Limited Asset Market Participation and Capital Controls in a Small Open Economy *

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Abstract

This paper sets up a canonical new Keynesian small open economy model with limited asset market participation to financial markets. Households who cannot have access to financial markets have difficulty in adjusting their consumption profiles to the terms of trade change, resulting in unnecessary fluctuations of trade balance. The paper shows that there is room for government to improve welfare by controlling international capital movement to productivity shocks in a flexible price equilibrium with unitary elasticities of substitution, i.e. for the Cole-Obstfeld preference, contrasting with Fahri and Werning (2013). More restricted asset market participation and less persistent the transitory productivity shocks, more effective the transitory capital controls to stabilize trade balance and the economy. This result reflects the fact that the existence of limited asset market participation to financial markets entails the unnecessary fluctuations of the economy to exogenous shocks by aggravating the externality of the terms of trade. The paper also finds that optimal capital controls displays acyclical for a moderate degree of limited asset market participation. Moreover, the domestic price stability is not optimal monetary policy in open economy with limited asset market participation, contrasting to the result of Bilbiie (2008) in a closed economy where the price stability is optimal monetary policy. Finally, it shows that the optimal capital control tax leans against the wind. Moreover, the difference between welfare associated with optimal capital control and welfare associated without monetary policy increases with the degree of asset market participations.

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1 Introduction

Conventional wisdom in international finance that capital controls are undesirable because they hinder the long-run growth by distorting the efficient resource allocation has been challenged by recent episodes with free capital mobility that ended in sudden stops followed by severe financial or exchange rate crises. Both economists and policy makers have understood that both advanced and emerging economies can be adversely affected by volatile capital flows, which have been blamed for booms and busts. They think that capital control is an appropriate macroeconomic instrument to stabilize the economy and manage the exchange rate. Capital control can reallocate spending over time by manipulating the terms of trade: it can lower the country's export prices in some periods and raises them in other times to improve the welfare. The question of how government should react to fluctuations in international capital movement as well as international relative prices is at the heart of the policy debate in open macroeconomics.

Two theoretical approaches to address the desirability of countercyclical capital control taxation are noteworthy. First, authors such as Bianchi (2010), Bianchi and Mendoza (2010), Korinek (2010), and Lorenzoni (2008) emphasize the desirability of capital controls in promoting the financial stability. They emphasize pecuniary externalities that work through prices in collateral constraints. They provide a rationale for prudential policies to prevent excessive borrowing. However, these papers are based on real, not nominal economy, making impossible to address the role of exchange rate regime in capital controls. The second approach which is the basis of the present paper endorses the capital controls in improving macroeconomic stability in economies with nominal rigidities. For example, Farhi and Werning (2012) and Schmitt-Grohé and Uribe (2015) base their analysis on the so-called new Keynesian models. Farhi and Werning (2012) extend Galí and Monacelli (2005)'s canonical new Keynesian framework by incorporating incomplete market, while Schmitt-Grohé and Uribe (2015) also analyze the optimal capital controls emphasizing nominal wage rigidities in a small open economy. Farhi and Werning (2012) show that there is a case for capital control to stabilize the economy and to regain monetary autonomy in a fixed exchange rate regime. Farhi and Werning (2013) go one step further to show that capital controls can be desirable in a flexible exchange rate regime, contrasting to the Mundellian view.

There is an extensive empirical literature showing that consumption tracks current income for a large fraction of US population. Using aggregate data, for example, Campbell and Mankiw (1989) found that 40-50 % of the US population merely consumed their current income. Many studies using asset holdings data also show that a small fraction of the US population holds assets. No exception in the European countries. In light of these empirical findings, monetary policy implications in the dynamic stochastic general equilibrium (hereafter DSGE) models embedded with non-asset holders who cannot have access to the financial markets warrant a closer look.

This paper extends the existing literature on optimal capital controls in a small economy framework with nominal rigidities by incorporating limited asset market participation (LAMP hereafter) into otherwise a standard model. Along the line of Campbell and Mankiw (1989), Gali, Lopez-Salido and Valles (2004 hereafter Gali et al.), Bilbiie (2008), and Bilbiie and Straub (2013), we assume that a fraction of households, called the non-asset holders have zero assets and just consume their current disposable income, while other fraction of households have all assets to smooth their consumption profile.

In this paper, we address the role of capital controls in a new Keynesian small open economy with LAMP. In particular, we investigate the following questions. First, is there room for the government to implement capital control policies to improve the welfare of the domestic resident in the Cole-Obstfeld case, i.e. in the unitary inter- and intra-temporal elasticity of substitution case when the economy is hit by domestic and foreign productivity shocks? If so, what sort of forces are behind the effectiveness of capital controls? Second, we discuss the properties of optimal capital controls and the welfare gain from the optimal capital controls in a small open economy with LAMP. Finally, we discuss whether price stability is optimal in the presence of LAMP in otherwise a canonical new Keynesian model with productivity shocks only.

Since the net export is exactly balanced in the flexible price equilibrium with a Cole-Obstfeld preference and productivity shocks only, and monetary policy is independent under a flexible exchange rate regime, any theoretical basis for the capital controls does not exist in international finance at first glance. The presence of non-asset holders (or the rule of thumb households) who cannot have access to the financial markets generates a wedge between production and expenditures in the Cole-Obstfeld case because they must spend all of their current income to purchase current consumption goods, generating unnecessary capital movements to the international relative price change. Hence, in the presence of LAMP, there is room for government to intervene in the international capital movements to improve the welfare by stabilizing these economic fluctuations with capital controls.

The main findings of this paper can be summarized as follows.

Firstly, we show that there is room for government to improve welfare in the flexible price equilibrium with the presence of LAMP and the Cole-Obstfeld preference (i.e. a unitary intertemporal and intratemporal elasticity of substitution) and efficient productivity shocks by controlling international capital movement. This result complements Farhi and Werning (2013) who find no room for capital controls in flexible exchange rate regime with the Cole-Obstfeld preference and productivity shocks, but without LAMP. The existence of LAMP entails the unnecessary fluctuations of the economy even to technology shocks by preventing the non-asset holders from smoothing their consumption profiles to the international relative price changes induced by the macroeconomic shocks. Hence, the capital controls to smooth out capital flows can dampen down the unnecessary swings of the economy by alleviating the terms of trade externality compounded with LAMP.

Secondly, the optimal capital control tax rate moves acyclically over business cycles in the sticky price model with moderate degree of limited asset market participations for the Cole-Obstfeld preferences, while it moves countercyclically[1] over business cycles in the flexible price equilibrium. Government should mitigate the business cycles and international capital movements by leaning against the wind with optimal capital controls to the risk premium shocks.

Thirdly, the difference between the welfare associated with optimal capital control and the welfare without any capital control increases as the technology shock is more transitory and the asset market participation is more restricted. If the technology shock is permanent, then there is no role for capital controls to reallocate demand over time by manipulating the terms of

[1] While theoretical papers show that countercyclical capital control taxes are desirable, Fernández et al. (2015) presents that the acutual capital control taxes based on data set covering 91 countries are acyclical, and the unconditional standard deviation of capital control taxation is very small.

trade. The difference between the welfare associated with the optimal capital controls and the welfare associated with no capital control also increases with the fraction of the non-asset holders in the economy.

Finally, the domestic price stability is not optimal monetary policy, even if the fiscal authority implements an optimal capital control to dampen down the volatile capital movement across the border and the terms of trade fluctuations. Monetary authority should deviate from price stability to improve the welfare in a small open economy with Cole-Obstfeld preference with LAMP and productivity shocks only.

The remainder of the paper is organized as follows. Section 2 presents a canonical small open economy model with LAMP and nominal price rigidities and discusses equilibrium conditions. Section 3 addresses the Ramsey (constrained-efficient) optimal capital control and monetary policy in a small open economy, respectively. Section 4 presents a numerical analysis of the optimal capital controls and Section 5 concludes.

2 The Model

This section sets up a variant of new Keynesian model with LAMP persistence applied to an open-economy. The world is composed of two countries, home (H) and foreign (F) with population size n and $1-n$ respectively. In this paper, the small open economy is characterized as a limiting-case approach as in Faia and Monacelli (2008) and Galí and Monacelli (2005). It is assumed that the relative size of domestic economy is negligible relative to the rest of the world, i.e. $n \longrightarrow 0$.

2.1 Households

2.1.1 Asset Holders

Households who can have access to asset market, called asset holding households choose their consumption, asset holdings, and labor supply maximizes its expected lifetime utility function ($\mathcal{W}_{A_t}$) subject to sequence of budget constraints:

$$\mathcal{W}_{A_t} \equiv E_t \left[\sum_{k=0}^{\infty} \beta^k u(C_{A,t+k}, N_{A,t+k}) \right], \; 0 < \beta < 1, \tag{1}$$

where $u(C_{A,t+k}, N_{A,t+k}) = \frac{C_{A,t+k}^{1-\sigma}-1}{1-\sigma} - \frac{N_{A,t+k}^{1+\nu}}{1+\nu}$ for $\sigma \neq 1$, and $u(C_{A,t+k}, N_{A,t+k}) = \ln(C_{A,t+k}) - \frac{N_{A,t+k}^{1+\nu}}{1+\nu}$ for $\sigma = 1$. β is the household's discount factor, and E_t denotes the mathematical expectation operator over all possible states of nature on history x^t.[2] $C_{A,t+k}$, $N_{A,t+k}$ represent the asset holding household's consumption and working hours in period $t+k$, respectively. $C_{A,t}$ is a composite consumption index defined by

$$C_{A,t} = \begin{cases} [\theta^{\frac{1}{\eta}} C_{A_{H},t}{}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} C_{A_{F},t}{}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}, & \text{if } \eta > 0,\ \eta \neq 1 \\ C_{A_{H},t}^{\theta} C_{A_{F},t}^{1-\theta} & \text{if } \eta = 1 \end{cases} . \quad (2)$$

Here $C_{A_{H},t}$ and $C_{A_{F},t}$ are indices of domestic and foreign consumption goods consumed by domestic asset holding households, and θ and $1-\theta$ represent the share of domestic consumption allocated to domestic goods, and imported goods. The indices are given by the following CES aggregator of the quantities consumed of each variety of good:

$$C_{A_{H},t} = [\int_0^1 C_{A_{H},t}(j)^{\frac{\epsilon-1}{\epsilon}} dj]^{\frac{\epsilon}{\epsilon-1}}, \quad C_{F,t} = [\int_0^1 C_{Ft}(j)^{\frac{\epsilon-1}{\epsilon}} dj]^{\frac{\epsilon}{\epsilon-1}}, \quad \epsilon > 1. \quad (3)$$

Here η and ϵ measure the elasticity of substitution between domestic and foreign goods, and the elasticity of substitution among goods within each category.

Assume that only Ricardian households have access to the asset market. There is a domestic currency-denominated bond market. It is assumed that domestic households can trade only one-period nominal riskless bonds denominated in home and foreign currency, while foreign households trade one-period nominal riskless bonds denominated in foreign currency. It is also assumed that the international trade of foreign currency denominated bonds are subject to intermediation costs as in Benigno (2008) and Turnovsky (1985).[3] Then the domestic asset holding household's budget constraint can be written as

[2] Here $x^t = \{x_0, ...x_t\}$ denotes the history of events up to period t.

[3] This intermediation cost assumption is made for technical reasons. See Schmitt-Grohé and Uribe (2001) for alternative assumptions to overcome the stationary problem in a small open economy model.

$$P_tC_{A,t} + B_{A,t} + \mathcal{E}_tB_{F,t} + S_{t+1}Q_{E,t} \leq R_{t-1}B_{A,t-1} + W_t(1-\tau_{A,t})N_{A,t} + (Q_{E,t} + P_tD_t)S_t + TR_{A,t} + \mathcal{E}_t\Psi_{t-1}R^*_{t-1}(1+\tau_{B,t-1})\Xi(\frac{\mathcal{E}_{t-1}B_{F,t-1}}{P_{t-1}})B_{F,t-1} \quad (4)$$

Here S_t, D_t, and $Q_{E,t}$ are domestic share holdings, dividends, and market value of domestic shares at time t, respectively. $B_{A,t}$ and $B_{F,t}$ denote domestic and foreign currency denominated nominal bonds, while R_t and R^*_t are the interest rate corresponding to the bonds, respectively. W_t, $TR_{A,t}$,and $\tau_{A,t}$ denote nominal wages, government lump-sum tax/ transfers given to the domestic household, the tax rate on labor income in period t. Capital controls are modeled as follows: $\tau_{B,t}$ is a subsidy on capital outflows and a tax on capital inflows in the domestic economy. We assume that the rest of the world does not impose capital controls. Ψ_t is the risk premium shock at time t. We assume that the risk premium shock follows an $AR(1)$ process as $\ln\Psi_t = \rho_\psi \ln\Psi_{t-1} + \xi_{\Psi,t}, \quad -1 < \rho_\psi < 1$, where $E(\xi_{\Psi,t}) = 0$ and $\xi_{\Psi,t}$ is i.i.d. over time.

The function $\Xi(\frac{\mathcal{E}_tB_{F,t}}{P_t})$ incorporates the cost or the risk premium from international borrowings. The risk premium or $\Xi(\frac{\mathcal{E}_tB_{F,t}}{P_t}) - 1$ is increasing with the country's foreign debt, i.e. $\Xi^{'}(.) < 0$, and it is equals to zero when the economy is in the steady state, i.e. $\Xi(\mathcal{B}_F) = 1$ in the steady state where $\mathcal{B}_{F,t} \equiv \frac{\mathcal{E}_tB_{F,t}}{P_t}$.

$$C^{-\sigma}_{A,t} = \beta R_tE_t[C^{-\sigma}_{A,t+1}\frac{P_t}{P_{t+1}}], \quad (5)$$

$$C^{-\sigma}_{A,t} = \beta R^*_t(1+\tau_{B,t})\Psi_t\Xi(\mathcal{B}_{F,t})E_t[C^{-\sigma}_{A,t+1}\frac{\mathcal{E}_{t+1}P_t}{\mathcal{E}_tP_{t+1}}], \quad (6)$$

$$Q_{E,t} = \beta R_tE_t[Q_{E,t+1} + P_tD_t] \quad (7)$$

$$N^{\nu}_{A,t} = (1-\tau_{A,t})w_tC^{-\sigma}_{A,t}, \quad (8)$$

where w_t is the real wage in period t.

Similarly, the foreign household's intertemporal decision of bond holdings is given by

$$C^{*-\sigma}_t = \beta R^*_tE_t[C^{*-\sigma}_{t+1}\frac{P^*_t}{P^*_{t+1}}]. \quad (9)$$

(6) and (9) imply that the equilibrium nominal exchange rate is determined by

$$E_t[\left[\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma}\frac{P^*_t}{P^*_{t+1}}\right]] = \Xi(\mathcal{B}_{F,t})\Psi_t(1+\tau_{B,t})E_t\left[\left(\frac{C_{A,t+1}}{C_{A,t}}\right)^{-\sigma}\frac{\mathcal{E}_{t+1}P_t}{\mathcal{E}_t P_{t+1}}\right]. \quad (10)$$

2.1.2 Non-Asset Holders

The non-asset holding households who cannot have access to the financial market just supply labor $N_{R,t}$ and consumes their whole wage income determined in each period:

$$P_t C_{R,t} = (1-\tau_{R,t})W_t N_{R,t} + TR_{R,t}, \quad (11)$$

where $\tau_{R,t}$ is the tax rate on labor income and $TR_{R,t}$ is the lump-sum tax or transfer to the non-asset holding households' in period t.

Non-asset holders who cannot have access to asset market choose their consumption and labor supply maximizes its expected lifetime utility function ($\mathcal{W}_{R_t}$) subject to sequence of budget constraint (11):

$$\mathcal{W}_{R_t} \equiv E_t\left[\sum_{i=0}^{\infty}\beta^i u(C_{R,t+k}, N_{R,t+k})\right], \ 0<\beta<1, \quad (12)$$

where $u(C_{R,t+k}, N_{R,t+k}) = \frac{C^{1-\sigma}_{R,t+k}-1}{1-\sigma} - \frac{N^{1+\nu}_{R,t+k}}{1+\nu}$ for $\sigma \neq 1$, and $u(C_{R,t+k}, N_{R,t+k}) = \ln(C_{R,t+k}) - \frac{N^{1+\nu}_{R,t+k}}{1+\nu}$ for $\sigma = 1$.

Rule-of thumb household's optimization conditions are given by

$$C^{\sigma}_{R,t}N^{\nu}_{R,t} = (1-\tau_{R,t})w_t, \quad (13)$$

and the budget constraint (11).

2.2 Aggregation

The aggregate level of any household-specific variable X_t is given by $X_t \equiv \int_0^1 X_t(j)dj = (1-\gamma)X_{A,t} + \gamma X_{R,t}$. Hence, aggregate consumption and aggregate hours are given by

$$C_t = (1-\gamma)C_{A,t} + \gamma C_{R,t} \tag{14}$$

and

$$N_t = (1-\gamma)N_{A,t} + \gamma N_{R,t}. \tag{15}$$

Finally, aggregate lump-sum taxes or transfers are also given by

$$T_t = \gamma T_{A,t} + (1-\gamma)T_{R,t}. \tag{16}$$

2.3 Domestic Firms

Differentiated goods and monopolistic competition are introduced along the lines of Dixit and Stiglitz (1977). Suppose that there is a continuum of firms producing differentiated goods, and each firm indexed by i, $0 \leq i \leq 1$, produces its product with a linear technology $Y_t(i) = Z_t N_t(i) - \mathbf{F}$, where Z_t is a technology process in home country at period t, and $Y_t(i)$, $N_t(i)$, and $\mathbf{F}$ are output, total labor input of the ith firm, and fixed cost, respectively. We assume that the productivity shock follows an $AR(1)$ process as $\ln Z_t = (1-\rho_Z)\ln Z + \rho_Z \ln Z_{t-1} + \xi_{A,t}, \quad 0 < \rho_Z < 1$, where $E(\xi_{Z,t}) = 0$ and $\xi_{Z,t}$ is i.i.d. over time.

Since the input markets are perfectly competitive, the firm $j^{'}$s demand for labor is determined by its cost minimization as follows:

$$w_t = \text{mc}_t Z_t \frac{P_{H,t}}{P_t}, \tag{17}$$

where $\text{mc}_t \equiv \frac{MC_t}{P_{H,t}}$ is a domestic firm's markup in period t.

Real profits of firm i are given by

$$D_t(i) = \begin{cases} \frac{P_{H,t}(i)}{P_{H,t}} Y_t(i) - \frac{W_t}{P_{H,t}} N_t(i) & \text{if } Z_t N_t(i) > \overline{\mathbf{F}} \\ 0 & \text{if } Z_t N_t(i) \leq \overline{\mathbf{F}} \end{cases}.$$

Next, the CPI-DPI ratio $\frac{P_t}{P_{H,t}}$ can be expressed in terms of the terms of trade $\mathcal{T}_t \equiv \frac{P_{F,t}}{P_{H,t}}$ as follows:

$$\frac{P_t}{P_{H,t}} = [(1-\theta) + \theta \mathcal{T}_t^{1-\eta}]^{\frac{1}{1-\eta}} \equiv \mathcal{K}(\mathcal{T}_t) \tag{18}$$

or

$$\frac{1+\pi_t}{1+\pi_{H,t}} = \frac{\mathcal{K}(\mathcal{T}_t)}{\mathcal{K}(\mathcal{T}_{t-1})} \ , \tag{19}$$

where $\pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}} - 1$ and $\pi_t \equiv \frac{P_t}{P_{t-1}} - 1$ represent the domestic price index inflation rate and the consumer price index inflation rate at time t, respectively.

Hence, the labor market equilibrium condition can be rewritten in terms of the terms of trade

$$\frac{N_{i,t}^{\nu}}{MU_{C_i,t}} = \mathrm{mc}_t(1-\tau_{it})Z_t\mathcal{K}(\mathcal{T}_t), \tag{20}$$

for $i = A$ and R. The real exchange rate is also linked to the terms of trade through the following expression:

$$\mathcal{E}_t \equiv \frac{\mathcal{S}_t P_t^*}{P_t} = \mathcal{T}_t[(1-\theta)+\theta\mathcal{T}_t^{1-\eta}]^{\frac{1}{\eta-1}} \equiv \mathcal{H}(\mathcal{T}_t). \tag{21}$$

Aggregate real profits, $D_t = Y_t - Z_t\mathrm{mc}_t N_t$, are distributed to asset holders as dividend every period.

Next, consider a staggered-price model a la Calvo (1983) and Yun (1996). Each firm resets its optimal price $\widetilde{P}_{H,t}(j)$ with probability $(1-\alpha)$ in any given period, independent of the time elapsed since the last adjustment firms sets the new price. Other fraction of firms, α, sets its current price at its previous price level. The firm j's problem that maximizes the current market value of the profits generated while that price remains effective can be written as follows.

$$\max_{\widetilde{P}_{Ht}(j)} \ E_t\{\sum_{k=0}^{\infty}\alpha^k Q_{t,t+k}\left(\frac{P_t}{P_{t+k}}\right)[\widetilde{P}_{H,t}(j)Y_{Ht,t+k}(j) - MC_{t+k}Y_{Ht,t+k}(j)]\}, \tag{22}$$

subject to the sequence of demand constraints

$$Y_{Ht,t+k}(j) \leq \left(\frac{\widetilde{P}_{H,t}(j)}{P_{H,t+k}}\right)^{-\epsilon} Y_{H,t+k},$$

where $Q_{t,t+k} \equiv \beta^k \frac{U_C(C_{A,t})}{U_C(C_{A,t+k})}$, $\widetilde{P}_{H,t+k}(j) = \widetilde{P}_{H,t}(j)$ with a probability α^k and $k = 0, 1, 2...\infty$.

The optimal price setting equation can be expressed as a recursive form as in Schmitt-Grohé and Uribe (2004) and Yun (2005):

$$\frac{\epsilon}{\epsilon-1}\mathcal{X}_t = \mathcal{Y}_t, \tag{23}$$

where

$$\mathcal{X}_t = \widetilde{p}_{H,t}^{-1-\epsilon}\frac{Z_t N_t}{\Delta_{H,t}}\text{mc}_t + \alpha E_t[(1+\pi_{H,t+1})^{1+\epsilon}(1+\pi_{t+1})^{-1}Q_{t,t+1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-1-\epsilon}\mathcal{X}_{t+1}], \tag{24}$$

$$\mathcal{Y}_t = \widetilde{p}_{H,t}^{-\epsilon}\frac{Z_t N_t}{\Delta_{H,t}} + \alpha E_t[Q_{t,t+1}(1+\pi_{H,t+1})^{\epsilon}(1+\pi_{t+1})^{-1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-\epsilon}\mathcal{Y}_{t+1}]. \tag{25}$$

Here $\widetilde{p}_{H,t} \equiv \frac{\widetilde{P}_{H,t}}{P_{H,t}}$ is the relative price of any domestic good whose price was adjusted in period t. (23) is a short-run nonlinear aggregate supply relation between inflation and output, given expectations regarding future inflation, output and disturbances. The domestic price aggregator implies that the relative price $\widetilde{p}_{H,t}$ satisfies the relationship:

$$1 = (1-\alpha)\widetilde{p}_{H,t}^{1-\epsilon} + \alpha(1+\pi_{H,t})^{\epsilon-1}. \tag{26}$$

2.4 Importing Firms

To focus the effect of LAMP on the role of capital controls, we consider only the case of a perfect exchange rate pass-through, a case in which foreign companies do not have any role in setting price as in Galí and Monacelli (2005) and De Paoli (2009, 2010).

Assume that the Law of One Price holds, such that the price of foreign good j in domestic currency, $P_{F,t}(j)$, equals its price denominated in foreign currency, $P^*_{F,t}(j)$, multiplied by the nominal exchange rate, $\mathcal{S}_t$:

$$P_{F,t}(j) = \mathcal{S}_t P^*_{F,t}(j). \tag{27}$$

In the rest of the world, a representative household faces a problem identical to the one outlined above. The only difference is that a negligible weight is assigned to consumption goods produced in a small economy ($\theta^* = 1$). Therefore, $P^*_t = P^*_{Ft}$ and $C^*_t = C^*_{Ft}$ for all t.

2.5 Government

In this paper, we consider Ramsey optimal monetary policy rules and the government who can consume a fraction of the final good faces the following budget constraint:

$$P_{H,t}(G_t + (1-\gamma)T_{A,t} + \gamma T_{R,t}) = (1-\gamma)\tau_{A,t}N_{A,t}W_t + \gamma\tau_{R,t}N_{R,t}W_t.$$

2.6 Equilibrium

Aggregating individual output across firms, one finds a wedge between the aggregate output Y_t and aggregate labor hours N_t

$$Y_t = \frac{Z_t N_t}{\Delta_{H,t}} - \mathbf{F}, \tag{28}$$

where $\Delta_{H,t} = \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\epsilon} dj$ is the relative price dispersion in period t. The relative price distortion $\Delta_{H,t}$ that results from the firms' staggered price setting practice in the Calvo-type model can be rewritten as a recursive form:

$$\Delta_{H,t} = (1-\alpha)\widetilde{p}_{H,t}^{-\epsilon} + \alpha(1+\pi_{H,t})^{\epsilon}\Delta_{H,t-1}, \tag{29}$$

with $\Delta_{H,-1}$ given. Also (19) can be rewritten in terms of the CPI inflation rate and DPI inflation rate:

$$\frac{1+\pi_t}{1+\pi_{H,t}} = \frac{\mathcal{K}(\mathcal{T}_t)}{\mathcal{K}(\mathcal{T}_{t-1})} \tag{30}$$

Assuming symmetric degree of home bias across countries with the negligible relative size of home country, goods market clearing in home and foreign countries requires that

$$Y_t = (1-\theta)\mathcal{K}(\mathcal{T}_t)^{\eta}((1-\gamma)C_{A,t} + \gamma C_{R,t}) + \theta\mathcal{T}_t^{\eta}C_t^*, \tag{31}$$

$$Y_t^* = C_t^*. \tag{32}$$

Also, the resource constraint relating production expenditures can be written as

$$((1-\gamma)C_{A,t}+\gamma C_{R,t})+\mathcal{B}_{F,t} \leq (1-\gamma)R^*_{t-1}\Psi_{t-1}\digamma(\mathcal{B}_{Ft-1})\mathcal{B}_{Ft-1}\frac{\mathcal{J}(\mathcal{T}_t)}{\mathcal{J}(\mathcal{T}_{t-1})}\frac{P^*_{t-1}}{P^*_t}+\mathcal{H}(\mathcal{T}_t)^{-1}(\frac{Z_tN_t}{\Delta_{H,t}}-\mathbf{F}). \tag{33}$$

Note that (28) and (31) can be simplified as

$$\frac{Z_tN_t}{\Delta_{H,t}} - \mathbf{F} = (1-\theta)\mathcal{K}(\mathcal{T}_t)^\eta((1-\gamma)C_{A,t}+\gamma C_{R,t}) + \theta\mathcal{T}_t^\eta C_t^*. \tag{34}$$

Domestic aggregate real profits can be written as

$$D_t = Y_t - \text{mc}_t Z_t \mathcal{K}(\mathcal{T}_t)N_t. \tag{35}$$

Net supply of bonds must satisfy

$$B_{F,t} + B^*_{F,t} = 0. \tag{36}$$

The competitive equilibrium conditions consist of the efficiency conditions and the budget constraint of the households and firms, and the market clearing conditions of each goods market, labor market, money, and bond market under each asset market regime. Then, the symmetric equilibrium is an allocation of $\{C_{A,t}, C_{R,t},\ C^*_t, N_{A,t}, N_{R,t}, N^*_t, Y_t, Y^*_t\}_{t=0}^\infty$, a sequence of prices and costate variables for the home and foreign country $\{P_{H,t}, P_{F,t}, P^*_{F,t}, P^*_{H,t}, P_t, P^*_t, B_{H,t}, B^*_t$, mc_t, $\text{mc}^*_t, \Delta_{H,t}, \Delta^*_{Ft}\}_{t=0}^\infty$ and a sequence of the real exchange rate $\{\mathcal{E}_t\}_{t=0}^\infty$ such that (1) the asset holding and non-asset holders decision rules solve their optimization problem given the states and the prices; (2) the demands for labor solves each firm's cost minimization problem and price setting rules solve its present value maximization problem given the states and the prices; (3) each goods market, labor market, and bond market are cleared at the corresponding prices, given the initial conditions for the state variables ($\Delta_{H,-1},\ \Delta^*_{F,-1}$), and the exogenous productivity shock processes $\{\ Z_t, Z^*_t\}_{t=0}^\infty$ as well as the monetary and fiscal policies $\{\tau_{B,t}, \tau^*_{B,t}, R_t, R^*_t\}_{t=0}^\infty$.

3 Optimal Capital Controls and Monetary Policy

In this section, we will first discuss the optimal capital controls and monetary policy in a benchmark model, i.e. the flexible price equilibrium, i.e. $\Delta_{H,t} =$

$\Delta_t^* = 1$, with Cole-Obstfeld preferences and productivity shocks under the assumption that the fiscal authority does not implement any tax to deal with distortions associated with monopolistic competition in goods market. Given distortions associated with monopoly power in goods market, the Ramsey planner who internalizes both the terms of trade externality and LAMP chooses optimal capital control tax and monetary policy prescriptions for $\{\tau_{B,t}, R_t\}_{t=0}^{\infty}$ as well as plans for $\{C_{A,t},\ N_{A,t}, C_{R,t},\ N_{R,t}, \mathcal{B}_{F,t},$
$\pi_{H,t},\ \mathsf{mc}_t, \pi_t, \mathcal{T}_t, \widetilde{p}_{H,t}, \mathcal{X}_t, \mathcal{Y}_t\}_{t=0}^{\infty}$ to maximize the weighted average of the asset holder and non-asset holders's welfare

$$\mathcal{W}_t \equiv (1-\gamma)\mathcal{W}_{A_t} + \gamma\mathcal{W}_{R_t} \tag{37}$$

subject to 13 equations of private sector optimization and market clearing conditions: (4), (10), (13), (20), (23), (24), (25), (26), (30), (31), (34), taking the exogenous technology and risk premium shock processes $\{Z_t,\ Z_t^*,\ \Psi_t\}_{t=0}^{\infty}$, and foreign variables as given.

Before turning to discussing the properties of optimal capital control and monetary policy in a small open economy with nominal price rigidities, we will look at the effect of LAMP in relation to the optimal capital controls in flexible price equilibrium with the Cole-Obstfeld preference as a benchmark.

3.1 Optimal Capital Control in the Cole-Obstfeld Preference

We first turn to optimal capital controls in a flexible price model with productivity shocks only, where firms set their optimal price as $P_{H,t} = \mathcal{M}MC_t$. Let $\mathrm{V}(Z_t, \mathcal{F}_t)$ represent the value function in the Bellman equation for the optimal policy problem in period t, where $\mathcal{F}_t$ represents the given variables of foreign country and exogenous shocks in period t. To have some intuitions of capital controls in the presence of LAMP, we will focus on the Cole-Obstfeld preferences, i.e. unitary elasticities of substitution ($\sigma = \eta = 1$) and discuss the implications by comparing the results with the findings of Farhi and Werning (2012, 2013), where capital control is not necessary in the small open economy with efficient productivity shocks.

Since $N_{R,t} = N$ for $\sigma = 1$, the Ramsey problem for unitary elasticities of substitution without risk premium shock can be simplified as follows:

$$\mathrm{V}(Z_t,\mathcal{F}_t) = \max_{\{\tau_{B,t},C_{A,t},N_{A,t},C_{R,t},\ \mathcal{B}_{Ft},,\mathcal{T}_t\}}.[(1-\gamma)\left(\log C_{A,t} - \frac{N_{A,t}^{1+\nu}}{1+\nu}\right) \tag{38}$$
$$+\gamma\left(\log C_{R,t} - \frac{N_R^{1+\nu}}{1+\nu}\right) + \beta E_t \mathrm{V}(Z_{t+1},,\mathcal{F}_{t+1})],$$

subject to

$$Z_t((1-\gamma)N_{A,t} + \gamma N_R) - \mathbf{F} = (1-\theta)\mathcal{T}_t^{\theta}((1-\gamma)C_{A,t} + \gamma C_{R,t}) + \theta\mathcal{T}_t C_t^*, \tag{39}$$

$$C_{A,t}N_{A,t}^{\nu}\mathcal{T}_t^{\theta} = Z_t\mathcal{M}^{-1}(1-\tau_A) \tag{40}$$

$$C_{R,t}N_R^{\nu}\mathcal{T}_t^{\theta} = Z_t\mathcal{M}^{-1}(1-\tau_R), \tag{41}$$

$$C_{R,t} = \mathcal{M}^{-1}(1-\tau_R)Z_t\mathcal{T}_t^{-\theta}N_R - TR_{R,t}, \tag{42}$$

$$\Xi(\mathcal{B}_{F,t})(1+\tau_{B,t})E_t[\frac{C_{A,t}}{C_{A,t+1}}\left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t}\right)^{1-\theta}\frac{P_t^*}{P_{t+1}^*}] = E_t[\frac{C_t^*}{C_{t+1}^*}\frac{P_t^*}{P_{t+1}^*}], \tag{43}$$

$$\mathcal{T}_t^{-\theta}(Z_t((1-\gamma)N_{A,t} + \gamma N_R) - \overline{\mathbf{F}}) = ((1-\gamma)C_{A,t} + \gamma C_{R,t}) \tag{44}$$
$$-(1-\gamma)[\left(\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}}\right)^{1-\theta}\frac{P_{t-1}^*}{P_t^*}\Xi(\mathcal{B}_{F,t-1})R_{t-1}^*\mathcal{B}_{F,t-1} - \mathcal{B}_{F,t}].$$

The income effect and substitution effect arising from the international relative price changes just cancel out and the net export is always balanced in the Cole-Obstfeld case, if every household can have access to the financial market (Cole and Obstfeld (1991) and Farhi and Werning (2012, 2013)). However, if there are some households who cannot have access to the financial markets, then their inability to optimally adjust consumption to the terms of trade change results in imbalance of trade balance even in the Cole-Obstfeld case, leaving room for capital controls to stabilize capital movements across the borders.

Proposition 1

Suppose that all prices in both domestic economy with limited asset market participation and the rest of the world described in Section 2.1 are flexible.

Then the net export is not always balanced to the productivity shocks for the Cole-Obstfeld case, i.e. $\sigma = \eta = 1$*.*

Proof: Please refer to the Appendix.

In the presence of LAMP where non-asset holders cannot have access to financial market, the exchange rate is determined by domestic asset holders and the foreign householders. The equilibrium exchange rate cannot balance the net export in the economy with a Cole-Obstfeld preference with productivity shocks only, leaving room for government to intervene in the international capital market to stabilize the economy contrary to Farhi and Werning (2012, 2013). To improve the social welfare by minimizing the undesirable fluctuations of trade balance associated with the terms of trade externality, the government needs to control international capital movement.

Proposition 2

In the presence of the non-asset holders who cannot have access to the financial markets described in Section 2.1, the optimal capital controls are not zero for the Cole-Obstfeld preference ($\sigma = \eta = 1$*) in the flexible price equilibrium with domestic and foreign productivity shocks.*

Proof: Please refer to the Appendix**.**

Non-asset holders who do not have financial assets to smooth out their consumption have to spend all their current income to finance current consumption, entailing undesirable fluctuations of terms of trade and trade balance to the exogenous shocks. The efficient productivity shock is no exception in the economy with LAMP. Hence, the government has an incentive to control international capital movement in the presence of limited asset market participation. In response to productivity shocks, capital controls can mitigate variations in domestic nominal interest rate in the economy, where the interest rate channel is partially muted by the presence of LAMP. This result contrasts with existing literature such as Farhi and Werning (2012, 2013), where there is no room for capital controls in a flexible price equilibrium with productivity shocks for the unitary elasticity of substitution, but without any limit to financial market participation.

3.2 Optimal Monetary Policy in the Cole-Obstfeld Preference

In this subsection, we turn to the optimal monetary policy in a small open economy of nominal rigidities with LAMP. Asset-holders' consumption is loosely linked to their current income, while non-asset holders' consumption is tightly linked their current income. Moreover, the non-asset holders cannot improve their utility by decreasing the utility of labor hours, but without an equivalent reduction in the utility of consumption to the productivity shocks in the unitary elasticity of intertemporal elasticity of substitution. In the economy with home bias, non-asset holders may prefer consumer price index stability or exchanged rate stability to domestic price stability which hurts overall purchasing power even for a unitary elasticity of substitution between home and foreign goods.

Capital control is an effective, but imperfect instrument to stabilize economy hit by exogenous shocks, because trade account fluctuates to the productivity shocks even for unitary elasticity of substitutions in the presence of non-asset holders. Cooperative monetary policy and capital controls are better in improving the welfare than capital controls only. The monetary authority who maximizes the weighted average of non-asset holders and asset holders' welfare should implement optimal monetary policy taking into account the fact that the formers cannot buffer their consumption profiles from the exogenous shocks by having access to the financial market. In the presence of the non-asset holders, the monetary authority should deviate from domestic price stability to improve the welfare as in proposition 3.

Proposition 3

In the presence of the non-asset holders who cannot have access to the financial markets described in Section 2.1, the domestic price stability is not optimal in the economy with productivity shocks for $\sigma = \eta = 1$.

Proof: Please refer to the Appendix**.**

In the presence of LAMP, the monetary authority should optimally try to undo the time-varying distortions associated with LAMP and monopoly power in goods market by deviating from price stability even if households have the unitary elasticity of intertemporal and intratemporal elasticity of substitution.

4 Quantitative Analysis

In this section, we will explore the effect of LAMP on the dynamic properties of resource allocations under alternative capital control tax regimes in a small open economy. Specifically, the effect of capital control on welfare and resource allocations is explored in depth by employing the second-order approximation methods along the line of Schmitt-Grohé and Uribe (2006).

4.1 Parameter Values

All parameter values used in this paper are reported in Table 1 which are taken from De Paoli (2009), Faia and Monacelli (2008), and Galí and Monacelli (2005). First, we set both the intertemporal and intratemporal elasticities of substitution, i.e. σ^{-1} and η to 1, and the Frisch labor supply elasticity of labor supply ν^{-1} to 1 in the benchmark model. Because these parameter values play a key role in the welfare ranking of simple monetary policy rules, we also consider other values of them as in Table 1. In particular, the intratemporal elasticity between home and foreign goods η which plays a key role in the dynamic properties of the selected macroeconomic variables in the model is set to values in $[1, 5]$. We set the subjective discount factor to $1.04^{-1/4}$, which is consistent with an annual real rate of interest of 4 percent as in Prescott (1986). Next, we set the elasticity of substitution among varieties ϵ to 6, implying the average size of markup, μ to be 1.2 as in Galí and Monacelli (2005). The value of the nominal rigidity parameter α is set to 2/3 to match the value of Bils and Knelow (2004).

Finally, the exogenous driving process, i.e. the (log) productivity, $z_t(\equiv \log Z_t)$ and $y_t^*(\equiv \log Y_t^*)$ is assumed to follow an AR(1) process as in De Paoli (2009), Faia and Monacelli (2008), and Galí and Monacelli (2005). The (log) risk premium shock, $\psi_t(\equiv \log \Psi_t)$ is also assumed to follow an AR(1) process:.

4.2 Some Intuitions on Capital Controls

Suppose that prices are flexible in both domestic and the rest of the world for all time t and both intertemporal and intratemporal elasticity of substitution are one ($\sigma = \eta = 1$). First, the market clearing condition for no LAMP case yields

$$(1+\nu)n_{A,t} = -\beta^{-1}\mathcal{B}_{F,t-1} + \mathcal{B}_{F,t}. \tag{45}$$

(45) shows that if the net foreign asset holdings are zero in the initial, i.e. if $\mathcal{B}_{F,t-1} = 0$, then the labor hours are zero if and only if the net foreign asset holdings are zero in current period.

$$n_{A,t} = 0 \text{ iff } \mathcal{B}_{F,t} = 0, \text{ given } \mathcal{B}_{F,t-1} = 0.$$

As shown in Farhi and Werning (2010) and Galí and Monacelli (2005), the income effect and substitution effect on trade balance and labor hours arising from the terms of trade variation in the Cole-Obstfeld preference if all households can have access to asset markets.

To look at the effect of LAMP on labor hours and trade balance, consider the resource constraint and goods market clearing conditions whose log-linearization can be simplified as:

$$-(1-\gamma)(1+\nu(1-\theta))n_{A,t} + \theta\widehat{\mathcal{T}}_t = \theta(1-\gamma)z_t - \theta y_t^* \tag{46}$$

(46) shows that if there is no LAMP, i.e. $\gamma = 0$, then $\frac{\Delta\widehat{\mathcal{T}}_t}{\Delta z_t} = 1$ at the moment of domestic productivity shock. That is, the terms of trade depreciates just enough to balance the trade account. Also, note that the log-linearization of the real dividend is given by

$$d_t = \frac{\mu}{1+\mu}y_t - \frac{1+\mathrm{f}}{1+\mu}\mathrm{mc}_t,$$

where μ is the steady-state markup and $\mathrm{f} \equiv \frac{\mathrm{F}}{Y}$.

Next, consider the LAMP case. In (46),

A positive domestic productivity shock increases output, consumption as well as real dividend. As the fraction of non-asset holders increases, each asset holders have more shares, and a larger share of profits. The more restricted asset market participation, the larger wedge between domestic output and expenditure: the propensity of consumption of asset holders is smaller than the propensity of non-asset holders. The more restricted the asset market participation, the larger the trade surplus.

Next, the log-linearization of (10) around the steady-state in the Cole-Obstfeld case leads to

$$\widehat{\tau}_{B,t} = -\widehat{\psi}_t + \eta \mathcal{B}_{F,t} + \gamma E_t[\Delta(c_{A,t+1} - c_{R,t+1}) - (\overline{C}\theta)^{-1}(1-\gamma)(\beta^{-1}\Delta\mathcal{B}_{F,t} - \Delta\mathcal{B}_{F,t+1})]. \tag{47}$$

First, consider the response of capital controls to the domestic productivity shock, where $\widehat{\psi}_t = 0$ in (47). The log-linearization of the equilibrium conditions show that the optimal capital controls should positively respond to the difference between the asset holder's expected future consumption growth rate and the non-asset holder's expected future consumption growth rate, while it has to positively respond to the expected future trade balance.

Note that the trade account marginally changes to the productivity shock in the benchmark case. In the presence of LAMP, the required optimal capital control tax/ subsidy rate is proportional to the degree of LAMP as well as the expected consumption growth rate difference between the asset holder and the non-asset holder. Because the change in asset holder's foreign bond holdings is marginal, the capital control tax/ subsidy rate is approximately proportional to the mass of non-asset holders and the expected relative consumption growth rate between asset holders and non-asset holders. Keeping in mind that asset holder's consumption increases more than non-asset holder's consumption to the positive domestic productivity shock, the optimal capital control should be taxation (subsidy) to capital outflow (inflow) with a positive (negative) domestic productivity shock. If there is only asset holder, i.e. if $\gamma = 0$, then the trade account is always balanced to the productivity shock, i.e. $\mathcal{B}_{F,t} = 0$, implying a time-invariant optimal capital control tax rate ($\widehat{\tau}_{B,t} = 0$).

Next, consider the response of the optimal capital controls to the risk premium shock. The positive risk premium shock generates capital outflows and a depreciation of the nominal exchange rate. The monetary authority needs to increase the interest rate to reverse the capital flow across borders. The contractionary monetary policy results in a decrease of domestic household's demand for consumption and a current account surplus. The government can implement optimal capital controls that takes the form of temporary subsidies on capital inflows and taxes on capital outflows to smooth the responses of endogenous variables. This mitigates the required depreciation of exchange rate, the increase in interest rates, the drop of consumption, and the reversal in trade account: Two imperfect instruments are better than a single instrument to stabilize the economy to the exogenous shocks.

4.3 Dynamics in Flexible Price Equilibrium

4.3.1 Impulse Response to Productivity Shocks

If every household can have access to financial market in the flexible price equilibrium with a Cole-Obstfeld preference, no intervention to capital movements across borders is required to the efficient productivity shocks because the income effect and substitution effect to the terms of trade change arising from the shocks just cancel out. However, the terms of trade deviates from the relevant value to balance the trade account in the presence of the non-asset holders, generating undesirable trade balance fluctuations. The non-asset holders who cannot have access to financial markets cannot adjust their consumption profiles, yielding a wedge between production and expenditure in a small open economy.

A positive domestic productivity shocks expands domestic production and profit, which induces higher increase in consumption of asset holders than the one of non-asset holders, and a trade surplus. In the flexible price equilibrium, asset holders increase their labor hours to utilize the favorable productivity, while non-asset holders cannot adjust their work hours. Hence, the domestic aggregate demand increases less in the economy composed with asset holders and non-asset holders than in the economy with only asset holders, leading to trade surplus. Hence, there is room for government to improve the welfare by dampening down the economic fluctuations with capital controls in the small open economy with LAMP.

Figure 1 shows the response of some selected variables to the positive domestic productivity shock with persistence equal to 0.95 for different degrees of LAMP, i.e. for $\gamma \in [0.1,\ 0.5]$. A positive domestic productivity shock leads to an expansion of domestic output and a depreciation the terms of trade. The asset holders who can use financial assets to smooth out their consumption profiles against the shock increase their consumption, work hours, and real dividend. However, the non-asset holders who do not have any asset to buffer their consumption against the shocks end up with little change in consumption and work hours. This asymmetric non-asset holder's response to the shock induces the terms of trade to deviate from the level that balances the trade account in the Cole-Obstfeld case. That is, the presence of the non-asset holders generates a wedge between domestic production and expenditure in the Cole-Obstfeld presence case. Trade account which is balanced in the absence of LAMP turns into a marginal surplus in the presence of LAMP. The temporary capital flows are not desirable to the economy because the flows can be reversed depending upon the nature of shocks. This undesirable capital flows call for government's capital control tax/subsidy policy which can mitigate the capital movements.

A positive domestic productivity shock expands domestic output with domestic price decrease, which leads to a depreciation of terms of trade. As the relative price of domestic goods decreases, the demand for domestic goods increases, yielding a marginal trade surplus. Under this circumstance, the government needs to implement a tax to capital outflow to mitigate a trade surplus. To moderate the terms of trade depreciation and trade surplus to the favorable domestic productivity shock, a lower domestic interest rate and a depreciation of the real exchange rate are accommodated by a tax to the capital outflows, i.e. a negative value of $\widehat{\tau}_{Bt}$ to the the positive domestic productivity shock as in Figure 2. Taxation to the capital outflows induces asset holders to increase their consumption, moderating the trade surplus. Inspection of Figure 1 and 2 shows that capital controls mitigate capital outflows and increase consumption by decreasing the rate of return to the foreign bonds. Figure 2 also presents the response of some selected variables to the domestic productivity shock for various degree of LAMP, i.e. for $\gamma \in [0.1, 0.5]$ in the presence of optimal capital control policy. The more restricted the asset market participations, the higher trade surplus, calling for the higher capital control tax rate to moderate the capital flows.

Finally, Figure 3 represents the response of selected variables to the positive productivity shock as the degree of transitory productivity shock persistence (ρ_a) varies from 0 to 1. The persistence of response of relevant variables such as output, consumption, trade balance, and the terms of trade increase with the degree of persistence, implying that the efficacy of capital controls declines with the persistence of productivity shocks. For example, in the case of permanent productivity shocks which immediately and permanently change macroeconomic variables such as output, consumption, and the terms of trade, there is no room for government to use capital controls which change spending over time.

4.3.2 Impulse Response to Risk Premium Shock

Next, consider the response of the optimal capital control tax to the risk premium shock $(\widehat{\psi}_t)$.

Figure 4 and 5 show the impulse response of some selected variables to the positive risk premium shock in the flexible price model for different degree of LAMP, i.e. $\gamma \in [0.1, 0.5]$, depending on capital controls. Asset holders who own firms run them by financing the necessary funds from financial market, while non-asset holders are hand to mouth consumers. Under this circumstance, the risk premium shock affects more seriously asset holders than non-asset holders as in the Figure 4 and 5.

The risk premium shock increases the borrowing interest rate from the rest of the world, making domestic households to reduce their expenditures substantially. There occurs a large depreciation of the exchange rate and the terms of trade with a sizable trade surplus. The optimal capital controls lean against the wind, with the optimal tax on capital outflows about 0.3%. Hence, the fall in both asset holder and non-asset holder consumption is smaller, the terms of trade depreciation is smaller, and the shift toward trade surplus is also smaller. However, the domestic output increase changes little.

4.4 Dynamic Response in Sticky Price Equilibrium

4.4.1 Impulse Response to Productivity Shocks

Figure 6 shows the response of some selected variables to the positive domestic productivity shock for different degree of LAMP, i.e. $\gamma = 0.3$. The long circle lines (-o) represent the response of variables under optimal monetary and capital controls and the long dotted lines (-) represent the response of variables under a domestic price index inflation targeting (hereafter DPI rule) and optimal capital controls regime.

The favorable domestic productivity shock results in a substantial depreciation of the terms of trade which presses an increase in the real marginal cost of domestic firms. Hence, firms slowly increase their prices over time. However, domestic output gap is still negative to the shock, forcing the monetary authority to decrease its policy rate to boost the expenditure and to stabilize the trade balance and the economy. Since capital controls can shift spending across time, government implements capital control taxation to capital outflow to mitigate the trade surplus and to expand spending.

Government needs to more strongly levy capital control tax rate to stabilize trade balance under DPI rule regime than under optimal monetary and capital controls regime. Hence, macroeconomic variables are more stabilized with both optimal capital controls and monetary policy in place than with optimal capital controls and DPI rule in place.

4.4.2 Impulse Response to Risk Premium Shock

Next, consider the response of the optimal capital control tax to the risk premium shock ($\widehat{\psi}_t$) when the monetary authority implements either optimal monetary policy or DPI policy.

Figure 7 shows the impulse response of some selected variables to the positive risk premium shock in the sticky price equilibrium for different degree of LAMP, i.e. $\gamma = 0.3$. Without capital taxation on capital outflows, the risk premium shock results in a large drop in consumption, a sharp depreciation of exchange rates, and a substantial increase in nominal interest rates. Hence, the exchange rate depreciates substantially, leading to a strong trade surplus.

The optimal capital taxations on capital outflows induces households to consume more, decreasing the trade trade surplus associated with risk premium shock. The depreciation of exchange rates and the expantion of domestic output become smaller. When optimal monetary policy is implemented in addition to optimal capital controls, nominal interest rates increase more and capital control taxations on capital outflows are higher compared to the ones associated with only capital controls. Compared to the resource allocations assoicted with capital controls and DPI rule, the depreciation of the exchange rates is smaller and the drop in consumption is smaller as in Figure 7. Furthermore, since the risk premium shock decreases firm's profit, the the asset holders are more adversely affected by the risk premium than non-asset holders. Hence, the optimal monetary policy and captial controls that mitigate these negative effects are more favorable to asset holders than non-asset holders.

4.5 Welfare and Resource Allocations

In this subsection, we will discuss the effect of LAMP on resource allocations and the optimal capital tax by employing the second-order approximation methods along the line of Schmitt-Grohé and Uribe (2006).

Table 2 presents the welfare and resource allocations with productivity shocks only for the Cole-Obstfeld case when prices are flexible. In Table 2, $\mathcal{W}_{C_1}$ and $\mathcal{W}_{C_2}$ represent the welfare under only efficient domestic and foreign productivity shocks and the welfare under a risk premium shock as well as domestic and foreign productivity shocks, respectively.

First, the difference between the welfare associated with the optimal capital controls and the welfare associated with no capital control increases as the autocorrelation of the technology shock, i.e. ρ_A and ρ_{Y^*} decreases. If the technology shock is permanent, i.e. $\log(A)$ and $\log(Y^*)$ are nonstationary, then there is no role for capital control to reallocate demand intertemporally. Hence, the welfare associated with capital controls equals the one without capital controls. If the technology shocks are i.i.d., then the welfare difference between two policy regimes equals 4.8×10^{-4} percent of the steady-state consumption level.

Second, the difference between the welfare associated with the optimal capital controls and the welfare associated with no capital control increases with the degree of LAMP because the role of optimal capital controls to stabilize the economy associated with external balance also increases with the degree of LAMP.

Third, the difference between the welfare associated with the optimal capital controls and the welfare associated with no capital control is 2.6×10^{-4} % of the steady-state consumption under efficient productivity shocks in the Cole-Obstfeld case with flexible prices. The benefit from capital control increases 0.2319% of steady-state consumption when the economy is hit by a risk premium shock as well as productivity shocks.

Finally, the optimal capital control tax moves countercyclically over business cycles as expected. As international capital inflows during booms, exacerbating the seed for the future capital outflows during bust, the government needs to put some frictions to the wheel of international capital flows.

5 Conclusion

In the present paper, we have extended the existing literature on optimal capitals in a small economy framework by incorporating limited asset market participation into the model. We have shown that there is room for government to improve welfare by controlling international capital movement to a productivity shock even in the flexible price equilibrium with unitary elasticities of substitution, i.e. in the Cole-Obstfeld case. The difference between the welfare associated with capital controls and the welfare associated without capital controls is substantial in the Cole-Obstfeld case with efficient productivity shocks only.

Moreover, the monetary authority should deviate from price stability to improve the welfare in the small open economy with a Cole-Obstfeld preference with productivity shocks only if there exists households who cannot have access to the financial market. Finally, we have shown that the optimal capital controls tax leans against the wind.

Table 1:The Calibrated Parameters

Parameter	Values	Description and definitions
γ	0.3	Fraction of non-asset holders
ϵ	6	Elasticity of demand for a good with respect to its own price
σ	1, 2	Relative risk aversion parameter
α	0, 2/3	Fraction of firms that do not change their prices in a given period
η	1, 2, 4, 5	Elasticity of substitution between home and foreign goods
ν	0.5, 1, 3	Inverse of elasticity of labor supply
ρ_z	[0,1]	Autocorrelation of domestic productivity shock
ρ_{y^*}	[0,1]	Autocorrelation of foreign productivity shock
ρ_ψ	0.9	Autocorrelation of risk premium shock
σ_z	0.007	Standard deviation of domestic productivity shock
σ_{y^*}	0.007	Standard deviation of foreign productivity shock
σ_ψ	0.007	Standard deviation of risk premium shock
r	0.016	Steady state real interest rate

Appendix

Proof of Proposition 1

Consider the resource constraint

$$\begin{aligned} Y_t &= (1-\theta)\mathcal{T}_t^{\theta} C_t + \theta \mathcal{T}_t C_t^* \\ &= \mathcal{T}_t^{\theta} C_t + \theta(\mathcal{T}_t C_t^* - \mathcal{T}_t^{\theta} C_t). \end{aligned}$$

$$(1+\tau_{B,t})\Psi_t \Xi(\mathcal{B}_{F,t}) E_t \left[\frac{C_{A,t}}{C_{A,t+1}} \left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t} \right)^{1-\theta} \frac{P_t^*}{P_{t+1}^*} \right] = E_t \left[\frac{C_t^*}{C_{t+1}^*} \frac{P_t^*}{P_{t+1}^*} \right]$$

$$Y_t = \mathcal{T}_t^{\theta} C_t - (1-\gamma)[\Psi_{t-1} \left(\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}} \right)^{1-\theta} \frac{P_{t-1}^*}{P_t^*} \Xi(\mathcal{B}_{F,t-1}) R_{t-1}^* \mathcal{B}_{F,t-1} - \mathcal{B}_{F,t}]$$

Since $\tau_{B,t} = 0$, and $\Psi_t = 1$,

$$\Xi(\mathcal{B}_{F,t}) E_t \left[\frac{C_{A,t}}{C_{A,t+1}} \left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t} \right)^{1-\theta} \frac{P_t^*}{P_{t+1}^*} \right] = E_t \left[\frac{C_t^*}{C_{t+1}^*} \frac{P_t^*}{P_{t+1}^*} \right] \tag{A1}$$

$$Y_t = \mathcal{T}_t^{\theta} C_t - (1-\gamma)[\left(\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}} \right)^{1-\theta} \frac{P_{t-1}^*}{P_t^*} \Xi(\mathcal{B}_{F,t-1}) R_{t-1}^* \mathcal{B}_{F,t-1} - \mathcal{B}_{F,t}].$$

Note that

$$\theta(\mathcal{T}_t C_t^* - \mathcal{T}_t^{\theta} C_t) = (1-\gamma)[\mathcal{B}_{F,t} - \left(\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}} \right)^{1-\theta} \frac{P_{t-1}^*}{P_t^*} \Xi(\mathcal{B}_{F,t-1}) R_{t-1}^* \mathcal{B}_{F,t-1}]. \tag{A2}$$

To show that $\mathcal{B}_{F,t} = 0$ cannot be a solution of equations of (A1) and (A2), suppose that $\mathcal{B}_{F,t} = 0$ for all time t. Then, (A2) implies that $\mathcal{T}_t^{1-\theta} = \frac{C_t}{C_t^*}$. Since $\Xi(0) = 1$, the LHS of (A1) can be rewritten as

$$E_t \left[\frac{C_{A,t}}{C_{A,t+1}} \left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t} \right)^{1-\theta} \frac{P_t^*}{P_{t+1}^*} \right] = E_t \left[\frac{C_{A,t}}{C_{A,t+1}} \frac{(1-\gamma)C_{A,t+1} + \gamma C_{R,t+1}}{(1-\gamma)C_{A,t} + \gamma C_{R,t}} \frac{C_t^*}{C_{t+1}^*} \frac{P_t^*}{P_{t+1}^*} \right]. \tag{A3}$$

Hence, only if $\gamma = 0$, the LHS of equation (A1) equals (A3), i.e. $\mathcal{B}_{F,t} = 0$. Otherwise, $E_t\left[\frac{C_{A,t}}{C_{A,t+1}}\left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t}\right)^{1-\theta}\frac{P_t^*}{P_{t+1}^*}\right] \neq E_t\left[\frac{C_t^*}{C_{t+1}^*}\frac{P_t^*}{P_{t+1}^*}\right]$.

Therefore, $\mathcal{B}_{F,t} \neq 0$.■

Proof of Proposition 2

Under the assumption that $\Psi_t = 1$, the domestic social planner's problem can be written as follows:

$$\mathrm{V}(Z_t,\mathcal{F}_t) = \max_{\{\tau_{B,t}C_{A,t},\, N_{A,t},C_{R,t},\, N_{R,t},\ \mathcal{B}_{Ft},\mathcal{T}_t\}} .[(1-\gamma)\left(\log C_{A,t} - \frac{N_{A,t}^{1+\nu}}{1+\nu}\right) \tag{A4}$$
$$+\gamma\left(\log C_{R,t} - \frac{N_R^{1+\nu}}{1+\nu}\right) + \beta E_t \mathrm{V}(Z_{t+1},,\mathcal{F}_{t+1})],$$

subject to

$$Z_t((1-\gamma)N_{A,t} + \gamma N_R) - \overline{\mathbf{F}} = (1-\theta)\mathcal{T}_t^{\theta}((1-\gamma)C_{A,t} + \gamma C_{R,t}) + \theta \mathcal{T}_t C_t^*, \tag{A5}$$
$$C_{A,t}N_{A,t}^{\nu} = \mathcal{T}_t^{-\theta} Z_t \mathcal{M}^{-1} \tag{A6}$$
$$C_{R,t}N_R^{\nu} = \mathcal{T}_t^{-\theta} Z_t \mathcal{M}^{-1}, \tag{A7}$$
$$C_{R,t} = \mathcal{M} Z_t \mathcal{T}_t^{-\theta} N_R, \tag{A8}$$
$$\Xi(\mathcal{B}_{F,t})(1+\tau_{B,t})E_t[\frac{C_{A,t}}{C_{A+1,t}}\left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t}\right)^{1-\theta}\frac{P_t^*}{P_{t+1}^*}] = E_t[\frac{C_t^*}{C_{t+1}^*}\frac{P_t^*}{P_{t+1}^*}], \tag{A9}$$

$$\mathcal{T}_t^{-\theta}[Z_t((1-\gamma)N_{A,t} + \gamma N_{R,t}) - \overline{\mathbf{F}}] = ((1-\gamma)C_{A,t} + \gamma C_{R,t}) \tag{A10}$$
$$-(1-\gamma)[\left(\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}}\right)^{1-\theta}\frac{P_{t-1}^*}{P_t^*}\Xi(\mathcal{B}_{F,t-1})R_{t-1}^*\mathcal{B}_{F,t-1} - \mathcal{B}_{F,t}].$$

From (A5) and (A10), $(1-\gamma)[\left(\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}}\right)^{1-\theta}\frac{P_{t-1}^*}{P_t^*}\Xi(\mathcal{B}_{F,t-1})R_{t-1}^*\mathcal{B}_{F,t-1} - \mathcal{B}_{F,t}] = \theta[(1-\gamma)C_{A,t} + \gamma C_{R,t} - \mathcal{T}_t^{1-\theta}C_t^*]$. Hence, (A9) implies that

$$\Xi(\mathcal{B}_{F,t})(1+\tau_{B,t})E_t[\frac{C_{A,t}}{C_{A+1,t}}\frac{P_t^*}{P_{t+1}^*}\frac{\theta((1-\gamma)C_{A,t+1} + \gamma C_{R,t+1} - \mathcal{T}_{t+1}^{1-\theta}C_{t+1}^*)}{(1-\gamma)(\Xi(\mathcal{B}_{F,t})R_t^*\mathcal{B}_{F,t} - \mathcal{B}_{F,t+1})}]$$
$$= E_t[\frac{C_t^*}{C_{t+1}^*}\frac{P_t^*}{P_{t+1}^*}].$$

Log-linearization of the risk-sharing condition leads to

$$
\begin{aligned}
& -\eta\mathcal{B}_{F,t} + \tau_{B,t} - E_t[\Delta\widehat{c}_{A,t+1} - \Delta\widehat{c}^*_{t+1}] \\
= \;& \theta E_t[(1-\theta)\widehat{\mathcal{T}}_{t+1} + \widehat{c}^*_{t+1} - (1-\gamma)\widehat{c}_{A,t+1} - \gamma\widehat{c}_{R,t+1}] + (1-\gamma)[\beta^{-1}\mathcal{B}_{F,t} - E_t(\mathcal{B}_{F,t+1})],
\end{aligned}
$$

where η is the elasticity of risk premium to the net foreign asset.

If $\mathcal{B}_{F,t} = 0$ for all time, then any capital control is not necessary, i.e. τ_{Bt} is zero for all time. (A5) and (A10) show that $\tau_{B,t} = 0$ if $(1-\gamma)C_{A,t} + \gamma C_{R,t} = \mathcal{T}_t C^*_t$ for all t. If $\tau_{Bt} = 0$ and $C_t = \mathcal{T}_t C^*_t$, it follows that

$$
E_t[\frac{C_{A,t}}{C_{A+1,t}}\left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t}\right)^{1-\theta}\frac{P^*_t}{P^*_{t+1}}] = E_t[\left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t}\right)\frac{P^*_t}{P^*_{t+1}}\frac{(1-\gamma)C_{A,t} + \gamma C_{R,t}}{(1-\gamma)C_{A,t+1} + \gamma C_{R,t+1}}]. \tag{A11}
$$

Hence, if $(1-\gamma)C_{A,t} + \gamma C_{R,t} = C_{A,t}\mathcal{T}^{\theta}_t$, that is, if $\mathcal{T}^{1-\theta}_t = \frac{C_{A,t}}{C^*_t}$, then (A11) equals the RHS of (A9). However, the incomplete market does not imply that $\mathcal{T}^{1-\theta}_t = \frac{C_{A,t}}{C^*_t}$ for all time. Hence, the optimal capital control tax rate cannot be zero in the presence of LAMP. The capital control should respond to the productivity shocks in the presence of the non-asset holders for the Cole-Obstfeld case.

■

Proof of Proposition 3

The Ramsey problem for unitary elasticity of substitution, i.e. for $\sigma =$

$\eta = 1$, can be simplified as

$$
\begin{aligned}
\mathcal{L} \;=\; & E_t \sum_{i=0}^{\infty} \beta^{t+i} \{ \left((1-\gamma)(\log C_{A,t+i} - \frac{N_{A,t+i}^{1+v}}{1+v}) + \gamma(\log C_{R,t+i} - \frac{1}{1+v}) \right) \\
& + \lambda_{1,t+i}[\frac{Z_{t+i}((1-\gamma)N_{A,t+i}+\gamma)}{\Delta_{H,t+i}} - F - (1-\theta)\mathcal{T}_{t+i}^{\theta}((1-\gamma)C_{A,t+i} + \gamma C_{R,t+i}) - \theta \mathcal{T}_{t+i} C_{t+i}^{*}] \\
& + \lambda_{2,t+i}[1 - (1-\alpha)\widetilde{p}_{H,t+i}^{1-\epsilon} - \alpha(1+\pi_{H,t+i})^{\epsilon-1}] \\
& + \lambda_{3,t+i}[\Delta_{H,t+i} - (1-\alpha)\widetilde{p}_{H,t+i}^{-\epsilon} - \alpha(1+\pi_{H,t+i})^{\epsilon}\Delta_{H,t+i-1}] \\
& + \lambda_{4,t+i}[Z_{t+i}(1-\tau)\mathrm{mc}_{t+i} - \mathcal{T}_{t+i}^{\theta} N_{A,t+i}^{\nu} C_{A,t+i}] \\
& + \lambda_{5,t+i}[\frac{\epsilon}{\epsilon-1}\mathcal{X}_{t+i} - \mathcal{Y}_{t+i}] + \lambda_{6,t+i}[\mathcal{X}_{t+i} - \widetilde{p}_{H,t+i}^{-1-\epsilon}\frac{Z_{t+i}((1-\gamma)N_{A,t+i}+\gamma)}{\Delta_{H,t+i}}\mathrm{mc}_{t+i} \\
& - \alpha\beta[(1+\pi_{H,t+i+1})^{\epsilon}\frac{\mathcal{T}_{t+i}^{\theta}}{\mathcal{T}_{t+i+1}^{\theta}}(\frac{C_{A,t+i+1}}{C_{A,t+i}})^{-1}\left(\frac{\widetilde{p}_{H,t+i}}{\widetilde{p}_{H,t+i+1}}\right)^{-1-\epsilon}\mathcal{X}_{t+i+1}] \\
& + \lambda_{7,t+i}[\mathcal{Y}_{t+i} - \widetilde{p}_{H,t+i}^{-\epsilon}\frac{Z_{t+i}((1-\gamma)N_{A,t+i}+\gamma)}{\Delta_{H,t+i}} \\
& - \alpha\beta(\frac{C_{A,t+i+1}}{C_{A,t+i}})^{-1}(1+\pi_{H,t+i+1})^{\epsilon-1}\frac{\mathcal{T}_{t+i}^{\theta}}{\mathcal{T}_{t+i+1}^{\theta}}\left(\frac{\widetilde{p}_{H,t+i}}{\widetilde{p}_{H,t+i+1}}\right)^{-\epsilon}\mathcal{Y}_{t+i+1}]\}
\end{aligned}
$$

Then, the first order conditions are given by

$$
\begin{aligned}
C_{A,t} \;:\; & (1-\gamma)C_{A,t}^{-1} + \alpha\epsilon(1+\pi_{H,t})^{\epsilon-1}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_{t}^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}C_{A,t}^{-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-1-\epsilon}\mathcal{X}_t\lambda_{6,t} \\
& + \alpha(\epsilon-1)(1+\pi_{H,t+1})^{\epsilon-2}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_{t}^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}C_{A,t}^{-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-\epsilon}\mathcal{Y}_t\lambda_{7,t} \\
= \;& (1-\theta)(1-\gamma)\mathcal{T}_t^{\theta}\lambda_{1,t} + \mathcal{T}_t^{\theta}N_{A,t}^{\nu}\lambda_{4,t} \qquad \text{(A12)} \\
& - \alpha\beta E_t[\epsilon(1+\pi_{H,t+1})^{\epsilon-1}\frac{\mathcal{T}_{t}^{\theta}}{\mathcal{T}_{t+1}^{\theta}}C_{A,t+1}^{-1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-1-\epsilon}\mathcal{X}_{t+1}\lambda_{6,t+1} \\
& + (\epsilon-1)(1+\pi_{H,t+1})^{\epsilon-2}\frac{\mathcal{T}_{t}^{\theta}}{\mathcal{T}_{t+1}^{\theta}}C_{A,t+1}^{-1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-\epsilon}\mathcal{Y}_{t+1}\lambda_{7,t+1}],
\end{aligned}
$$

$$
\begin{aligned}
N_{A,t} \;:\; & (1-\gamma)N_{A,t}^{\nu} + (1-\gamma)Z_t\Delta_{H,t}^{-1}(\mathrm{mc}_t\widetilde{p}_{H,t}^{-1-\epsilon}\lambda_{6,t} + \widetilde{p}_{H,t}^{-\epsilon}\lambda_{7,t}) \quad \text{(A13)} \\
= \;& (1-\theta)(1-\gamma)Z_t\cdot_{H,t}^{-1}\lambda_{1,t} + \nu\mathcal{T}_t^{\theta}N_{A,t}^{\nu}C_{A,t}\lambda_{4,t},
\end{aligned}
$$

$$C_{R,t} : \gamma C_{R,t}^{-1} = (1-\theta)\gamma \mathcal{T}_t^{\theta}\lambda_{1,t}, \tag{A14}$$

$$\text{mc}_t : Z_t(1-\widetilde{\tau})\lambda_{4,t} = \widetilde{p}_{H,t}^{-1-\epsilon}\frac{Z_t((1-\gamma)N_{A,t}+\gamma)}{\Delta_{H,t}}\lambda_{6,t} \tag{A15}$$

$$\begin{aligned}\pi_{H,t} \quad : \quad & 0 = \alpha(\epsilon-1)(1+\pi_{H,t})^{\epsilon-2}\lambda_{2,t} + \alpha\epsilon(1+\pi_{H,t})^{\epsilon-1}\lambda_{3,t} \\ & +\alpha\epsilon(1+\pi_{H,t})^{\epsilon-1}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-\sigma}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-1-\epsilon}\mathcal{X}_t\lambda_{6,t} \\ & +\alpha(\epsilon-1)(1+\pi_{H,t})^{\epsilon-2}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-\sigma}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-\epsilon}\mathcal{Y}_t\lambda_{7,t}\end{aligned} \tag{A16}$$

$$\begin{aligned}\Delta_{H,t} \quad : \quad & Z_t((1-\gamma)N_{A,t}+\gamma)\Delta_{H,t}^{-2}\lambda_{1,t} + \alpha(1+\pi_{H,t+i})^{\epsilon}\lambda_{3,t} \\ = \quad & Z_t((1-\gamma)N_{A,t}+\gamma)\Delta_{H,t}^{-2}(\widetilde{p}_{H,t}^{-1-\epsilon}\text{mc}_t\lambda_{6,t} + \widetilde{p}_{H,t}^{-\epsilon}\lambda_{7,t})\end{aligned} \tag{A17}$$

$$\begin{aligned}\widetilde{p}_{H,t} \quad : \quad & (1-\alpha)(1-\epsilon)\widetilde{p}_{H,t}^{-\epsilon}\lambda_{2,t} - (1-\alpha)\epsilon\widetilde{p}_{H,t}^{-\epsilon-1}\lambda_{3,t} \\ & -(1+\epsilon)\widetilde{p}_{H,t}^{-2-\epsilon}\frac{Z_t((1-\gamma)N_{A,t}+\gamma)}{\Delta_{H,t}}\text{mc}_t\lambda_{6,t} - \epsilon\widetilde{p}_{H,t}^{-\epsilon-1}\frac{Z_t((1-\gamma)N_{A,t}+\gamma)}{\Delta_{H,t}}\lambda_{7,t} \\ & +\alpha\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}[(1+\epsilon)(1+\pi_{H,t})^{\epsilon-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-1-\epsilon}\widetilde{p}_{H,t}^{-1}\mathcal{X}_t\lambda_{6,t} \\ & +\epsilon(1+\pi_{H,t})^{\epsilon}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-\epsilon}\widetilde{p}_{H,t}^{-1}\mathcal{Y}_t\lambda_{7.t}] \\ = \quad & \alpha\beta\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}E_t[(1+\epsilon)[(1+\pi_{H,t+1})^{\epsilon-1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-1-\epsilon}\widetilde{p}_{H,t}^{-1}\mathcal{X}_{t+1}\lambda_{6,t+1} \\ & +\epsilon[(1+\pi_{H,t+1})^{\epsilon}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-\epsilon}\widetilde{p}_{H,t}^{-1}\mathcal{Y}_{t+1}\lambda_{7,t+1}],\end{aligned} \tag{A18}$$

$$\begin{aligned}
\mathcal{T}_t \quad : \quad & \theta[(1-\theta)\mathcal{T}_t^{\theta-1}((1-\gamma)C_{A,t}+\gamma C_{R,t})+C_t^*]\lambda_{1,t}+\theta\mathcal{T}_t^{\theta-1}N_{A,t}^{\nu}C_{A,t}\lambda_{4,t} \\
& +\theta\alpha\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}\mathcal{T}_t^{-1}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}[(1+\pi_{H,t})^{\epsilon-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-1-\epsilon}\mathcal{X}_t\lambda_{6,t} \\
& +(1+\pi_{H,t})^{\epsilon}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-\epsilon}\mathcal{Y}_t\lambda_{7,t}] \qquad \text{(A19)} \\
= \quad & \theta\alpha\beta E_t[\frac{\mathcal{T}_t^{\theta-1}}{\mathcal{T}_{t+1}^{\theta}}(\frac{C_{A,t+1}}{C_{A,t}})^{-1}[(1+\pi_{H,t+1})^{\epsilon-1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-1-\epsilon}\mathcal{X}_{t+1}\lambda_{6,t+1} \\
& +(1+\pi_{H,t+1})^{\epsilon}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-\epsilon}\mathcal{Y}_{t+1}\lambda_{7,t+1}]
\end{aligned}$$

$$\mathcal{X}_t : \frac{\epsilon}{\epsilon-1}\lambda_{5,t}+\lambda_{6,t}=\alpha[(1+\pi_{H,t})^{\epsilon}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-1-\epsilon}]\lambda_{6,t}, \quad \text{(A20)}$$

$$\mathcal{Y}_t : \lambda_{7,t}=\lambda_{5,t}+\alpha[(1+\pi_{H,t})^{\epsilon-1}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-\epsilon}]\lambda_{7,t}. \qquad \text{(A21)}$$

Equations (A20) and (A21) imply that

$$\begin{aligned}
& \lambda_{7,t}[1-\alpha[(1+\pi_{H,t})^{\epsilon-1}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-\epsilon}]] \qquad \text{(A22)} \\
= \quad & \frac{\epsilon-1}{\epsilon}[1-\alpha[(1+\pi_{H,t})^{\epsilon}\frac{\mathcal{T}_{t-1}^{\theta}}{\mathcal{T}_t^{\theta}}(\frac{C_{A,t}}{C_{A,t-1}})^{-1}\left(\frac{\widetilde{p}_{H,t-1}}{\widetilde{p}_{H,t}}\right)^{-1-\epsilon}]]\lambda_{6,t}.
\end{aligned}$$

$\lambda_{6,t}$ and $\lambda_{7,t}$ can be expressed in terms of the endogenous variables such as $C_{A,t}$, $C_{R,t}$, $N_{A,t}$, Z_t, $\mathcal{T}_t$, $\widetilde{p}_{H,t}$, $\Delta_{H,t}$, $\pi_{H,t}$ from (A13), (A14), (A15), and (A22). Plugging $\lambda_{6,t}$ and $\lambda_{7,t}$ into (A17), (A16), and (A15), $\lambda_{2,t}$, $\lambda_{3,t}$, and $\lambda_{4,t}$ are also expressed in terms of these endogenous variables. Hence, $\pi_{H,t}$ depends on the path of $C_{A,t}$, $C_{R,t}$, $N_{A,t}$, Z_t, $\mathcal{T}_t$, $\widetilde{p}_{H,t}$, and $\Delta_{H,t}$.

■

Table 1: Parameter Values

Parameter	Values	Description and definitions
γ	[0, 0.5]	Fractions of the Rule of Thumb Consumers
ϵ	6	Elasticity of demand for a good with respect to its own price
σ	1, 2	Relative risk aversion parameter
α	0, 2/3	Nominal Price Rigidities
η	1, 2, 4, 5	Elasticity of substitution between home and foreign goods
ν	0.5, 1, 3	Inverse of elasticity of labor supply
r	0.016	Steady state real interest rate

Table 2 : Dynamic Properties of the Resource Allocations in a Flexible Price Equilibrium with productivity shocks only ($\sigma = \eta = 1,\ \gamma = 0.3$)

Variable	Mean	Std. Dev.	Auto. Corr	$Corr(x,y)$
Optimal	Capital	Control	Policy	
$\mathcal{W}_{C1} = 0$				
τ_B	0.0000	0.0605	0.9003	0.0464
$\mathcal{T}$	1.0000	2.7881	0.9324	0.6926
TB	0.0000	0.0730	0.7965	0.0386
c	1.0000	1.3035	0.9327	0.8055
y	1.0000	1.8556	0.9256	1
No	Capital	Control		
$\mathcal{W}_{C1} = -4.3108 \times 10^{-4}$				
τ_B	0	0	-	-
$\mathcal{T}$	1.0013	2.7774	0.9260	0.6882
TB	0.0001	0.0348	0.9284	-0.1588
c	1.0002	1.3147	0.9261	0.8044
y	1.0007	1.8450	0.9250	1

Note: τ and τ_B are expressed in percentage points and $y,\ n,\ \mathcal{T}, TB$ and c in levels and $\mathcal{W}_C$ represents the difference between the welfare associated with the optimal time-varying labor income and capital controls and the welfare associated with the corresponding policy rules. The parameter values are $\beta = (1.04)^{-1/4},\ T = 200$, and $J = 1000$.

Table 3 : Dynamic Properties of the Resource Allocations in a Flexible Price Equilibrium with Productivity and Risk Premium Shocks ($\sigma = \eta = 1, \gamma = 0.3$)

Variable	Mean	Std. Dev.	Auto. Corr	$Corr(x, y)$
Optimal	Capital	Control	Policy	
$\mathcal{W}_{C1} = 0$				
τ_B	0.0100	0.7763	0.9614	-0.1240
$\mathcal{T}$	1.0000	4.0420	0.8605	0.7229
TB	0.0000	1.3699	0.7969	0.3847
c	1.0000	2.1990	0.8455	0.1274
y	1.0000	2.0181	0.9063	1
No	Capital	Control		
$\mathcal{W}_{C2} = -0.2319$				
τ_B	0	0	-	-
$\mathcal{T}$	1.0086	3.2836	0.9285	0.6973
TB	0.0036	0.8070	0.9313	0.2095
c	0.9957	1.6903	0.9316	0.4737
y	1.0026	1.9184	0.9270	1

Note: τ and τ_B are expressed in percentage points and y, n, $\mathcal{T}$, TB and c in levels and $\mathcal{W}_C$ represents the difference between the welfare associated with the optimal time-varying labor income and capital controls and the welfare associated with the corresponding policy rules. The parameter values are $\beta = (1.04)^{-1/4}$, $T = 200$, and $J = 1000$.

Table 4 : Dynamic Properties of the Resource Allocations in a Flexible Price Equilibrium with P
Productivity Shocks only ($\sigma = \ \eta = \ 1, \ \gamma = 0.5$)

Variable	Mean	Std. Dev.	Auto. Corr	$Corr(x, y)$
Optimal	Capital	Control	Policy	
$\mathcal{W}_C = 0$				
τ_B	0.0200	0.0606	0.8927	0.0534
$\mathcal{T}$	1.0000	2.8421	0.9321	0.7024
TB	0.0000	0.0729	0.7978	0.0453
c	1.0000	1.2874	0.9318	0.7940
y	1.0000	1.8552	0.9254	1
No	Capital	Control		
$\mathcal{W}_C = -5.0630 \times 10^{-4}$				
τ_B	0	0	-	-
$\mathcal{T}$	1.0004	2.8012	0.9262	0.6958
TB	0.0002	0.0592	0.9295	-0.0131
c	0.9998	1.3029	0.9277	0.8145
y	1.0001	1.8701	0.9271	1

Note: τ and τ_B are expressed in percentage points and $y, \ n, \ \mathcal{T}, TB$ and c in levels and $\mathcal{W}_C$ represents the difference between the welfare associated with the optimal time-varying labor income and capital controls and the welfare associated with the corresponding policy rules. The parameter values are $\beta = (1.04)^{-1/4}, \ T = 200$, and $J = 1000$.

Table 5 : Dynamic Properties of the Resource Allocations in a Flexible Price Equilibrium with Productivity and Risk Premium Shocks ($\sigma = \eta = 1,\ \gamma = 0.5$)

Variable	Mean	Std. Dev.	Auto. Corr	$Corr(x, y)$
Optimal	Capital	Control	Policy	
$\mathcal{W}_{C1} = 0$				
τ_B	0.0300	0.7364	0.9679	-0.1053
$\mathcal{T}$	1.0000	4.0509	0.8631	0.7246
TB	0.0000	1.3186	0.7981	0.3749
c	1.0000	2.1498	0.8474	0.1347
y	1.0000	1.9962	0.9062	1
No	Capital	Control		
$\mathcal{W}_{C2} = -0.2321$				
τ_B	0	0	-	-
$\mathcal{T}$	1.0077	3.2336	0.9291	0.6942
TB	0.0032	0.7224	0.9322	0.1902
c	0.9960	1.6324	0.9321	0.5185
y	1.0021	1.8994	0.9268	1

Note: τ and τ_B are expressed in percentage points and $y,\ n,\ \mathcal{T}, TB$ and c in levels and $\mathcal{W}_C$ represents the difference between the welfare associated with the optimal time-varying labor income and capital controls and the welfare associated with the corresponding policy rules. The parameter values are $\beta = (1.04)^{-1/4},\ T = 200$, and $J = 1000$.

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Figure 1 : Impulse Response to a Positive Domestic Technology Shock in a Flexible Price Model without Capital Control: ($\sigma = \phi = 1$)

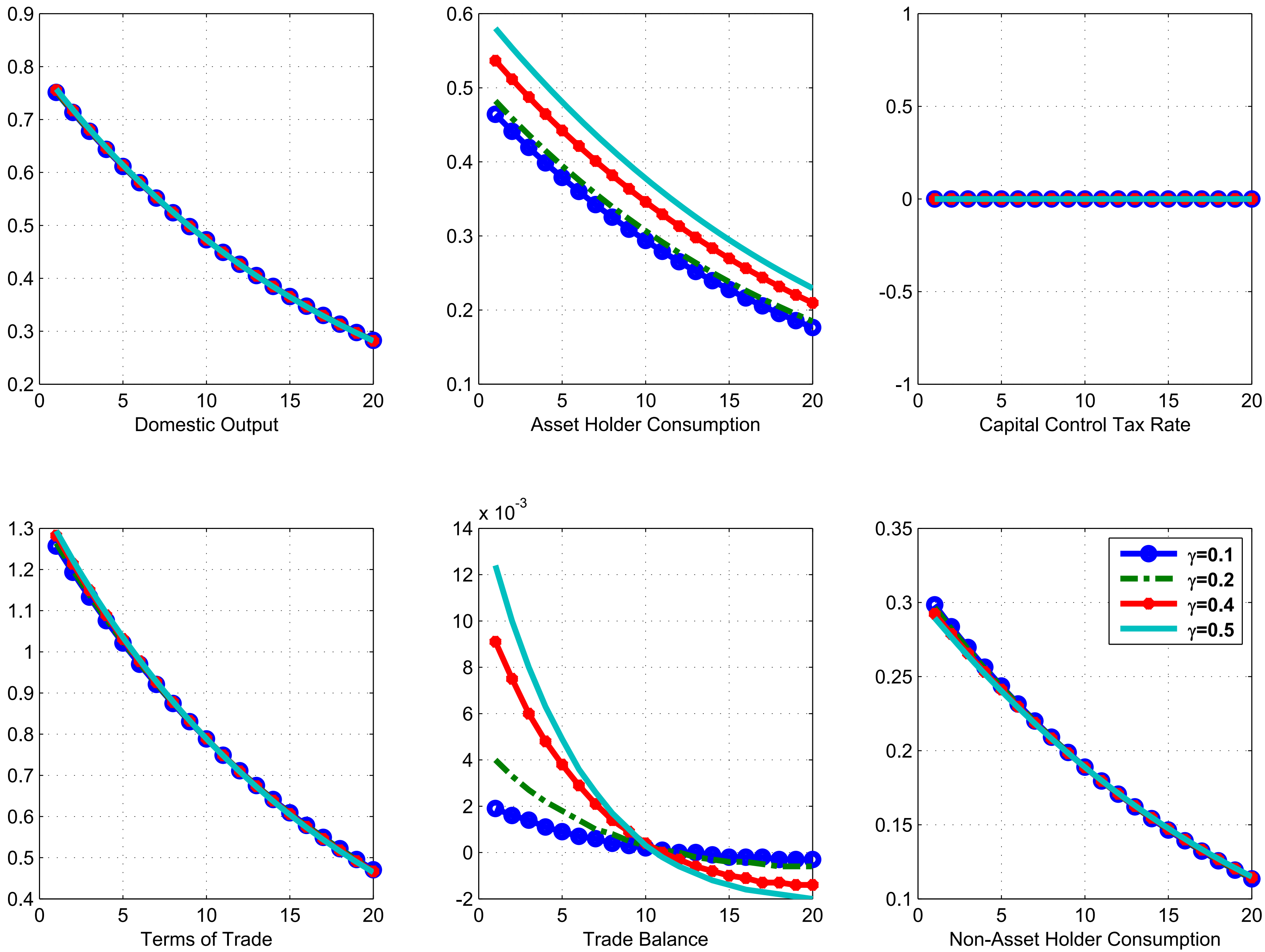

Figure 2 : Impulse Response to a Positive Domestic Technology Shock in a Flexible Price Model with Capital Control: ($\sigma = \phi = 1$)

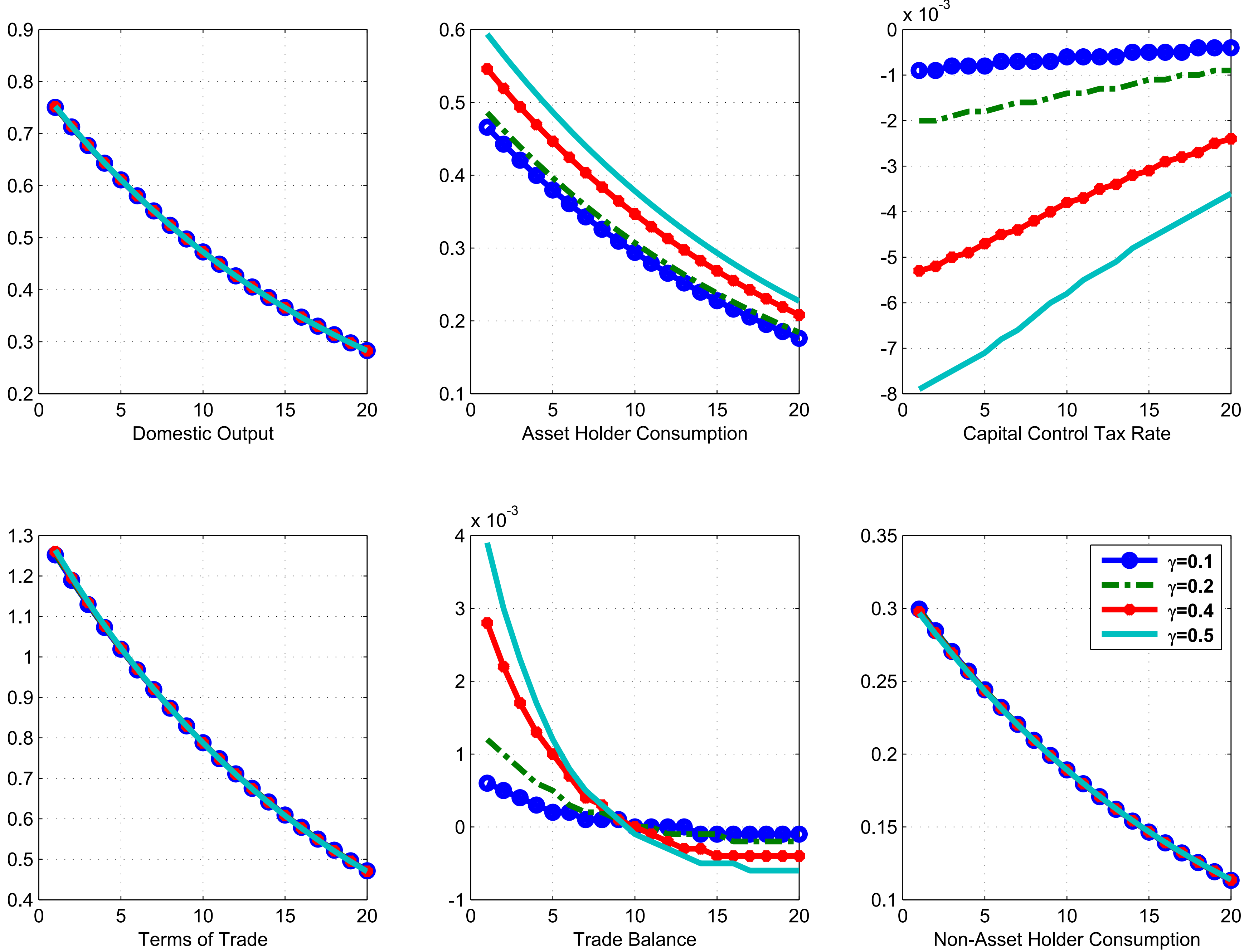

Figure 3 : Impulse Response to a Positive Domestic Technology Shock in Flexible Price Model with Capital Control: (σ= ϕ= 1)

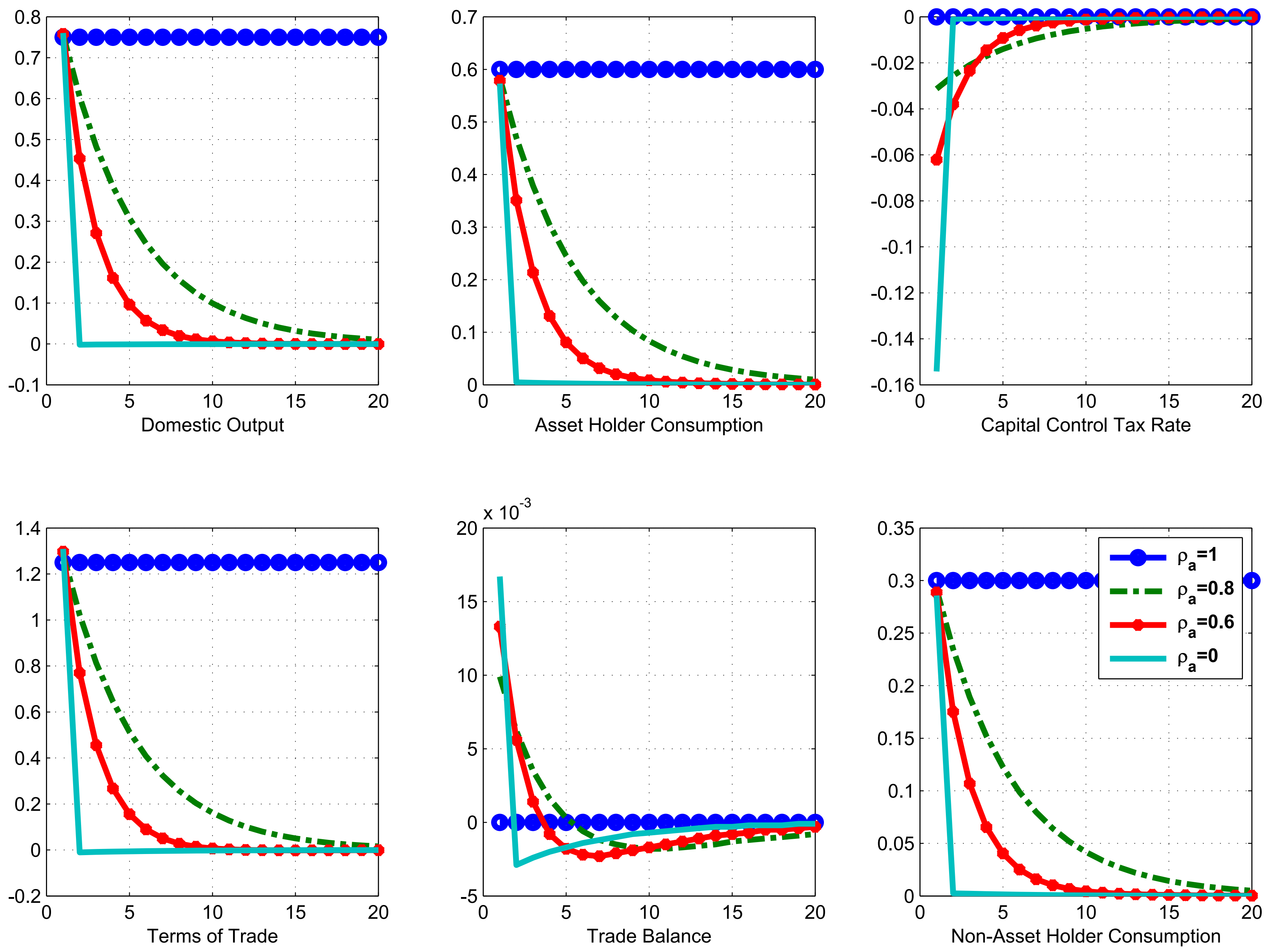

Figure 4 : Impulse Response to a Positive Risk Premium Shock in a Flexible Price Model without Capital Control (σ= ϕ= 1)

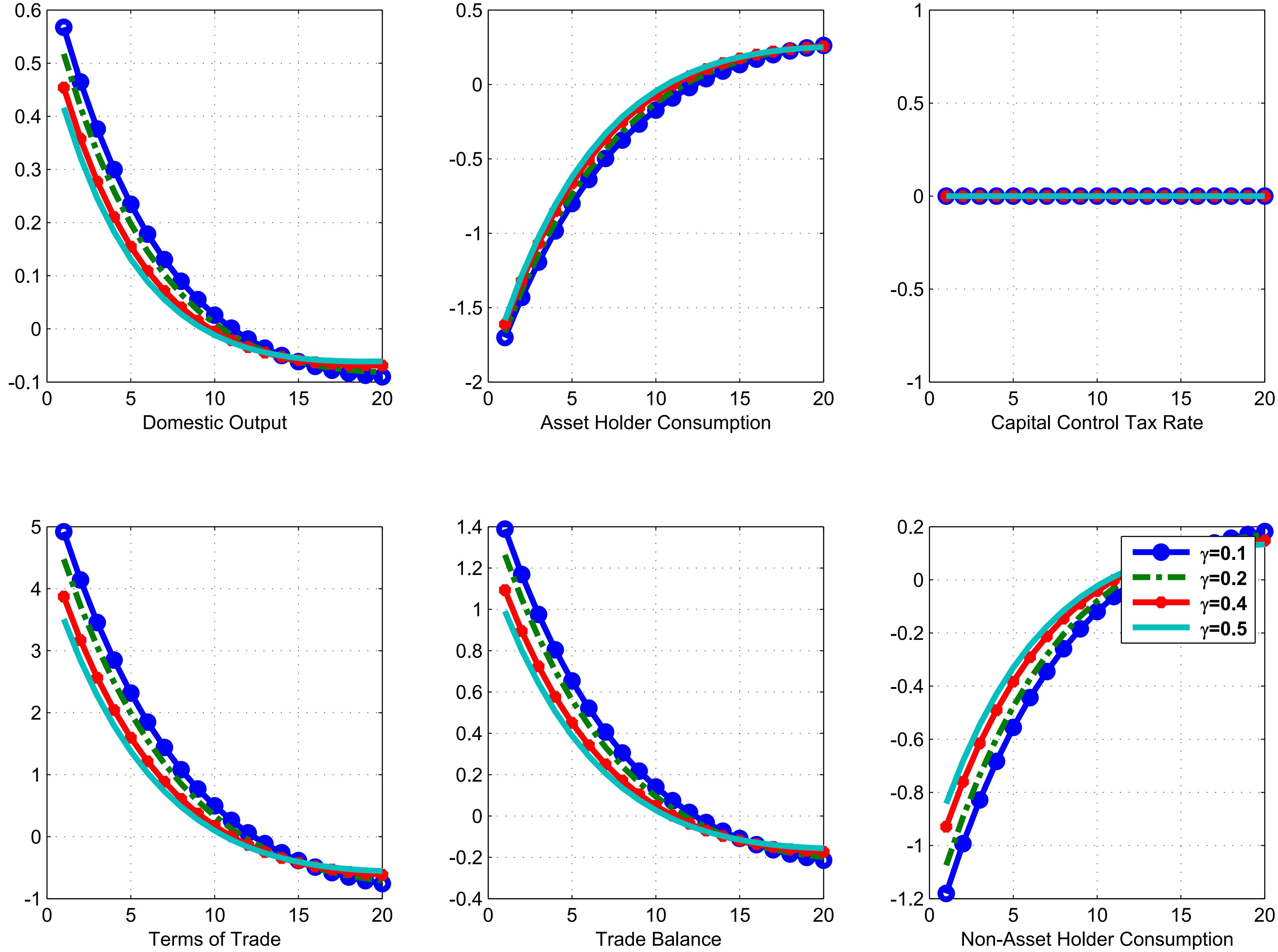

Figure 5 : Impulse Response to a Positive Risk Premium Shock in a Flexible Price Model with Capital Control (σ= ϕ=1)

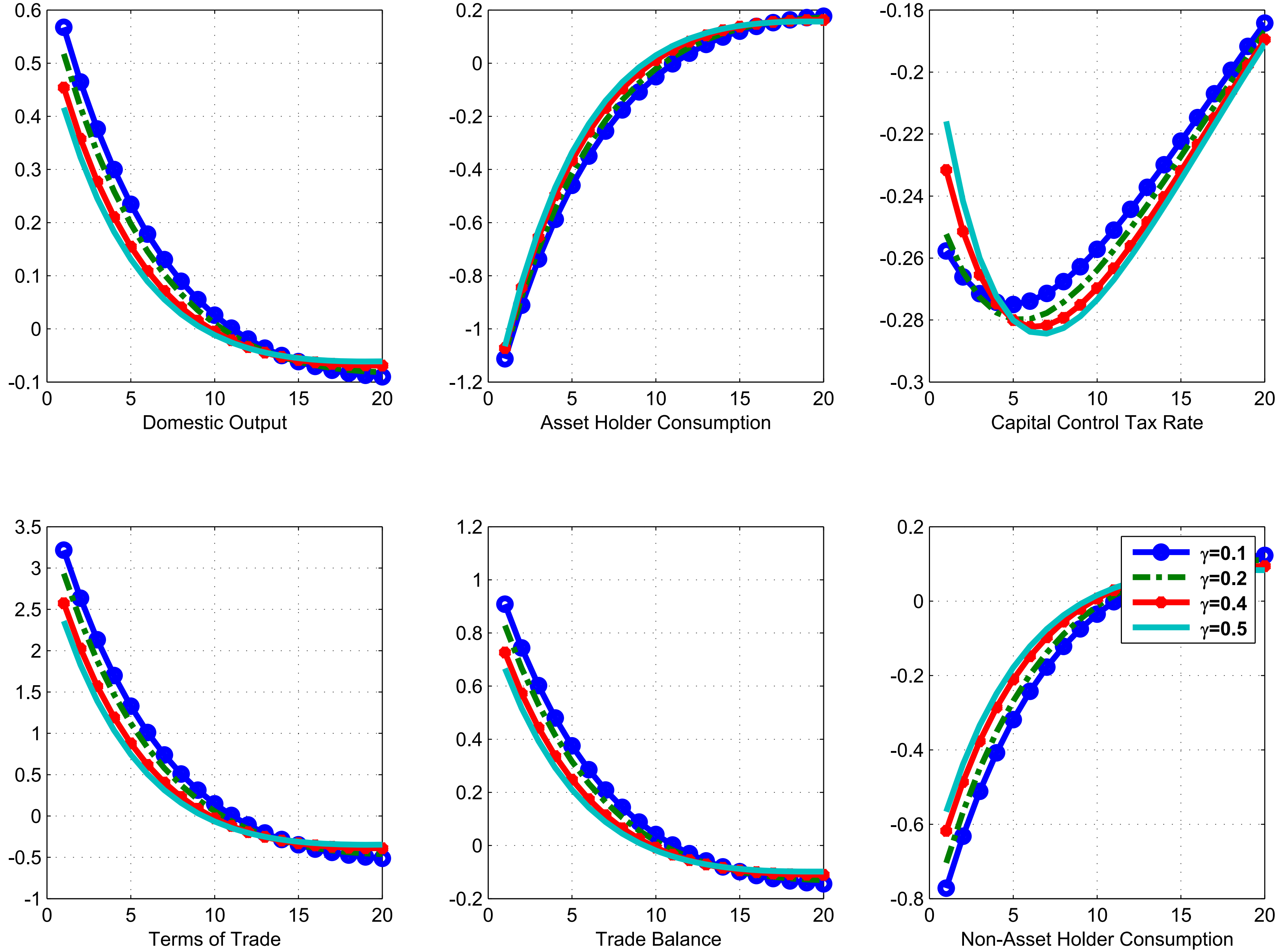

Figure 6 : Impulse Response to a Positive Domestic Productivity Shock in Sticky Price Model with Capital Controls ($\sigma = \phi = 1$, $\gamma = 0.3$)

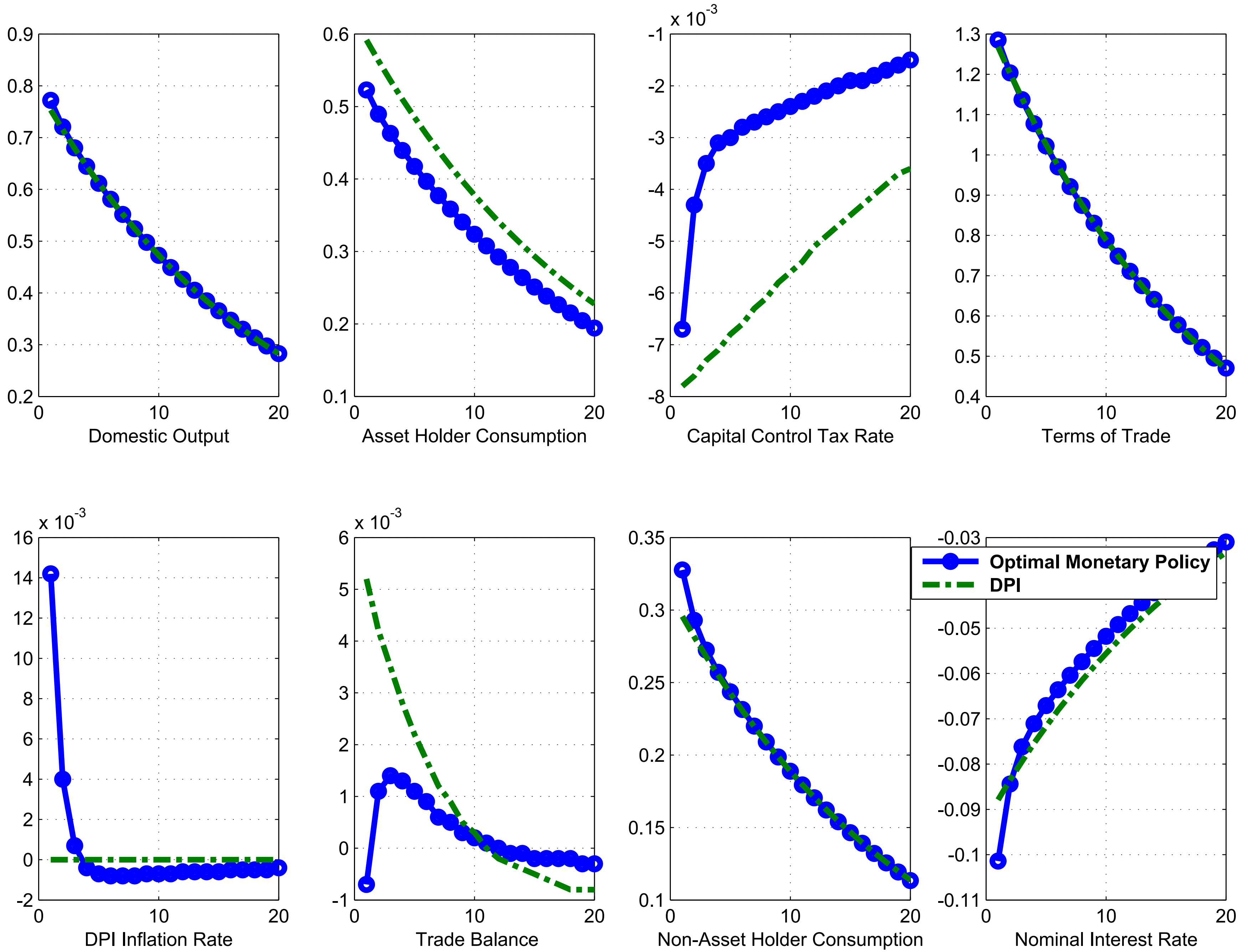

Figure 7 : Impulse Response to a Positive Risk Premium Shock in Sticky Price Model with Capital Controls ($\sigma = \phi = 1$, $\gamma = 0.3$)