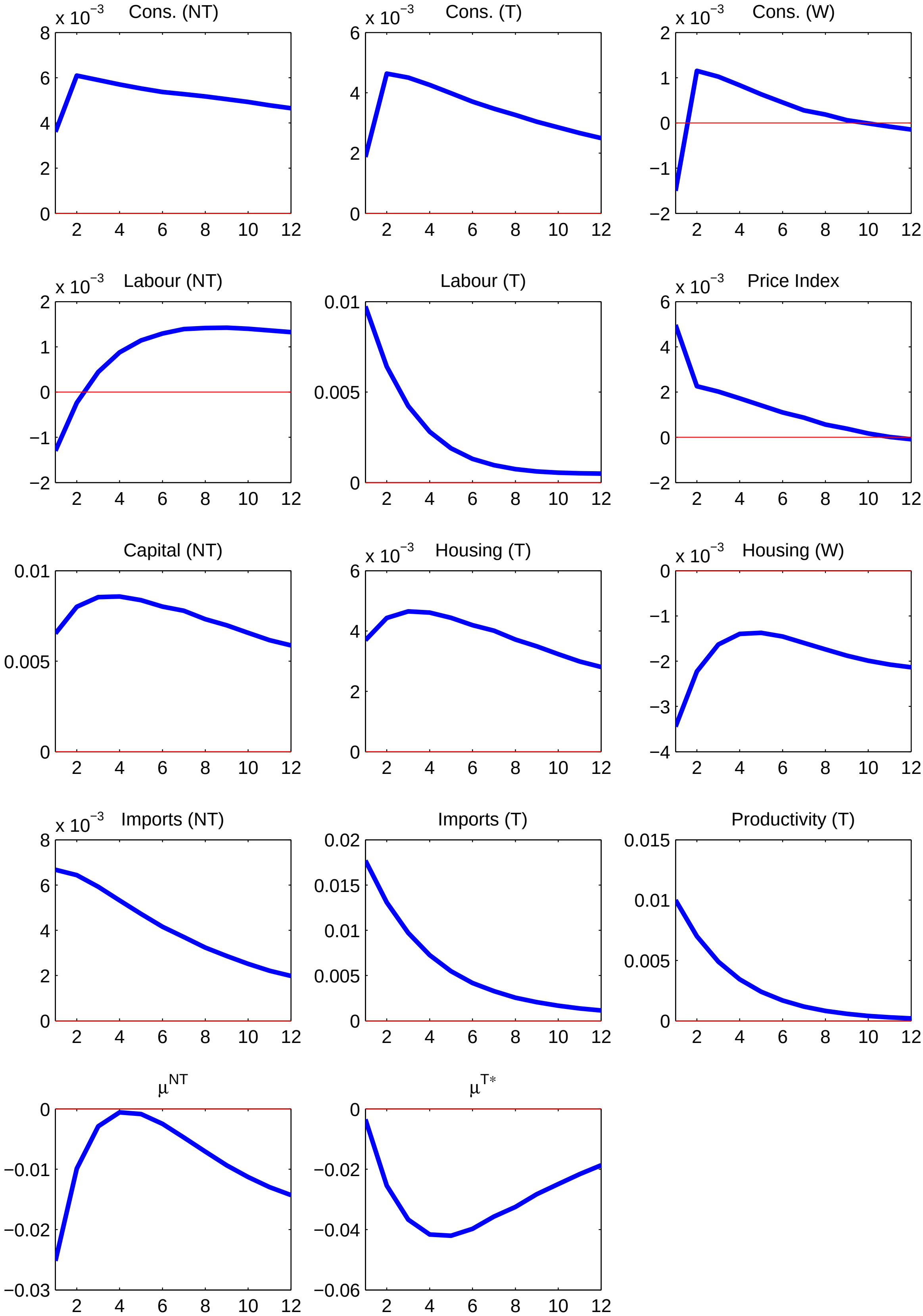

Figure 4: Tradable Productivity shock (II)

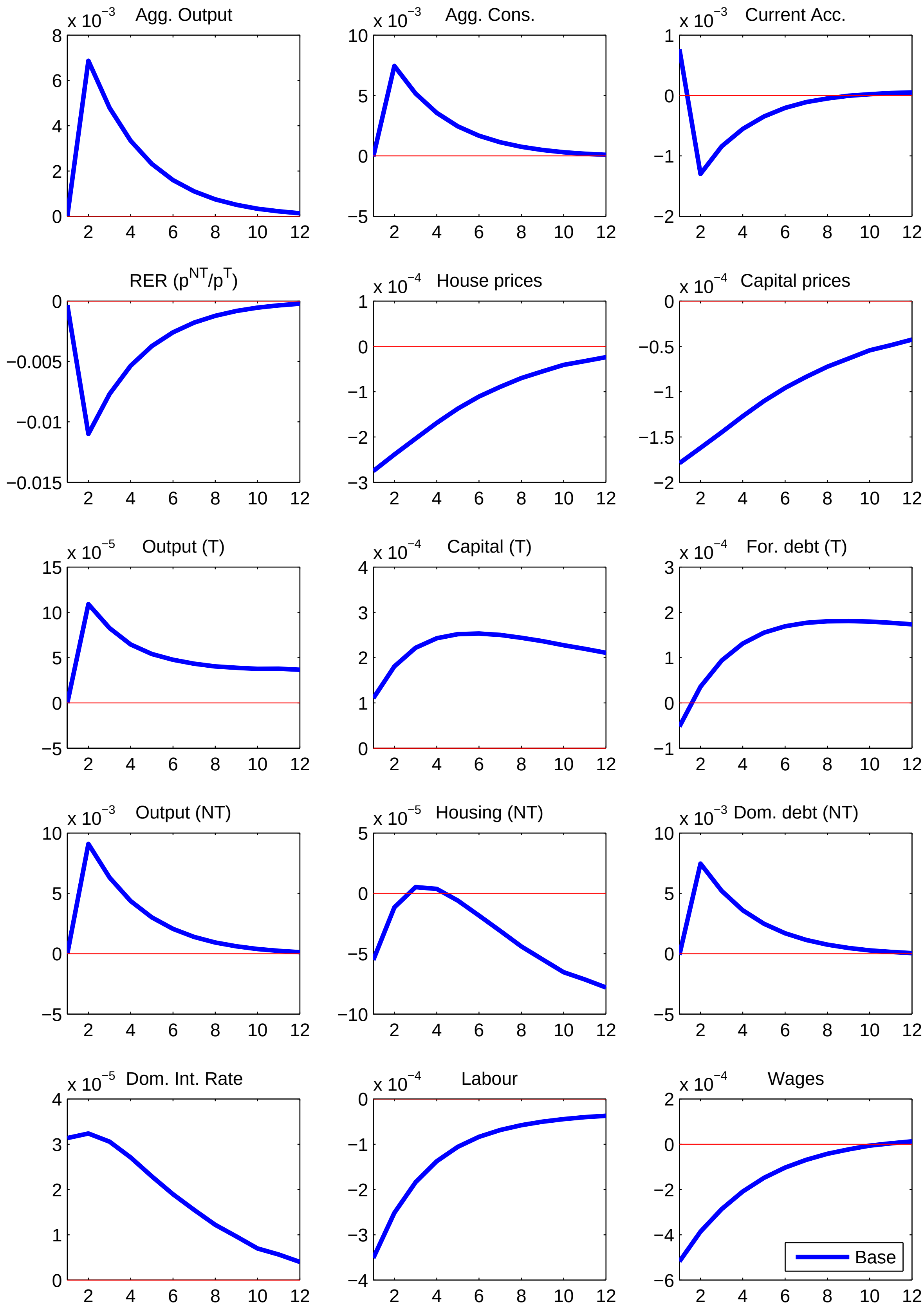

Figure 5: Non-tradable Productivity shock

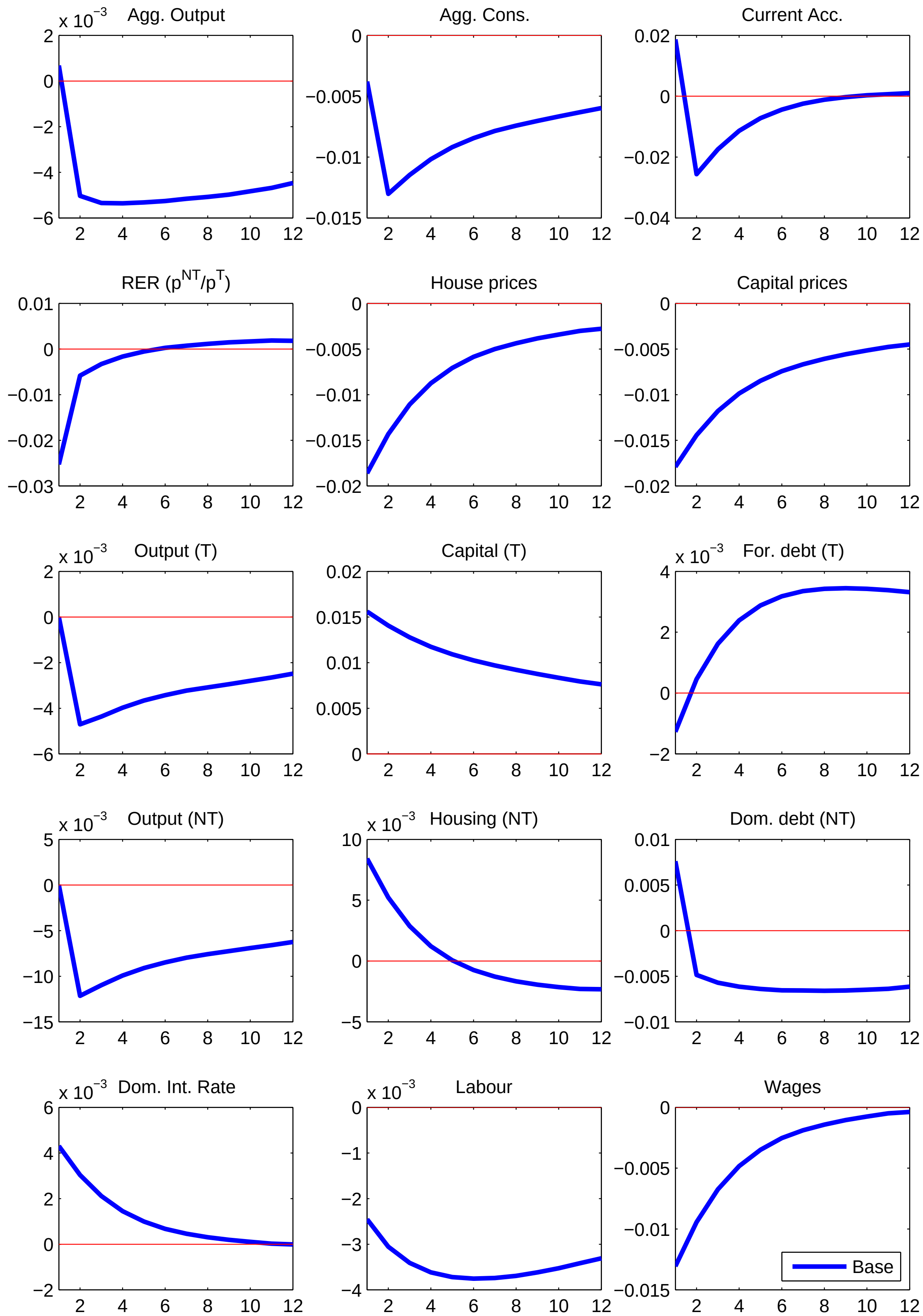

Figure 6: Foreign Interest Rate shock

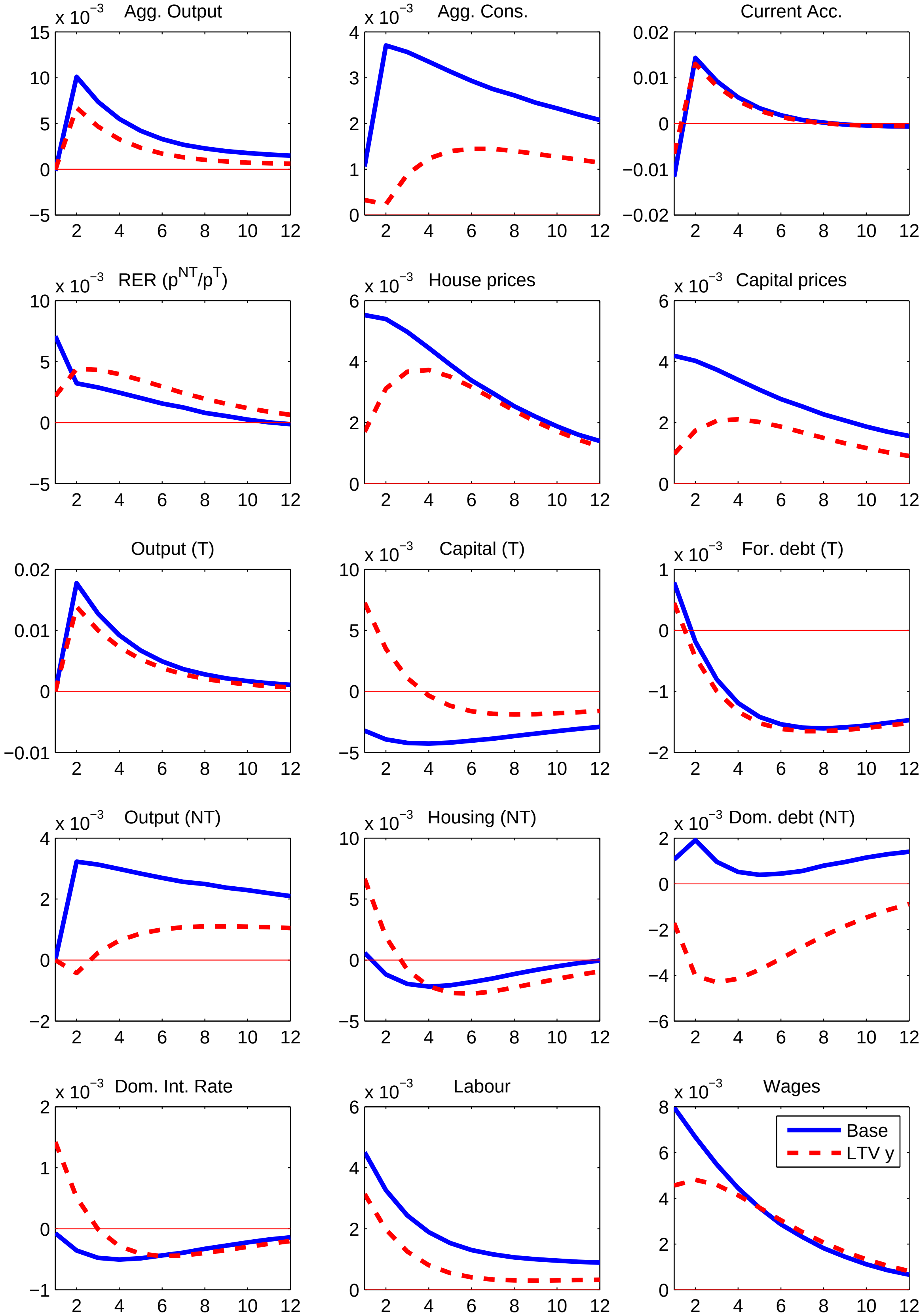

Figure 7: Countercyclical LTV: Tradable Productivity shock

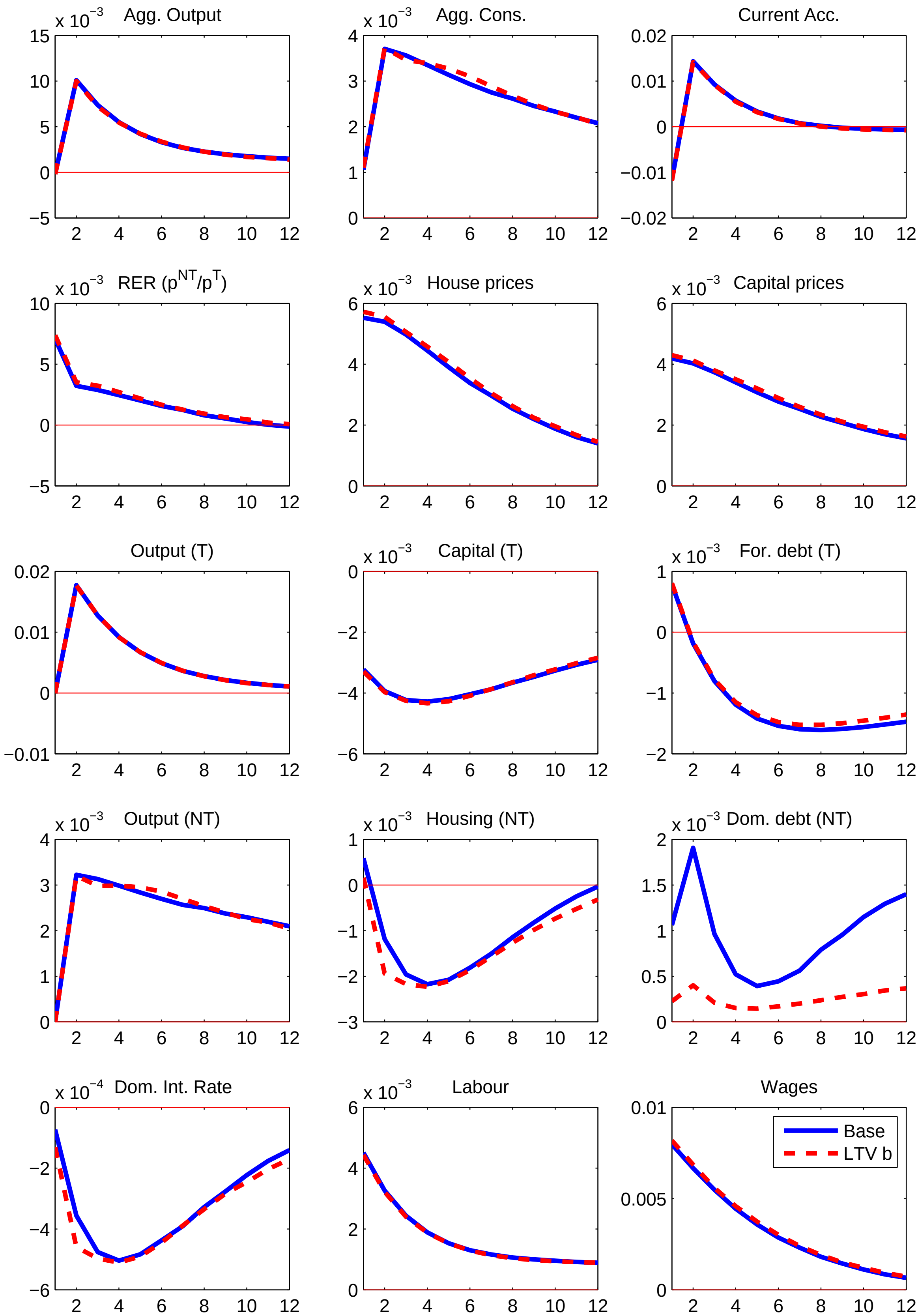

Figure 8: Non-tradable Debt LTV Rule: Tradable Productivity shock

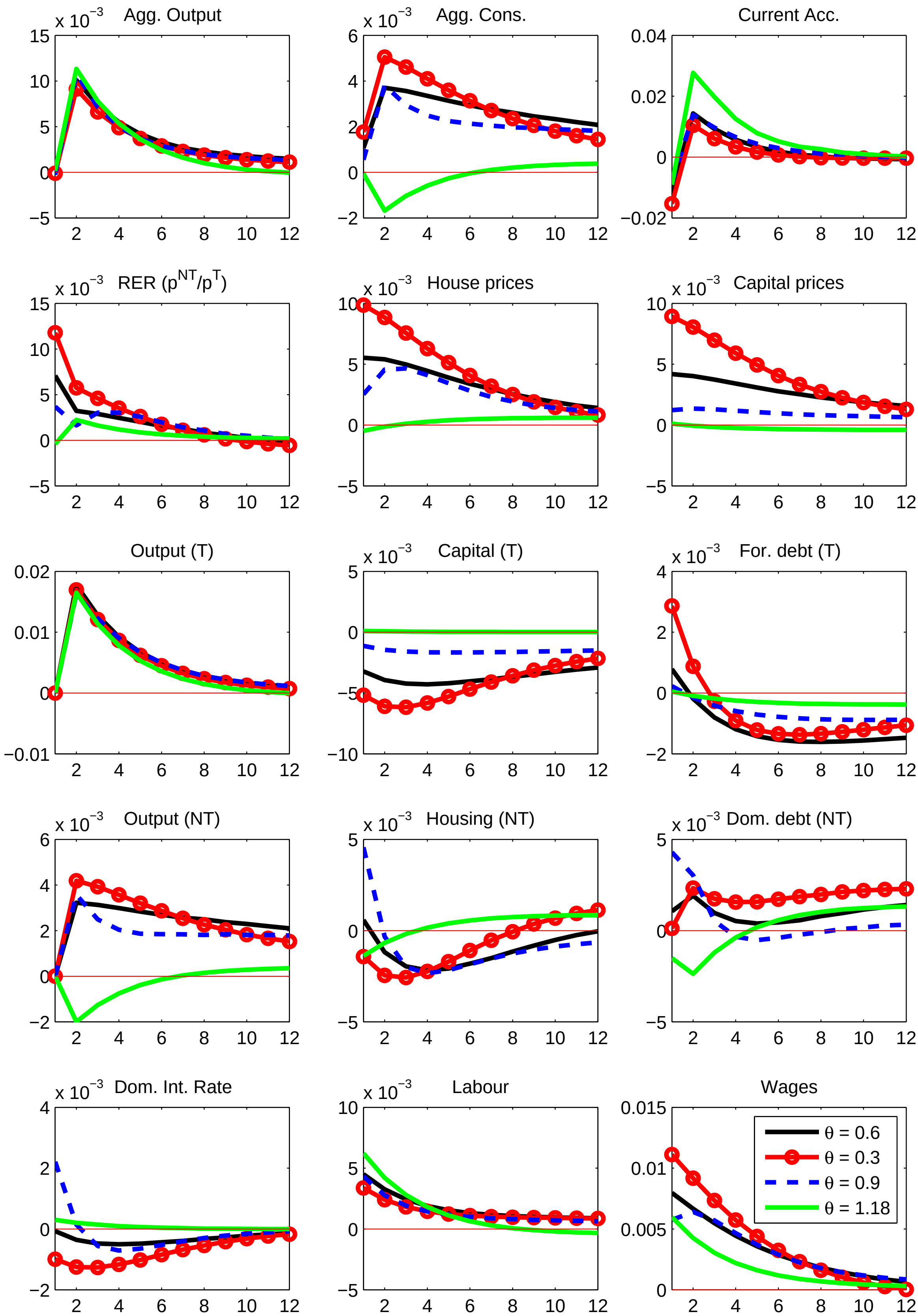

Figure 9: Robustness: θ and the Tradable Productivity shock

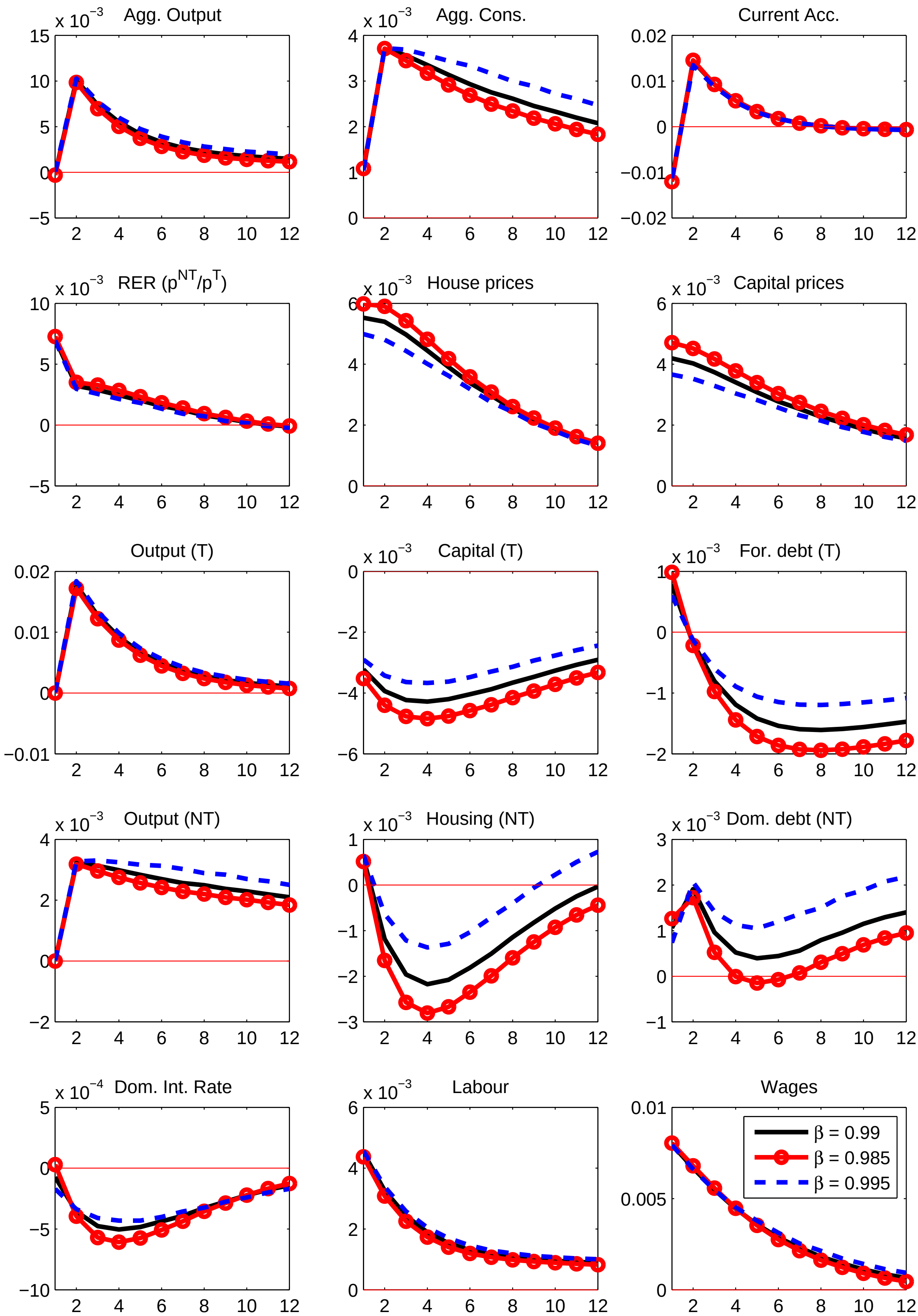

Figure 10: Robustness: β and the Tradable Productivity shock

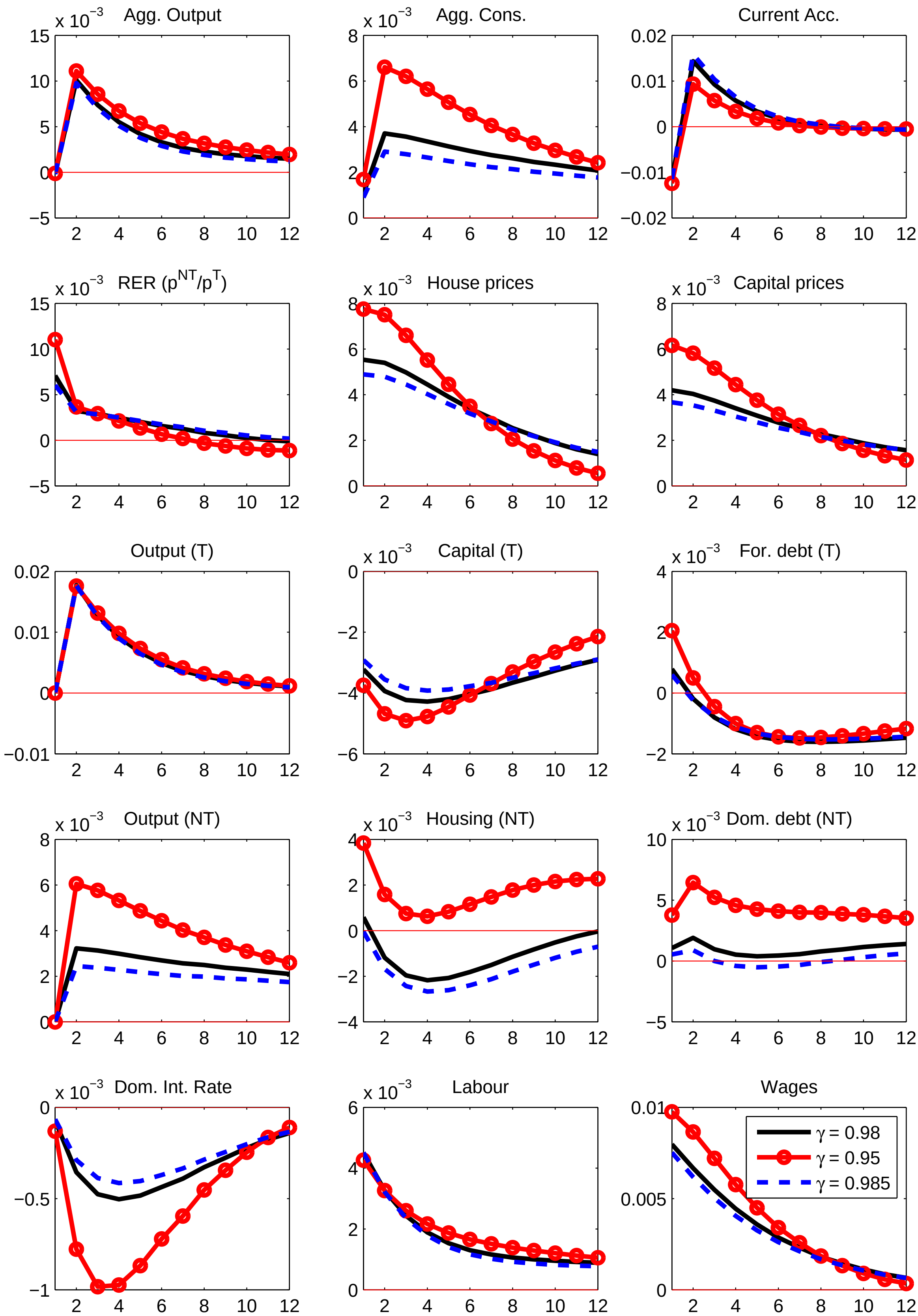

Figure 11: Robustness: γ and the Tradable Productivity shock

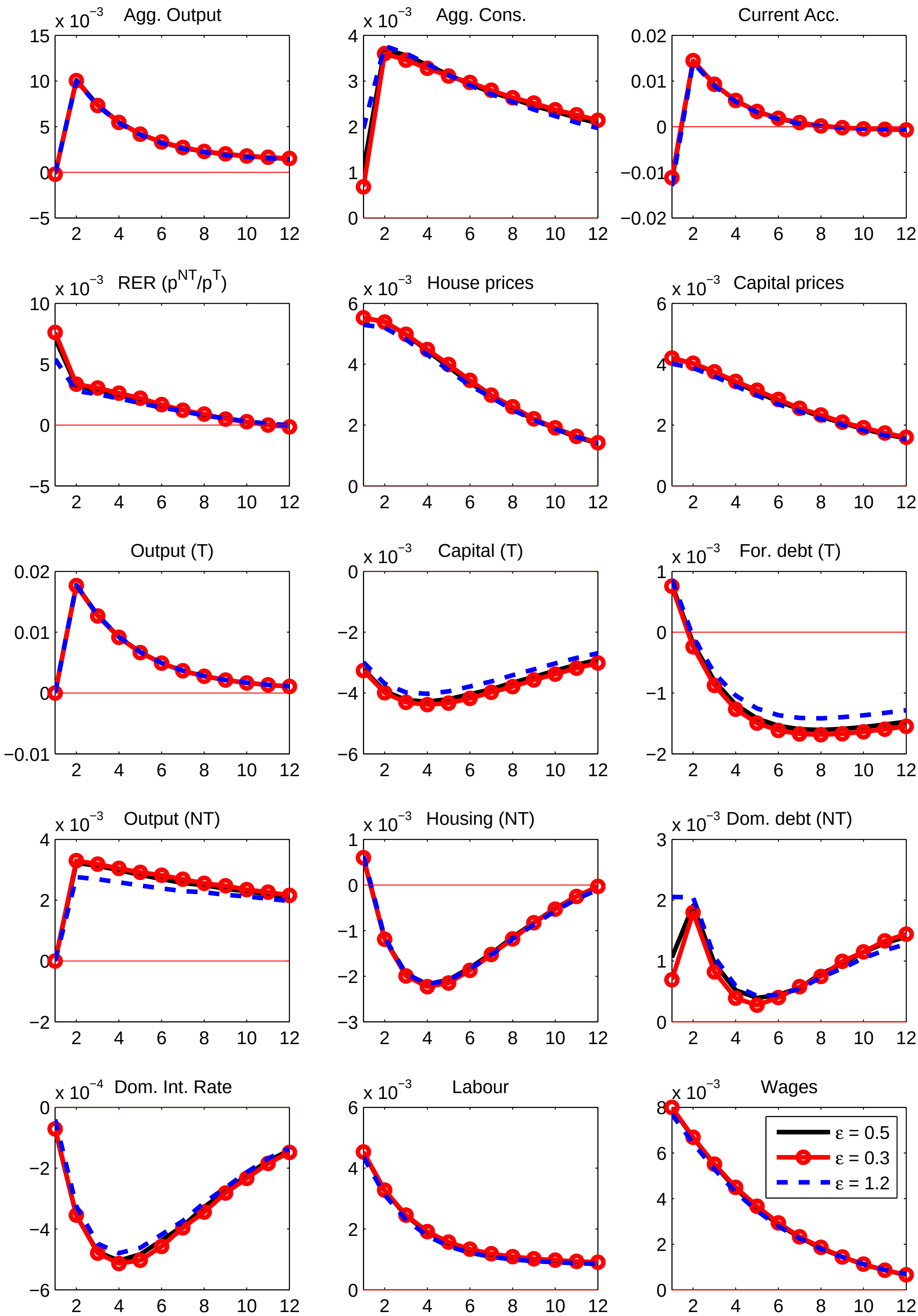

Figure 12: Robustness: ε and the Tradable Productivity shock