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# Capital Controls and Price Stability in a Small Open Economy with Habit Persistence*

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**Abstract** This paper introduces habit persistence in consumption into otherwise a canonical new Keynesian small open economy. Households' decision to suboptimally adjust their consumption and labor hours entails a prolonged undesirable terms of trade externality, leaving room for government to improve welfare by controlling international capital movement even in the economy with flexible prices and the Cole-Obstfeld preference, irrespective of nominal price rigidities. It shows that government can improve welfare by intervening capital movement across border in a small open economy with flexible prices, even if there are only permanent productivity shocks, contrasting with Farhi and Werning (2014). The paper also finds that higher the degree of habit persistence, more aggressive capital control to international capital movement required to stabilize the economy and to improve upon the welfare of either the flexible or sticky price economy. The nominal interest rate should countercyclically move to complement the procyclical capital control tax in stabilizing the capital movement across border. Moreover, the resource allocations associated with both optimal time-varying capital control show less volatile movements than the ones without any intervention.

**Keywords** Capital Control, Habit Persistence, Price Stability, Welfare Loss

**JEL Classification** E52, F41

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## 1. INTRODUCTION

At first glance, it seems that there is no theoretical basis for the capital controls in international finance, since monetary policy is independent under a flexible exchange rate regime. However, conventional wisdom in international finance that capital controls, hindering the long-run growth by distorting the efficient resource allocation, are undesirable in a flexible exchange rate regime has been challenged by recent episodes with free capital mobility that ended in sudden stops followed by severe financial or exchange rate crises. In particular, the Great Recession led both economists and policy makers to understand that both advanced and emerging economies can be adversely affected by volatile capital flows and capital controls are an appropriate macroeconomic instrument to stabilize the economy from the external shocks.

Two strands of academic literature on capital controls have grown since the Great Recession. First, Benigno *et al.* (2016), Bianchi (2011), and Korinek (2011) develop models of foreign borrowings subject to collateral constraints and pecuniary externalities to emphasize the desirability of capital controls in promoting the financial stability. Another strand of literature 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 Stephanie and Uribe (2016) 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 Stephanie and Uribe (2016) analyze 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 (2014) go one step further to show that capital controls can be desirable in a flexible exchange rate regime, contrasting to the Mundellian view.

In recent, many studies in macroeconomics have taken into account habit persistence in consumption to explain the observed behavior of macroeconomic variables over business cycles. For example, Christiano *et al.* (2005) and Smets and Wouters (2007) set up a medium scaled DSGE model and estimated the degree of habit persistence to be 0.65 and 0.71 using the US data, while Adolfson *et al.* (2007) found the estimate of the habit persistence to be 0.69 using Euro data in an open economy DSGE model. In an open economy context, Ravn *et al.* (2012) have introduced external deep habits occurring at the individual goods into the macroeconomic models and shown that the models with deep habits imply countercyclical markups and crowding in of private consumption following an increase in government spending as in the data.

This paper extends the existing literature on optimal capital controls in a small economy framework by incorporating habit persistence into the model. In light of the fact that the models embedded with habit persistence in consumption are successful in improving the explanatory power of the model over business cycles, the capital control policy implications in the model with habit persistence warrant a closer look. In this paper, we set up a canonical new Keynesian small open economy embedded with habit persistence. Then, we address the role of capital controls in a small open economy with the Cole-Obstfeld preference[1] and habit persistence where distortions associated with sluggish adjust of consumption aggravate undesirable capital movements.

There is no room for capital control in the economy embedded with the Cole-Obstfeld preference, the efficient productivity shocks, but no habit persistence, if the monetary authority stabilize domestic price (Farhi and Werning, 2012, 2014). However, the efficient productivity shock itself generates undesirable capital movements across border in the economy with habit persistence, leaving room for capital controls, even if the monetary authority implements optimal monetary policy to stabilize the economy. The main findings of this paper can be summarized as follows.

First, there is a welfare gain from capital controls in the economy with productivity shocks only, irrespective of intertemporal and intratemporal elasticity of substitution, if households have habit persistence in consumption, contrasting the findings of Farhi and Werning (2012, 2014). As households who have habit persistence suboptimally adjust their consumption profiles over time to the exogenous shocks, the endogenous variables such as the terms of trade and trade balance cannot immediately jump to the new equilibrium values to the permanent productivity shocks. The government can improve the welfare by manipulating the terms of trade to reallocate the expenditures over time with capital controls in domestic household's favor. The welfare gain from capital controls dampens with the persistence of the productivity shock because there is less room for government to intervene in international capital movement in the economy with more persistent productivity shocks.

Second, there is room for government to improve welfare by controlling international capital movements even in a unitary elasticity of substitution, i.e. in the Cole-Obstfeld preference case, if households have habit persistence in consumption with productivity shocks only, irrespective of nominal price rigidities. This result follows from the fact that the efficient productivity shocks generate a

[1] Both the inter- and intra-temporal elasticity of substiution equal one.

wedge between production and expenditure through the real exchange rate channel, contrasting with Farhi and Werning (2014) who find no room for capital controls in a flexible price equilibrium with productivity shocks in the Cole-Obstfeld preference case.

Thirdly, the higher the degree of habit persistence, the more aggressive capital control required to stabilize the economy and to improve upon the welfare, irrespective of the degree of nominal price rigidities. The habit persistence in consumption itself entails the unnecessary fluctuations of trade balance even to the efficient technology shocks by aggravating the externality of the terms of trade. Hence, the optimal capital control to moderate capital movements can dampen down the unnecessary swings of the economy by alleviating the terms of trade externality compounded with habit.

Finally, the optimal capital control tax leans against the wind, while the nominal interest rate countercyclically moves to improve welfare by stabilizing the capital flows across the border. Resource allocations and prices are less volatile under optimal time-varying capital control taxations than under laissez-faire. Also, domestic price stability is optimal if the fiscal authority implements an optimal time-varying labor income tax to completely eliminate distortions associated with habit persistence in consumption and monopolistic competition in goods market. Otherwise, monetary authority should deviate from price stability to improve welfare.

The remainder of the paper is organized as follows. Section 2 presents a canonical small open economy model with habit persistence 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 with habit persistence under a flexible price as well a sticky price equilibrium. Section 4 presents a numerical analysis of welfare associated with alternative capital control policy rules. Section 5 concludes.

## 2. THE MODEL

This section sets up a variant of new Keynesian model with habit persistence applied to an open-economy. The total measure of the world economy is normalized to unity, with Home ($H$) and Foreign ($F$) having size $n$ and $(1-n)$, respectively, where the relative size of domestic economy is negligible relative to the rest of the world, i.e. $n \longrightarrow 0$.

## 2.1. HOUSEHOLDS

The small open economy is inhabited by a household whose utility depends on consumption relative to a time-varying habit as in Abel (1990, 1999) and Smets and Wouters (2007). In particular, we assume that the utility function of the representative household takes the form:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\left(U(C_t^d)-\frac{N_t^{1+v}}{1+v}\right)\right],\ 0<\beta<1, \tag{1}$$

where $\beta$ is the household's discount factor, $E_0$ denotes the conditional expectations operator on the information available in period 0. $C_t^d = C_t - bH_t$. $C_t$, $N_t$, and $H_t$ represents the household's consumption for composite goods, work hours, and habit at time $t$, respectively, and $b \in [0,1)$ measures the degree of habit persistence. Here $U(C_t^d) = \frac{(C_t^d)^{1-\sigma}}{1-\sigma}$ for $\sigma \neq 1$, and $U(C_t^d) = \ln(C_t^d)$ for $\sigma = 1$. To make the discussion more concrete, a specific CES consumption index is assumed as follows:

$$C_t \equiv [(1-\gamma)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}},\ \eta \neq 1 \tag{2}$$

where $\gamma \equiv (1-n)\theta$ is the share of domestic consumption allocated to imported goods, $\theta$ is the degree of trade openness, and $\eta > 0$ is the intratemporal elasticity of substitution between domestic and foreign goods. In similar, foreign CES consumption index is assumed as follows:

$$C_t^* \equiv [(1-\gamma^*)^{\frac{1}{\eta}} C_{F,t}^{*\frac{\eta-1}{\eta}} + \gamma^{*\frac{1}{\eta}} C_{H,t}^{*\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} \tag{3}$$

where $\gamma^* \equiv n\theta^*$. Here, $C_{H,t}$ and $C_{F,t}$ are indices of consumption of domestic and foreign goods which are given by the following CES aggregators of the consumed amounts of each type of good:

$$C_{H,t} \equiv \left[\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}},\ C_{F,t} \equiv \left[\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{4}$$

where $\varepsilon$ measures the elasticity of substitution among goods within each category. In this context, the consumer price index is given by

$$P_t \equiv [(1-\gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta}]^{\frac{1}{1-\eta}} [2], \tag{5}$$

[2] In the case of $\phi = 1$, the CPI takes the form of $P_t = (P_{Ht})^{1-\gamma}(P_{Ft})^{\gamma}$, while the consumption index is given by $C_t = \frac{1}{(1-\gamma)^{1-\gamma}\gamma^{\gamma}} C_{Ht}^{1-\gamma} C_{Ft}^{\gamma}$.

where $P_{Ht}$ and $P_{Ft}$ denote the price of domestic goods and imported foreign goods in domestic currency unit in period $t$, given by

$$P_{H,t} = \left[\int_0^1 P_{H,t}(j)^{1-\varepsilon} dj\right]^{\frac{1}{1-\varepsilon}}, \quad P_{F,t} = \left[\int_0^1 P_{F,t}(j)^{1-\varepsilon} dj\right]^{\frac{1}{1-\varepsilon}}. \tag{6}$$

The law of one price is assumed to hold: $P_{H,t}(j) = \mathscr{E}_t P^*_{H,t}(j)$ and $P_{F,t}(j) = \mathscr{E}_t P^*_{F,t}(j)$ for all $j$, where $\mathscr{E}_t$ is the nominal exchange rate in period $t$.

We assume incomplete markets such that domestic households can trade only one-period nominal riskless bonds denominated in home and foreign currency subject to intermediation costs, while foreign households trade one-period nominal riskless bonds denominated in foreign currency. Then the domestic household's budget constraint can be written as

$$\begin{aligned} P_t C_t + B_{H,t} + \mathscr{E}_t B_{F,t} \leq & R_{t-1} B_{H,t-1} + \mathscr{E}_t \Psi_{t-1} R^*_{t-1}(1+\tau_{B,t-1}) \Xi(\frac{\mathscr{E}_t B_{F,t-1}}{P_{t-1}}) B_{F,t-1} \\ & + W_t(1-\tau_t) N_t + P_t TR_t. \end{aligned} \tag{7}$$

Here $B_{H,t}$[3] 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. $W_t$, $TR_t$,and $\tau_t$ denote nominal wages, government lump-sum tax/ transfers rebated to the domestic household as in Ljungqvist and Uhlig (2000), the tax rate on labor income in period $t$. Capital controls are modeled as follows: $\tau_{Bt}$ is a subsidy on capital outflows and a tax on capital inflows in the domestic economy.

For the sake of analytical simplicity, we assume that the rest of the world does not impose capital controls. $\Psi_t$ is the risk premium shock at time $t$. The risk premium shock is assumed to follow an $AR(1)$ process as $\log \Psi_t = \rho_\psi \log \Psi_{t-1} + \xi_{\Psi,t}, \quad -1 < \rho_\psi < 1$, where $E(\xi_{\Psi,t}) = 0$ and $\xi_{\Psi,t}$ is i.i.d. over time. The function $\Xi(\frac{\mathscr{E}_t B_{F,t}}{P_t})$ incorporates the cost or the risk premium from international borrowings. The risk premium or $\Xi(\frac{\mathscr{E}_t B_{F,t}}{P_t}) - 1$ 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. $\Xi(\mathscr{B}_F) = 1$ in the steady state, where $\mathscr{B}_{F,t} \equiv \frac{\mathscr{E}_t B_{F,t}}{P_t}$. In the subsequent analysis, $\Xi(\mathscr{B}_{F,t}) = \exp(-\chi \mathscr{B}_{F,t})$ is assumed.

Because foreign households are assumed to trade only in foreign currency bonds, their budget constraint can be written as

$$P^*_t C^*_t + B^*_{F,t} \leq R^*_{t-1} B^*_{F,t-1} + W^*_t(1-\tau^*_t) N^*_t + TR^*_t + \Gamma_t, \tag{8}$$

[3]Net supply of domestic bonds must satisfy $B_{H,t} = 0$.

where $\Gamma_t$ is the intermediation profits from loans to the small country.

First order conditions with respect to consumption, labor hours, and bond holdings can be summarized as follows:

$$\Lambda_t = \beta R_t E_t[\Lambda_{t+1}\frac{P_t}{P_{t+1}}], \tag{9}$$

$$\Lambda_t = \beta R_t^*(1+\tau_{B,t})\Psi_t \Xi(\mathscr{B}_{F,t})E_t[\Lambda_{t+1}\frac{\mathscr{E}_{t+1}P_t}{\mathscr{E}_t P_{t+1}}], \tag{10}$$

$$N_t^{\nu} = (1-\tau_t)w_t\Lambda_t, \tag{11}$$

where $\Lambda_t$ is the Lagrange multiplier of (7) which is the marginal utility of consumption of the domestic households. Combining the risk-sharing conditions, the equilibrium nominal exchange rate is given by

$$E_t[\frac{\Lambda_{t+1}^*}{\Lambda_t^*}\frac{P_t^*}{P_{t+1}^*}] = \Xi(\mathscr{B}_{F,t})\Psi_t(1+\tau_{B,t})E_t[\frac{\Lambda_{t+1}}{\Lambda_t}\frac{\mathscr{E}_{t+1}P_t}{\mathscr{E}_t P_{t+1}}] \tag{12}$$

## 2.2. 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 $i \in [0,1]$ produces its product with a linear technology $Y_t(i) = A_t N_t(i)$, where $A_t$ is a technology process in home country at period $t$, and $Y_t(i)$ and $N_t(i)$ are the output and total labor input of the $i$th firm, respectively.

We consider two kinds of productivity shock process: First one is a transitory productivity shock that follows an $AR(1)$ process as $\log A_t = (1-\rho_A)\log A + \rho_A \log A_{t-1} + \xi_{A,t}$, $0 < \rho_A < 1$, where $E(\xi_{A,t}) = 0$ and $\xi_{A,t}$ is i.i.d. over time. Second one is a permanent productivity shock process such that

$$\mu_{A,t} \equiv \log(A_t/A_{t-1}) = \xi_{A,t},$$

where $E(\xi_{A,t}) = 0$ and $\xi_{A,t}$ is i.i.d. over time.

Each domestic firm $i$ takes $P_{H,t}$ and the aggregate demand as given, and chooses its own product price $P_{H,t}(i)$. In this economy, the distortion occurs due to the existence of monopolistic competition in the goods market and habit persistence. The CPI-DPI ratio $\frac{P_t}{P_{Ht}}$ is linked to the terms of trade $\mathscr{T}_t \equiv \frac{P_{Ft}}{P_{Ht}}$ as follows:

$$\frac{1+\pi_t}{1+\pi_{H,t}} = \frac{\mathscr{H}(\mathscr{T}_t)}{\mathscr{H}(\mathscr{T}_{t-1})}, \tag{13}$$

where $\mathscr{H}(\mathscr{T}_t) \equiv [(1-\gamma)+\gamma \mathscr{T}_t^{1-\eta}]^{\frac{1}{1-\eta}}$, $\pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}} - 1$, and $\pi_t \equiv \frac{P_t}{P_{t-1}} - 1$. The real exchange rate can be expressed in terms of the terms of trade as

$$\mathscr{Q}_t = \mathscr{T}_t \mathscr{H}(\mathscr{T}_t)^{-1} \equiv \mathscr{J}(\mathscr{T}_t) \tag{14}$$

Since the input markets are perfectly competitive, the labor market equilibrium condition can be expressed in terms of the terms of trade

$$\Lambda_t^{-1} N_t^{\nu} = \mathrm{mc}_t (1-\tau_t) A_t \mathscr{H}(\mathscr{T}_t) \tag{15}$$

where $\mathrm{mc}_t \equiv \frac{MC_t}{P_{H,t}}$ is a domestic firm's markup in period $t$ and $MC_t$ is the corresponding nominal marginal cost.

### 2.2.1 Staggered Pricing Firms

Next, consider a staggered-price model à 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, $\alpha$, 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:

$$\max_{\widetilde{P}_{H,t}(j)} E_t\{\sum_{k=0}^{\infty} (\alpha\beta)^k \frac{\Lambda_t}{\Lambda_{t+k}} \left(\frac{P_t}{P_{t+k}}\right) [\widetilde{P}_{H,t}(j) Y_{Ht,t+k}(j) - MC_{t+k} Y_{Ht,t+k}(j)]\}, \tag{16}$$

subject to the sequence of demand constraints

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

where $\widetilde{P}_{H,t+k}(j) = \widetilde{P}_{H,t}(j)$ with a probability $\alpha^k$.

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

$$\frac{\varepsilon}{\varepsilon-1} \mathscr{X}_t = \mathscr{Y}_t, \tag{17}$$

where

$$\mathscr{X}_t = \widetilde{p}_{H,t}^{-1-\varepsilon} Y_t \mathsf{MC}_t + \alpha\beta E_t [\frac{\Lambda_{t+1}}{\Lambda_t} (1+\pi_{H,t+1})^{1+\varepsilon} (1+\pi_{t+1})^{-1} \left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-1-\varepsilon} \mathscr{X}_{t+1}], \tag{18}$$

$$\mathscr{Y}_t = \widetilde{p}_{H,t}^{-\varepsilon} Y_t + \alpha\beta E_t[\frac{\Lambda_{t+1}}{\Lambda_t}(1+\pi_{H,t+1})^{\varepsilon}(1+\pi_{t+1})^{-1}\left(\frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t+1}}\right)^{-\varepsilon}\mathscr{Y}_{t+1}] \quad (19)$$

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 $t$. The domestic price aggregator implies that the relative price $\widetilde{p}_{Ht}$ satisfies the relationship:

$$1 = (1-\alpha)\widetilde{p}_{H,t}^{1-\varepsilon} + \alpha(1+\pi_{H,t})^{\varepsilon-1} \quad (20)$$

## 2.3. IMPORTING FIRMS

To focus on the effect of capital controls on the economy with habit persistence, 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).

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, $\mathscr{E}_t$:

$$P_{F,t}(j) = \mathscr{E}_t P^*_{F,t}(j) \quad (21)$$

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 $t$.

## 2.4. EQUILIBRIUM

Aggregating individual output across domestic firms yields

$$Y_t = \frac{A_t N_t}{\Delta_{H,t}}, \quad (22)$$

where $\Delta_{H,t} = \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} dj$ is the relative domestic price dispersion in period $t$. Note that the relative domestic price distortion $\Delta_{H,t}$ can be rewritten as a recursive form:

$$\Delta_{H,t} = (1-\alpha)\widetilde{p}_{H,t}^{-\varepsilon} + \alpha(1+\pi_{H,t})^{\varepsilon}\Delta_{H,t-1}, \quad (23)$$

with $\Delta_{H,-1}$ given.

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

$$\frac{A_t N_t}{\Delta_{H,t}} = \mathscr{H}(\mathscr{T}_t)^{\eta}[(1-\theta)C_t + \theta \mathscr{Q}_t^{\eta} C_t^*], \tag{24}$$

$$Y_t^* = C_t^* \tag{25}$$

Note that the budget constraint of the home country can be rewritten as

$$C_t + \mathscr{B}_{F,t} = R_{t-1}^* \Psi_{t-1} \Xi(\mathscr{B}_{Ft-1}) \mathscr{B}_{Ft-1} \frac{\mathscr{J}(\mathscr{T}_t)}{\mathscr{J}(\mathscr{T}_{t-1})} \frac{P_{t-1}^*}{P_t^*} + \mathscr{H}(\mathscr{T}_t)^{-1} \frac{A_t N_t}{\Delta_{H,t}} \tag{26}$$

## 3. OPTIMAL CAPITAL CONTROLS

In this section, we will discuss optimal capital controls under alternative tax regimes where the fiscal authority implements either a time-varying or time-invariant tax on labor income to deal with time-varying distortions associated with habit persistence in consumption and monopoly power in goods market.

### 3.1. CAPITAL CONTROLS IN FLEXIBLE PRICE EQUILIBRIUM

Before turning to the optimal capital control and monetary policy in the small open economy with habit persistence and nominal price rigidities, we will first look at the role of optimal capital control in the economy with flexible prices and habit persistence.

There occurs a wedge between domestic production and expenditure to the efficient productivity shock in the economy with the Cole-Obstfeld preference, if households with habit persistence sluggishly adjust their consumption profiles to the shock. Under this circumstance, the monetary authority cannot fully stabilize prices by managing aggregate demand and international capital movement stemming from externalities associated with habit persistence in consumption and the terms of trade. If capital controls are in place to stabilize international capital flows, then there is room for monetary policy to independently manage aggregate demand.

Optimal capital controls in a flexible price equilibrium with productivity shocks only can be addressed in the context of a sticky price equilibrium by setting $\alpha = 0$, $\pi_{H,t} = \pi_t^* = 0$, $\Psi_t = 1$, and $\Delta_{H,t} = \Delta_t^* = 1$ in the small open economy described above. The domestic Ramsey planner's problem can be specified as follows:

$$\max_{\{C_t, N_t, \mathscr{T}_t, \mathscr{B}_{Ft},, \tau_{B_t}\}} E_t \sum_{i=0}^{\infty} \beta^{t+i} \left( \log(C_{t+i} - bC_{t+i-1}) - \frac{N_{t+i}^{1+\nu}}{1+\nu} \right)$$

subject to

$$A_t N_t = (1-\theta)\mathscr{T}_t^{\theta} C_t + \theta \mathscr{T}_t C_t^* \tag{27}$$

$$MU_{C_t}^{-1} N_t^{\nu} = \mathscr{M}^{-1}(1-\tau_t) A_t \mathscr{T}_t^{-\theta} \tag{28}$$

$$E_t\left[\left(\frac{\mathscr{T}_{t+1}}{\mathscr{T}_t}\right)^{1-\theta} \frac{MU_{C_{t+1}}}{MU_{C_t}}\right] \exp(-\chi \mathscr{B}_{Ft})(1+\tau_{B_t}) = E_t\left[\frac{MU_{C^*_{t+1}}}{MU_{C^*_t}}\right] \tag{29}$$

$$\mathscr{T}_t^{-\theta} A_t N_t = C_t - \exp(-\chi \mathscr{B}_{Ft-1}) \left(\frac{\mathscr{T}_t}{\mathscr{T}_{t-1}}\right)^{1-\theta} R^*_{t-1} \mathscr{B}_{Ft-1} + \mathscr{B}_{Ft}. \tag{30}$$

### 3.1.1 Capital Flows without Habit

If households do not have habit persistence in the open economy with complete market, then it is enough for the fiscal authority to implement time-invariant subsidy on labor income equal to $1 - \frac{\varepsilon(1-\theta)}{\varepsilon-1}$ to attain the first best output in the Cole-Obstfeld preference ($\sigma = \eta = 1$) case.

If the fiscal authority implements a time-invariant subsidy on labor income in the open economy with productivity shocks only as in Galí and Monacelli (2005), then the wealth effect and substitution effect on labor hours just cancel out for the unitary substitution case. Proposition 1 shows that the household with a Cole-Obstfeld preference does not change its own working hours to the productivity shocks in the flexible price equilibrium with incomplete market as in the complete market.[4] Moreover, net exports are always balanced under this circumstance, nullifying the capital control intervention as in Farhi and Werning (2012, 2014).

Hence, there is no room for government to intervene in the international capital market to improve welfare in the small open economy with a Cole-Obstfeld preference and productivity shocks only as in Proposition 1.

**Proposition 1 (Farhi and Werning, 2012)**

[4]See Galí and Monacelli (2005) for the complete market case.

*Suppose that* $\Xi(\mathscr{B}_{F,t}) = \exp(-\chi \mathscr{B}_{F,t})$, *and all prices in both domestic and the rest of the world are flexible, i.e.* $\alpha = \alpha^* = 0$ *for all time t and there is no habit persistence. Then, no capital control is needed in the following case.*

*(i)* $\sigma = \eta = 1$ *(Cole-Obstfeld preference) with transitory productivity shocks only.*

(ii) *Permanent productivity shocks only, irrespective of the values of* $\sigma$ *and* $\eta$.

### 3.1.2 Capital Controls and Habit

The existence of habit persistence entails undesirable international capital movements aggravated by the externality of the terms of trade to the exogenous shocks, even if both the intertemporal and intratemporal elasticity of substitution equal one. As long as the income effect and the substitution effect arising from the international relative price change cannot cancel out, the exogenous shock generates undesirable international flows, leaving room for the government to stabilize the international capital movements to improve welfare.

Since it takes time for households to fully adjust their consumption profiles over time, the income effect and the substitution effect associated with the international relative price change do not exactly cancel out in the open economy with habit persistence, even if households have a Cole-Obstfeld preference. There occurs a wedge between home production and expenditure in the Cole-Obstfeld preference case.

**Proposition 2**

*Suppose that all prices in both domestic and the rest of the world are flexible, i.e.* $\alpha = \alpha^* = 0$ *for all time t and optimal labor income taxation to attain the efficient resource allocation within the class of preferences of internal or external habit in consumption, described in Section 2.1. Conditional upon the productivity shocks, net exports are imbalanced in the economy with a Cole-Obstfeld case* $(\sigma = \eta = 1)$.

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

The optimal time-varying labor income taxation[5] to completely eliminate the distortions associated with habit and monopoly power in goods market cannot

[5] We will discuss the optimal labor income tax to deal with distortions associated with habit persistence and monopolistically competitive goods market in next subsection.

guarantee the balance of net exports, leaving room for the government to stabilize the international capital movements using capital controls as in proposition 3.

**Proposition 3**

*Within the class of preferences of either internal or external habit in consumption, described in Section 2.1, it is optimal to implement capital control tax to a positive domestic productivity shock, while it should implement subsidy to a positive foreign productivity shock, regardless for $\sigma$ and $\eta$ in the flexible price equilibrium.*

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

Proposition 3 contrasts with Farhi and Werning (2012, 2014) who find no room for capital controls in flexible price equilibrium with either transitory productivity shocks for the Cole-Obstfeld preference case or permanent productivity shocks for general preference case when households do not have habit persistence in consumption.

In the small open economy with habit persistence, household's sluggish adjustment of consumption prevents from efficient resource allocation over time, entailing a wedge between domestic output and expenditure to production shocks even if household have a Cole-Obstfeld preference. Hence, government can intertemporally manipulate the terms of trade to reallocate demand and improve upon welfare.

It is notable that there is room for optimal capital controls to reallocate resources intertemporally to the permanent productivity shocks in the economy with habit persistence. To look at the role of capital control in the economy with flexible prices and habit persistence, consider the log-linearization of (12) around the steady-state:

$$\widehat{\tau}_{Bt} = -\psi_t + \eta \widehat{\mathscr{B}}_{Ft} - E_t[\widehat{\Lambda}_{t+1} - \widehat{\Lambda}_t] + E_t[\widehat{\Lambda}^*_{t+1} - \widehat{\Lambda}^*_t] - (1-\theta) E_t[\widehat{\mathscr{T}_{t+1}} - \widehat{\mathscr{T}_t}] \quad (31)$$

Suppose that a domestic productivity permanently increases one percentage. Then, both domestic consumption and the terms of trade immediately increase one percentage if households do not have any habit persistence in consumption. Hence, both the growth rate of the expected future marginal utility of consumption and the terms of trade depreciation rate equal zero, i.e. $E_t \widehat{\Lambda}_{t+1} = \widehat{\Lambda}_t$, $E_t \widehat{\mathscr{T}_{t+1}} = \widehat{\mathscr{T}_t}$, implying $\widehat{\tau}_{Bt} = 0$ in the absence of habit persistence. If households have habit persistence in consumption, then they sluggishly increase their consumption to the shock, inducing both the real interest rate and the terms of trade to increase one percentage over time. That is, $E_t\widehat{\Lambda}_{t+1} > \widehat{\Lambda}_t$, and $E_t\widehat{\mathscr{T}_{t+1}} > \widehat{\mathscr{T}_t}$ to the permanent domestic productivity shock. Hence, the government needs to implement capital control tax to stabilize international capital movement across the border to the permanent productivity shock in the presence of habit persistence in consumption.

## 3.2. CAPITAL CONTROLS AND MONETARY POLICY IN STICKY PRICE EQUILIBRIUM

Before turning to the optimal capital control and monetary policy in the economy with nominal price rigidities and habit persistence, we will first characterize the optimal tax rate on labor income to restore efficient output in the small economy described above.

### 3.2.1 A Simplification of the Ramsey Problem

Given distortions associated with habit persistence, monopoly power in goods market, and the terms of trade externalities, the Ramsey planner who internalizes both the terms of trade and habit persistence in consumption chooses optimal labor income tax, capital control tax, and monetary policy prescriptions for $\{\tau_t, \tau_{B,t}, R_t\}_{t=0}^{\infty}$ as well as the plans for $\{C_t, N_t, \mathscr{B}_{F,t}, \pi_{H,t}, \mathsf{mc}_t, \pi_t, \mathscr{T}_t, \widetilde{p}_{H,t}, \mathscr{X}_t, \mathscr{Y}_t, \Delta_{H,t}\}_{t=0}^{\infty}$ to maximize the welfare of the representative household subject to 11 equations of private sector optimization and market clearing conditions: (9), (12), (13), (15), (17), (18), (19), (20), (23), (24), (26), taking the initial conditions for the variables for $C_{-1}, \Delta_{H,-1}$, and the exogenous technology and risk premium shock processes $\{A_t, A_t^*, \Psi_t\}_{t=0}^{\infty}$, and foreign variables as given.

The Ramsey problem can be simplified by reformulating the problem with the set of constraints for the relevant Ramsey allocation as in Christiano *et al.* (2010).

**Proposition 4**

*The Ramsey problem in a small open economy associated with* $\{\tau_t, \tau_{B,t}, R_t, C_t, N_t, \mathscr{B}_{F,t}, \pi_{H,t}, \mathsf{mc}_t, \pi_t, \mathscr{T}_t, \widetilde{p}_{H,t}, \mathscr{X}_t, \mathscr{Y}_t, \Delta_{H,t}\}_{t=0}^{\infty}$ *to maximize (1) subject to 11 equations of private sector optimization and market clearing conditions: (9), (12), (13), (15), (17), (18), (19), (20), (23), (24), (26) can be simplified as the Ramsey problem associated with* $\{C_t, N_t, \pi_{H,t}, \mathscr{T}_t, \widetilde{p}_{H,t}, \Delta_{H,t}\}_{t=0}^{\infty}$ *to maximize (1)* *subject to 3 equations: (20), (23), (24), taking the optimal labor income and capital control tax rates, the initial conditions for the variables for $C_{-1}$, $\Delta_{H,-1}$, and the exogenous stochastic processes as given.*

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

Since the block of variables for $\{R_t, \tau_t, \tau_{B,t}, \mathsf{mc}_t, \pi_t, \mathscr{B}_{F,t}, \mathscr{X}_t, \mathscr{Y}_t\}$ do not enter the Ramsey problem anywhere else, the Ramsey problem can be simplified as the problem of finding optimal path for $\{C_t, N_t, \pi_{H,t}, \mathscr{T}_t, \widetilde{p}_{H,t}, \Delta_{H,t}\}_{t=0}^{\infty}$ with four constraints, (20), (23), and (24), given an optimal time-varying tax rate as well as $C_{-1}$, $\Delta_{H,-1}$, and the exogenous stochastic variables. The block of variables for $\{R_t, \tau_t, \tau_{B,t}, \mathsf{mc}_t, \pi_t, \mathscr{B}_{F,t}, \mathscr{X}_t, \mathscr{Y}_t\}$ can be obtained from the corresponding market equilibrium conditions, (9), (12), (13), (15), (17), (18), (19) and (26). This makes the analysis of optimal capital controls and monetary policy rules simple. We will first discuss the optimal monetary policy under a time-varying labor income tax and capital control rule and then turn to the optimal labor income tax and capital control problem.

### 3.2.2 Optimal Labor Income Tax

We now turn to optimal labor income taxation to completely eliminate distortions associated with habit persistence and monopoly power in goods market. As in the small open economy with complete markets, optimal tax on labor income takes a very complicated form in open economies with incomplete asset market and habit persistence even for the Cole-Obstfeld case: It depends on the past and current terms of trade, net foreign asset, and consumption as well as the degree of habit persistence and the degree of openness.[6]

Since the optimal time-varying tax on labor income requires an extreme fine tuning on the basis of precise and exact information about the state of the world such as the stochastic discount factor, future expected consumption surplus, it is

[6]The optimal labor income tax rate associated with a Cole-Obstfeld preference is given by

$$\tau_t = 1 - \frac{\varepsilon}{\varepsilon - 1} \frac{[\mathscr{T}_t^{\theta} + \mathscr{A}(\mathscr{B}_{F,t}, T_t, Y_t, \mathscr{B}_{F,t-1}, T_{t-1}, C_t^*, R_{t-1}^*, \Psi_t, \theta)]}{[(1-\theta)\mathscr{T}_t^{\theta} + \mathscr{A}(\mathscr{B}_{F,t}, T_t, Y_t, \mathscr{B}_{F,t-1}, T_{t-1}, C_t^*, R_{t-1}^*, \Psi_t, \theta)]}(1 - b\widetilde{R}_t^{-1})$$

for external habit, and

$$\tau_t = 1 - \frac{\varepsilon}{\varepsilon - 1} \frac{[\mathscr{T}_t^{\theta} + \mathscr{A}(\mathscr{B}_{F,t}, T_t, Y_t, \mathscr{B}_{F,t-1}, T_{t-1}, C_t^*, R_{t-1}^*, \Psi_t, \theta)]}{[(1-\theta)\mathscr{T}_t^{\theta} + \mathscr{A}(\mathscr{B}_{F,t}, T_t, Y_t, \mathscr{B}_{F,t-1}, T_{t-1}, C_t^*, R_{t-1}^*, \Psi_t, \theta)]}$$

for internal habit. Here $\widetilde{R}_t^{-1} \equiv \beta E_t\left[\frac{C_{t+1} - bC_t}{C_t - bC_{t-1}}\right]$ is the inverse of the domestic riskless real interest rate at time $t$ and practically difficult to restore the efficient natural level of output at every state and every period by implementing the optimal time-varying tax on labor income to completely eliminate time-varying distortions associated with habit persistence and monopoly power in goods market. Hence, it is more interesting and practical to address the resource allocations and welfare associated with capital controls and a time-invariant labor income tax regime wherein the fiscal authority implements time-invariant tax/subsidy $(\tau)$ to attain the efficient steady-state output in a small economy with internal or external habit.

As in the small open economy with complete markets, the optimal steady-state labor income tax rate to attain the efficient steady state in the economy with a Cole-Obstfeld preference equals $1-\mathscr{M}(1-b\beta)(1-\theta)$ and $1-\mathscr{M}(1-\theta)$, for external habit and internal habit, respectively.

### 3.2.3 Optimal Capital Controls and Monetary Policy

To find the optimal capital control and monetary policy prescription conditional on the optimal time-varying labor income tax to completely eliminate time-varying distortions associated with habit persistence and monopolistic competition in goods market, let $\mathrm{V}(C_{t-1},\mathscr{F}_t)$ represent the value function in the Bellman equation for the optimal policy problem in period $t$, where $\mathscr{F}_t$ represent the given variables of foreign country and exogenous shocks in period $t$.

The Ramsey monetary policy problem conditional on the optimal time-varying tax can be recast as follows:

$$\begin{aligned}\mathrm{V}(C_{t-1},\mathscr{F}_t) = \max{}_{\{C_t,N_t,\pi_{H,t},\mathscr{T}_t,\ \tilde{p}_{H,t},\ \Delta_{H,t}\}}[&\frac{(C_t-bC_{t-1})^{1-\sigma}}{1-\sigma}-\frac{N_t^{1+\nu}}{1+\nu}\\ &+\beta E_t\mathrm{V}(C_t,\mathscr{F}_{t+1})],\end{aligned} \tag{32}$$

subject to

---

$$\mathscr{A}(\mathscr{B}_{F,t},T_t,Y_t,\mathscr{B}_{F,t-1},T_{t-1},C_t^*,R_{t-1}^*,\Psi_t,\theta)\equiv\frac{-\theta[(1-\theta)\mathscr{T}_t^{\theta-1}C_t+C_t^*]}{\mathscr{F}(\mathscr{B}_{F,t},T_t,Y_t,\mathscr{B}_{F,t-1},T_{t-1},R_{t-1}^*,\Psi_t,\theta)},$$

$$\begin{aligned}&\mathscr{F}(\mathscr{B}_{F,t},T_t,Y_t,\mathscr{B}_{F,t-1},T_{t-1},R_{t-1}^*,\Psi_t,\theta)\\ \equiv\ &[(1-\theta)(\Xi'(\mathscr{B}_{F,t})\mathscr{B}_{F,t}+\Xi'(\mathscr{B}_{F,t}))^{-1}\Psi_t^{-1}\mathscr{T}_t^{-1}\Xi(\mathscr{B}_{F,t})\mathscr{B}_{F,t}\\ &+\theta\mathscr{T}_t^{-\theta-1}Y_t-(1-\theta)\left(\frac{\mathscr{T}_t}{\mathscr{T}_{t-1}}\right)^{1-\theta}\Psi_t^{-1}\mathscr{T}_t^{-1}\Xi(\mathscr{B}_{F,t-1})R_{t-1}^*\mathscr{B}_{F,t-1}].\end{aligned}$$

$$\frac{A_t N_t}{\Delta_{Ht}} = (1-\theta)\mathscr{H}(\mathscr{T}_t)^{\eta} C_t + \theta \mathscr{T}_t^{\eta} C_t^*, \tag{33}$$

$$1 = (1-\alpha)\widetilde{p}_{H,t}^{1-\varepsilon} + \alpha(1+\pi_{H,t})^{\varepsilon-1}, \tag{34}$$

$$\Delta_{Ht} = (1-\alpha)\widetilde{p}_{H,t}^{-\varepsilon} + \alpha(1+\pi_{H,t})^{\varepsilon}\Delta_{H,t-1}, \tag{35}$$

with the exogenous technology and risk premium shock processes $\{A_t, A_t^*, \Psi_t\}_{t=0}^{\infty}$ , an initial consumption $C_{-1}$, variables of foreign country in $\mathscr{F}_t$, and the optimal tax rates $\tau_t$ and $\tau_{Bt}$ given.

Proposition 5 states that conditional upon the time-varying optimal labor income tax in place, the monetary policy prescription of domestic price stability is optimal in a small open economy model with habit persistence.

**Proposition 5**

*Domestic price stability is optimal in a small open economy with habit persistence only if a time-varying optimal labor tax rate to completely eliminate distortions associated with habit and monopoly power in goods market is levied.*

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

It is well known that domestic price stability is optimal in the economy with the Cole-Obstfeld preference and productivity shocks only, irrespective of asset market structure (Corsetti *et al.*, 2010). Since the net export is always balanced under this circumstance, there is no room for government to implement capital controls. As we have discussed in the previous subsection, however, there occurs a wedge between domestic production and expenditure in the economy with a Cole-Obstfeld preference, habit persistence, and productivity shocks only.

Suppose that there occurs a positive domestic productivity shock. Since the domestic output expands and its price falls to the positive domestic productivity shock, the domestic monetary authority reacts by reducing its policy rate. There occurs a terms of trade depreciation, entailing undesirable trade surplus. Hence, it is necessary for the government to implement time-varying capital control tax to moderate the effect of shocks on the economy.

**Proposition 6**

*Conditional upon optimal monetary policy and either time-varying labor income tax or time-invariant labor income tax, the optimal capital control tax should be time-varying in the economy with staggered prices and productivity shocks for the Cole-Obstfeld preference case.*

## 4. QUANTITATIVE ANALYSIS

In this section, we will explore how government reacts to the exogenous shocks to improve welfare in the economy augmented with habit persistence under alternative tax regimes. Specifically, we discuss the effect of capital control on welfare and resource allocations by employing the second-order approximation methods along the line of Stephanie and Uribe (2004).

### 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. $\sigma^{-1}$ and $\eta$ to 1, and the Frisch labor supply elasticity of labor supply $\nu^{-1}$ to 1/3 in the benchmark model. The degree of habit persistence is set to values in $[0, 0.6]$ to look at how aggressive capital controls should be to dampen the undesirable capital fluctuations to the exogenous shocks.

Table 1: Parameter Values

| Parameter | Values | Description and definitions |
|---|---|---|
| $b$ | 0.5 | Degree of externality in consumption |
| $\varepsilon$ | 6 | Elasticity of demand for a good with respect to its own price |
| $\sigma$ | 1 | Relative risk aversion parameter |
| $\alpha$ | 0, 2/3 | Fraction of firms that do not change their prices in a given period |
| $\eta$ | 1 | Elasticity of substitution between home and foreign goods |
| $\chi$ | $10^{-2}$ | Risk premium |
| $\nu$ | 3 | Inverse of elasticity of labor supply |
| $r$ | 0.016 | Steady state real interest rate |
| $\rho_{A,}\ \rho_{Y^*}$ | [0,1] | Persistence of domestic and foreign productivity shock |
| $\sigma_A,\ \sigma_Y^*$ | 0.0056 | Standard deviation of domestic and foreign productivity shock |

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 Galí and Monacelli (2005). Next, we set the elasticity of substitution among varieties $\varepsilon$ to 6, implying the average size of markup, $\mu$ to be 1.2 as in Galí and Monacelli (2005). The value of the nominal rigidity parameter $\alpha$ is set to 2/3 to match the value of Bils and Knelow (2004).

Finally, the exogenous driving process, i.e. the (log) productivity, $a_t (\equiv \log A_t)$ 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).

$$\begin{aligned} a_t &= 0.85 a_{t-1} + \xi_{A,t}, \ \ \sigma_A = 0.0056, \\ y_t^* &= 0.85 y_{t-1}^* + \xi_t^*, \ \ \sigma_{y^*} = 0.0056. \end{aligned} \tag{36}$$

The permanent productivity shock $\mu_{A,t} (\equiv a_t - a_{t-1}) = \xi_{A,t}$ is also discussed. The (log) risk premium shock, $\psi_t (\equiv \log \Psi_t)$ is assumed to follow an AR(1) process:

$$\psi_t = 0.85 \psi_{t-1} + \xi_{\psi,t}, \ \sigma_\psi = 0.0056.$$

## 4.2. SOME INTUITION ON OPTIMAL CAPITAL CONTROLS

Suppose that both domestic and the rest of the world monetary authorities implement domestic price index inflation targeting rules, i.e. $\pi_{H,t} = \pi_t^* = 0$ for all time $t$. Then, the log-linearization of (12) around the steady state in the Cole-Obstfeld case leads to

$$\widehat{\tau}_{Bt} = -\widehat{\psi}_t + \eta \widehat{\mathscr{B}}_{Ft} - E_t[\widehat{\Lambda}_{t+1} - \widehat{\Lambda}_t] + E_t[\widehat{\Lambda}_{t+1}^* - \widehat{\Lambda}_t^*] - (1-\theta) E_t[\widehat{\mathscr{T}}_{t+1} - \widehat{\mathscr{T}}_t] \tag{37}$$

First, consider the flexible price equilibrium with a domestic productivity shock in the economy without habit persistence. Then, the trade account is always zero to productivity shocks as in Galí and Monacelli (2005):

$$Y_t = \mathscr{T}_t^{1-\theta} Y_t^*, \tag{38}$$

Therefore, (37) and (38) imply that $\widehat{\tau}_{B,t} = 0$ for productivity shocks in the flexible price equilibrium as in Farhi and Werning (2012, 2014).

Next, consider the flexible price equilibrium with habit persistence. The flexible price does not guarantee the balance of net export to the productivity shocks because the wealth effect and substitution effect to the international relative price change cannot cancel out even in the Cole-Obstfeld case.

Conditional on the optimal time-varying labor income taxation and monetary policy in place, we can inspect the role of optimal capital control tax/subsidy by log-linearizing the risk-sharing condition (12) around the steady state:

$$\widehat{\tau}_{Bt} = -\widehat{\psi}_t + \eta \widehat{\mathscr{B}}_{F,t} + (\widehat{R}_t - \widehat{R}_t^*) - E_t[\widehat{\mathscr{E}}_{t+1} - \widehat{\mathscr{E}}_t)] \tag{39}$$

(39) displays that the interest rate differential between home and foreign countries and the expected depreciation of the real exchange rate affect capital controls.

First, consider the response of capital controls to the domestic productivity shock. A positive domestic productivity shock expands domestic output and decreases domestic goods prices, depreciating the terms of trade and the real exchange rate. As the output gap and inflation gap are negative to the positive productivity shock, the domestic monetary authority needs to lower its interest rate. In the presence of habit persistence where consumption slowly responds to the interest rate change, the monetary authority needs to decrease its policy rate persistently to induce a specified size of consumption response. That is, the decrease in the nominal interest rate in the economy embedded with habit has to be larger than the interest rate decrease in the economy without habit, generating a trade surplus to the favorable domestic productivity shock: A lower domestic interest rate and a smaller depreciation of the real exchange rate are accommodated by capital control taxation to the capital outflows, i.e. a negative value of $\widehat{\tau}_{Bt}$ to the positive domestic productivity shock.

Next, consider the response of the optimal capital controls to the foreign productivity shock. The positive foreign productivity shock results in an appreciation of the terms of trade which induces households divert their demand for goods toward foreign goods. Hence, the implementation of the optimal capital control tax is needed to moderate the effect of the terms of trade appreciation on the domestic economy.

Finally, consider the response of the optimal capital controls to the risk premium shock. The unfavorable risk premium shock decreases the demand of domestic currency, resulting in the exchange rate depreciation. The monetary authority needs to rise its policy rate to induce foreign capital inflows toward the domestic economy. The contractionary monetary policy weakens the domestic household's demand for consumption, resulting a trade surplus. Note that the Euler equation implies that the domestic monetary authority needs to persistently raise its interest rate to the risk premium shock to achieve its objective as households with habit persistence adjust very slowly their consumption profiles to the shock. As households with habit adjust their consumption profiles more sluggishly than the households without habit, the government needs to implement capital control tax policy more persistently in the economy with habit than in the economy without habit.

The direction of the optimal capital controls depends upon the responsiveness of the interest rate to the shock. If the increase in the interest rate dominates the risk premium shock itself, then the optimal capital controls should take a form of subsidy rather than tax to capital outflows at the outset of the risk premium shock. (37) also shows that the optimal capital controls are more likely to take a form of subsidy rather than tax to capital outflows when households are less willing to adjust their labor supplies to the real wage change, i.e. as the Frisch labor supply elasticity of substitution $(\nu^{-1})$ decreases.

## 4.3. DYNAMIC RESPONSE IN FLEXIBLE PRICE EQUILIBRIUM

### 4.3.1 Dynamic Response to Productivity Shocks

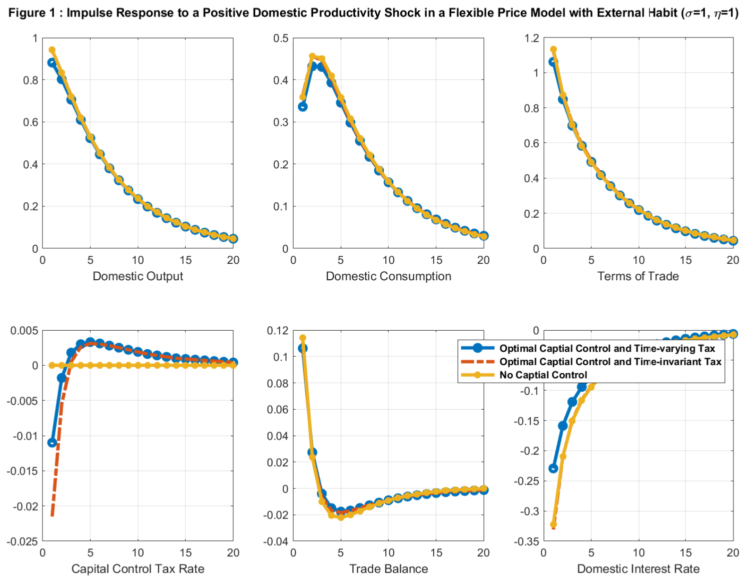
The resource allocation in the small open economy with incomplete markets is the same as the one of the complete markets and next exports are always balanced in the small open economy with a Cole-Obstfeld preference and flexible prices. Hence, government does not need to use capital control policy to stabilize the economy with transitory domestic and foreign productivity shocks (Farhi and Werning, 2014).

However, if households have habit persistence in consumption, then the income effect and substitution effect to the productivity shocks do not exactly cancel out even in the Cole-Obstfeld preference case because households gradually adjust their consumption profiles to the international relative price change. Hence, the government can improve upon its welfare by using capital controls in response to productivity shocks.

Figure 1 and Figure 2 show the response of some selected variables to the positive domestic productivity shock in the economy with external and internal habit persistence, respectively, when prices are flexible. The long star lines (-*) represent the response of variables under a time-invariant labor income tax, but no capital control regime, while the long circle lines (-o) and the long dotted lines (-.) represent the response of variables under an optimal capital control and labor income tax regime, and an optimal capital control and time-invariant labor income tax regime, respectively. First, note that the positive domestic productivity shock yields a depreciation of terms of trade with a trade account surplus, and an expansion of output with a fall of domestic prices. As the relative price of domestic goods falls, households divert their demand for goods toward domestic goods, yielding a strong expansion of the domestic output and trade surplus. As governments implements the optimal capital controls which leans against the wind, the terms of trade depreciation rate is moderated, which increases consumption.

Figure 3 and Figure 4 present the response of some selected variables to

Figure 1: Impulse Response to a Positive Domestic Productivity Shock in a Flexible Price Model with External Habit $(\sigma = 1, \eta = 1)$



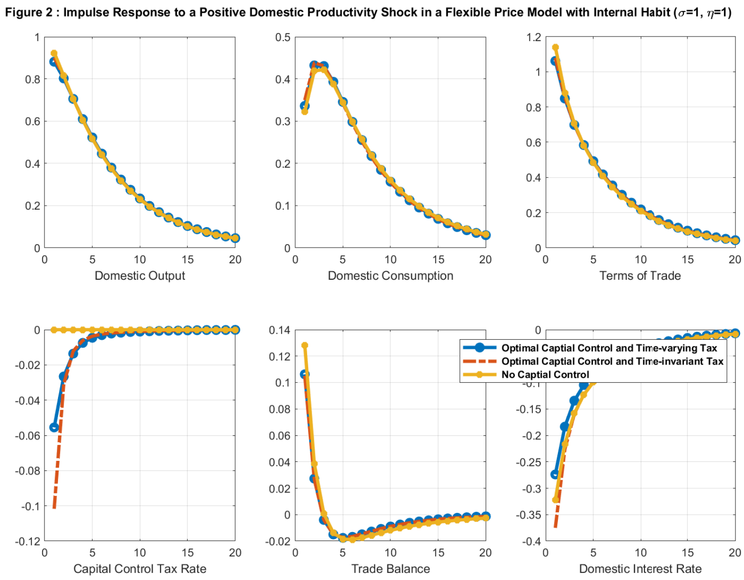

the positive domestic productivity shock in economies embedded with external and internal habit persistence, respectively, varying the persistence of the shock, when the fiscal authority implements time-invariant labor income tax rate to eliminate the distortions associated with habit and monopolistic competition in goods market. Figure 3 and Figure 4 displays that the more persistent is the productivity shock, the more prolonged is the response of consumption to the shock, and the less effective the capital control policy. The capital controls are still effective to stabilize the economy to permanent productivity shocks in the economy with habit persistence.

### 4.3.2 Dynamic Response to Risk Premium Shock

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

Under the laissez-faire wherein no capital controls are in place, the positive risk premium shock decreases the demand of domestic currency, resulting in

Figure 2: Impulse Response to a Positive Domestic Productivity Shock in a Flexible Price Model with Internal Habit ($\sigma = 1, \eta = 1$)

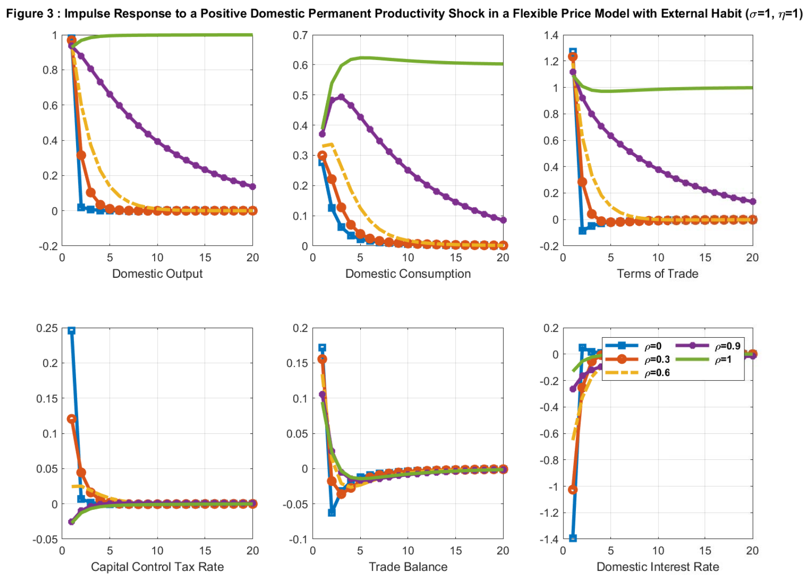



a large depreciation of the exchange rate and the terms of trade, a substantial drop in consumption, and a hike of the domestic interest rate. When an optimal taxation on capital outflows and optimal monetary policy are implemented, there occurs a smaller increase in nominal interest rate and the exchange rate. The optimal capital controls and monetary policy yield a moderate consumption fall and a mitigated trade surplus, compared to the laissez-faire.

Figure 5 and Figure 6 display the impulse response of some selected variables to the unfavorable risk premium shock in the sticky price model with external and internal habit persistence, respectively. The long dotted lines (-) represent the response of variables under a time-invariant labor income tax but no capital control regime, and the long circle lines (-o) represent the response of variables under an optimal labor income and capital control tax regime. The long star lines (-*) represent the response of variables under a time-invariant labor income tax and optimal capital control tax regime.

There occurs a very substantial increase in both the terms of trade and the interest rate to the risk premium shock, leading to a significant fall in domestic

Figure 3: Impulse Response to a Positive Domestic Permanent Productivity Shock in a Flexible Price Model with External Habit $(\sigma = 1, \eta = 1)$



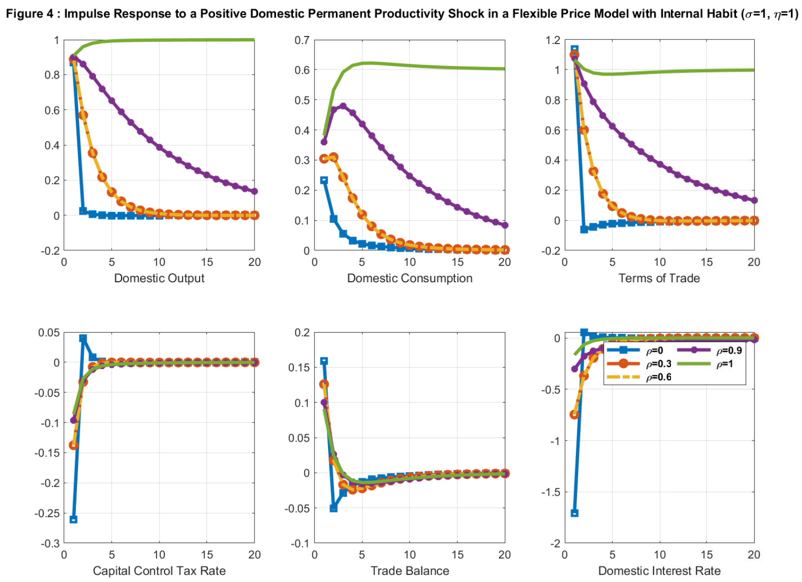

consumption, when the government does not implement any capital control tax to moderate the effect of the risk premium shock on capital outflow. Domestic output excessively expands to the risk premium shock as domestic households with habit persistence work more than necessary. As a result, there occurs a substantial trade surplus. Capital control taxes buffer the economy against the risk premium shock by moderating excessive capital outflows as well as the depreciation rate of the terms of trade. As a result, the purchasing power of the domestic households deteriorates less, playing a positive role in improving welfare. Resource allocations and relevant prices are more stabilized under capital controls in place than under laissez-faire.

#### 4.3.3 Habit Persistence and Capital Controls

In this subsection, we will discuss the effect of habit persistence on the optimal capital control tax.

Figure 7 and Figure 8 display that government implements more aggressive

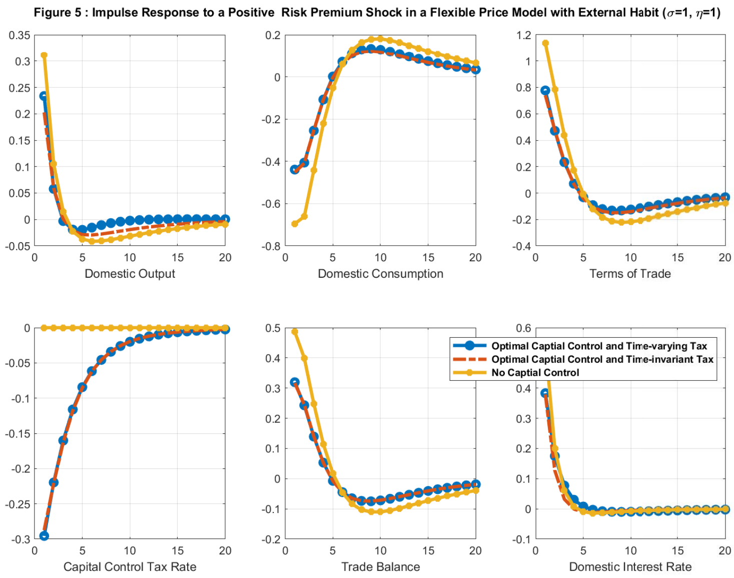
Figure 4: Impulse Response to a Positive Domestic Permanent Productivity Shock in a Flexible Price Model with Internal Habit $(\sigma = 1, \eta = 1)$




capital controls to moderate undesirable international capital movements to the productivity shocks in the economy with external and internal habit persistence, respectively. The habit in consumption aggravates the externality of the terms of trade even to the efficient productivity shocks in the economy with incomplete markets. Hence, the higher the degree of habit persistence in consumption, the more distorted the international resource allocations, calling for more aggressive capital control to international capital movement required to stabilize the economy and to improve upon welfare.

Figure 9 and Figure 10 present the impulse response of some selected variables to the inefficient risk premium shock in the economy with external and internal habit, varying the degree of habit persistence. Figure 9 and 10 show that the higher the degree of habit persistence, the more aggressive capital control to moderate capital movements. The optimal capital controls can dampen down the unnecessary swings of the economy by alleviating the terms of trade externality compounded with habit.

Figure 5: Impulse Response to a Positive Risk Premium Shock in a Flexible Price Model with External Habit $(\sigma = 1, \eta = 1)$



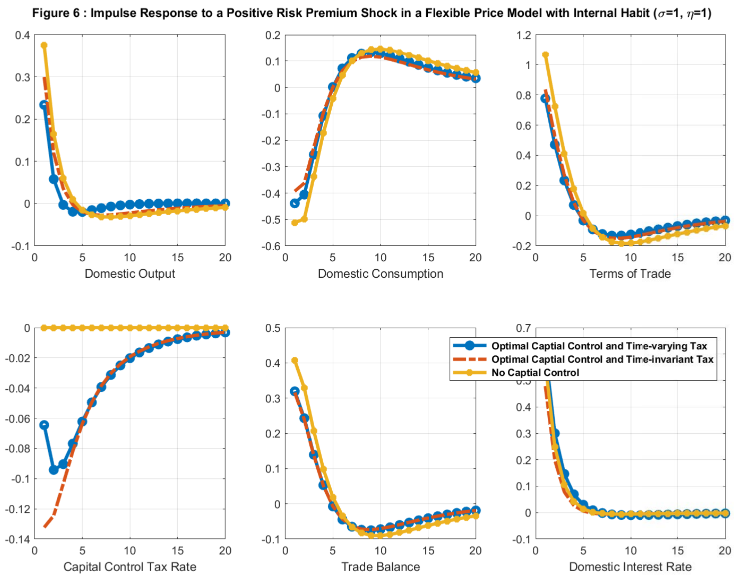

### 4.4. DYNAMIC RESPONSE IN STICKY PRICE EQUILIBRIUM

#### 4.4.1 Dynamic Response to Domestic Productivity Shock

Figure 11 and Figure 12 show the response of some selected variables to the positive domestic productivity shock in the staggered price economy embedded with external and internal habit, conditional on optimal time-varying labor income taxation. It is optimal to stabilize domestic price if time-varying distortions associated with habit persistence and monopolistically competitive goods market are completely eliminated by optimal labor income taxation as in Proposition 5.

Notice that the government does not need to react to productivity shocks using capital control policy when households do not have any habit persistence. In the presence of habit persistence in consumption, productivity shocks entail trade imbalances over time, leaving room for capital control policy to moderate capital movement across the border. As the degree of habit persistence increases, the productivity shock generates more sluggish consumption response as well as

Figure 6: Impulse Response to a Positive Risk Premium Shock in a Flexible Price Model with Internal Habit $(\sigma = 1, \eta = 1)$




more persistent capital movements across the border. Hence, the government needs to moderate the capital movement across the border using more persistent capital control taxation as in Figure 7 and Figure 8.

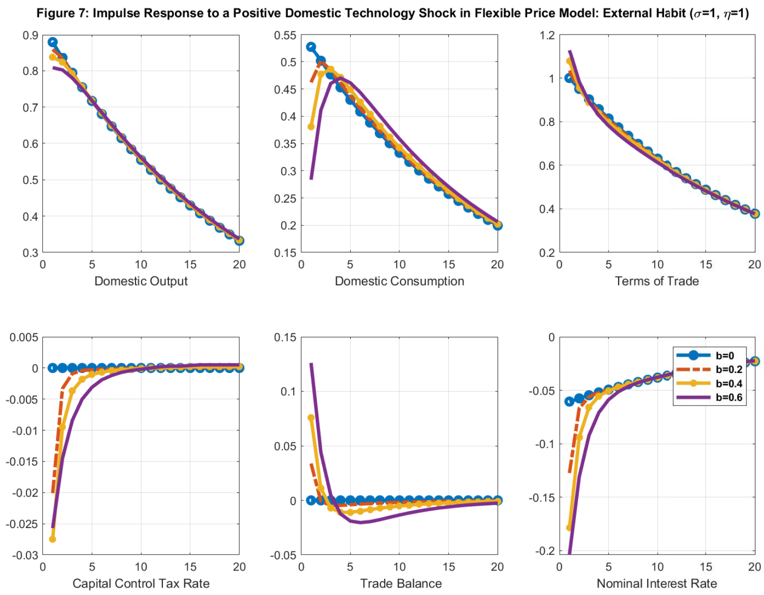
There is negligible difference between the responses of selected variables under a time-varying labor income tax regime and under a time-invariant labor income tax regime, except for the response of domestic price inflation. The burden of the monetary authority and capital control policy authority is smaller under a time-varying labor income tax regime than under a time-invariant labor income tax regime.

### 4.4.2 Dynamic Response to Risk Premium Shock

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

Figure 13 and Figure 14 show the impulse response of some selected variables to the unfavorable risk premium shock in the sticky price model with

Figure 7: Impulse Response to a Positive Domestic Technology Shock in a Flexible Price Model: External Habit ($\sigma = 1, \eta = 1$)

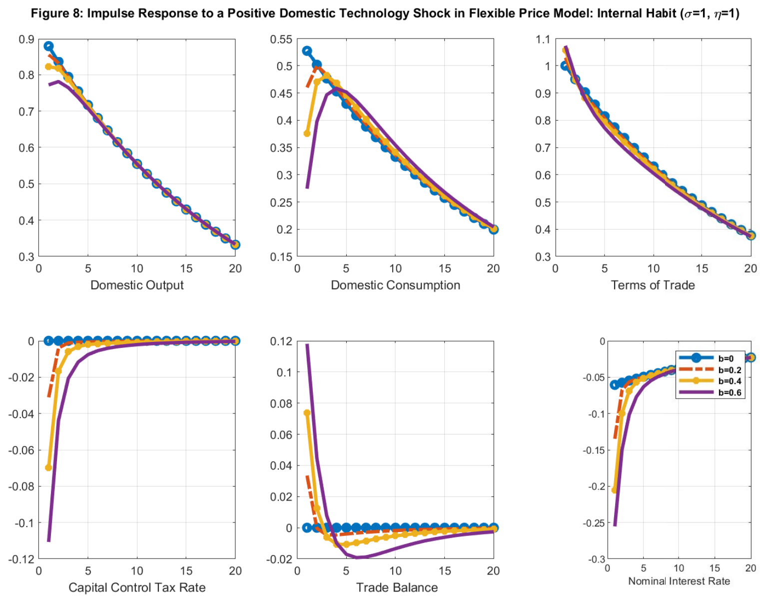



external and internal habit persistence, respectively. The long dotted lines (-) represent the response of variables under a time-invariant labor income tax and non-capital control regime, and the long circle lines (-o) represent the response of variables under an optimal labor income and capital control tax regime. The long star lines (-*) represent the response of variables under a time-invariant labor income tax and optimal capital control tax regime.

If the government does not implement any capital control tax to moderate the effect of the risk premium shock on the economy, then both the terms of trade and the interest rate increase very strongly to the risk premium shock. While domestic consumption significantly falls, domestic output excessively increases to the risk premium shock as domestic households with habit persistence work hard more than necessary.

Capital control tax moderates excessive capital outflows as well as a sharp depreciation of the terms of trade to buffer the impact of the risk premium shock against the domestic economy. The purchasing power of the domestic house-

Figure 8: Impulse Response to a Positive Domestic Technology Shock in a Flexible Price Model: Internal Habit ($\sigma = 1, \eta = 1$)



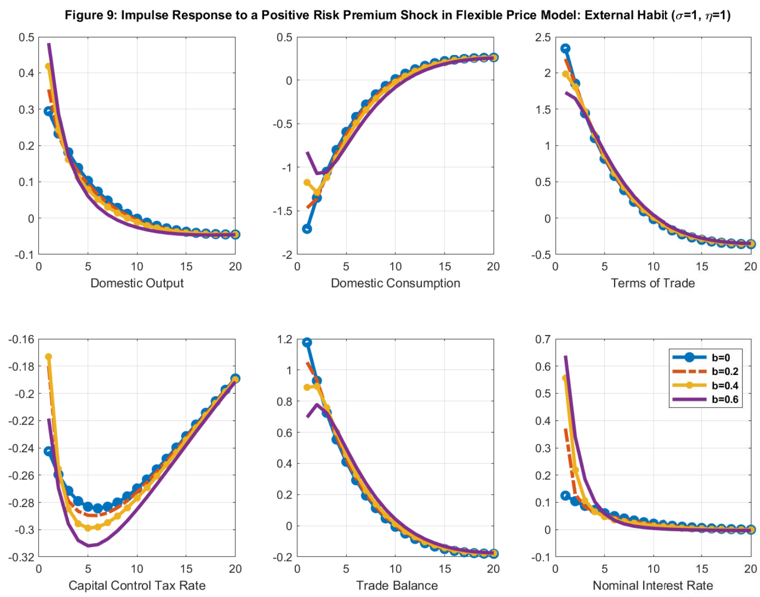

holds deteriorates less. Resource allocations as well as the prices are more stabilized under a capital control policy regime than under laissez-faire. The implementation of optimal labor income tax to completely eliminate the distortions associated with habit persistence and monopoly power in goods market leads the monetary policy authority to stabilize domestic prices. The optimal time-varying labor income taxation and capital control are more successful in stabilizing the resource allocations and prices than other policy mix regimes.

## 4.5. WELFARE AND RESOURCE ALLOCATIONS

In this subsection, we will discuss the effect of habit persistence on resource allocations and the optimal tax rate by employing the second-order approximation methods along the line of Stephanie and Uribe (2016).

Figure 15 shows the welfare gain from capital controls in the economy augmented with flexible price, external habit persistence, and productivity shocks only, varying the persistence of productivity shocks. The more persistent the

Figure 9: Impulse Response to a Positive Risk Premium Shock in a Flexible Price Model: External Habit ($\sigma = 1, \eta = 1$)

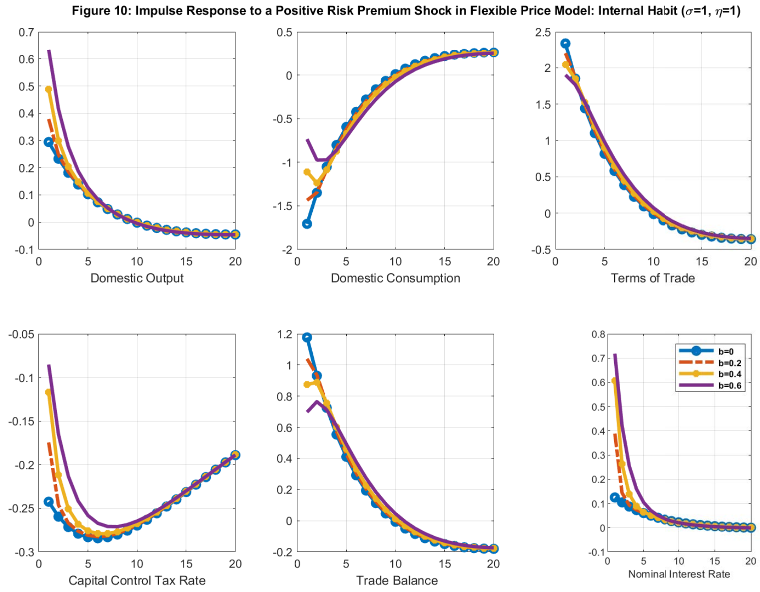



productivity shocks, the less effective the capital controls. There is less room for the government to shift expenditure over time by implementing capital controls. The difference between the welfare with optimal capital control and the welfare associated without optimal capital control amplifies with persistence of the productivity shock.

Table 2 and Table 3 present the welfare and resource allocations under alternative policy rules for the Cole-Obstfeld case when prices are flexible. In Table 2 and Table 3, $\mathscr{W}_{C1}$ denotes the welfare difference associated with three shocks, i.e. both domestic and foreign productivity shocks and risk premium shock, while $\mathscr{W}_{C2}$ represents the welfare difference associated with only both domestic and foreign productivity shocks.

First, notice that the difference between the welfare with the optimal time-varying labor income taxation and capital controls and the welfare associated with the optimal capital controls and time-invariant labor income taxation is negligible. However, the difference between the welfare associated with the optimal

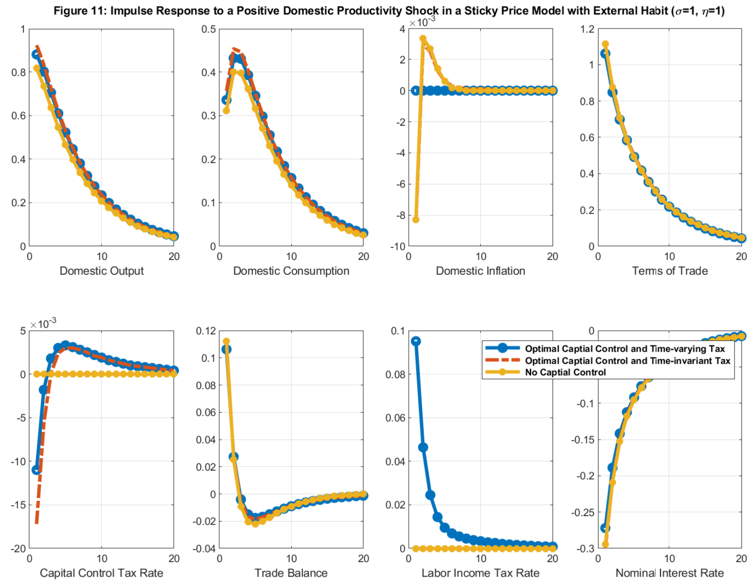
Figure 10: Impulse Response to a Positive Risk Premium Shock in a Flexible Price Model: Internal Habit $(\sigma = 1, \eta = 1)$




capital controls and time-invariant labor income taxation and the welfare associated with no capital controls and time-invariant labor income taxation is substantial, even if there are efficient productivity shocks only. The welfare gain from the optimal capital control and labor income taxation relative to time-invariant labor income taxation and no capital control amounts to 0.0013% and 0.0298% of the steady-state consumption for external and internal habit, respectively, when there are only efficient domestic and foreign productivity shocks. The large welfare gain from capital controls in internal habit relative to external habit reflects the fact that the effect of the productivity shock is more prolonged and persistent in the economy with internal habit than in the economy with external habit. These welfare gains increase to 0.0094% and 0.0302% of steady-state consumption in the economy augmented with productivity and risk premium shocks for external habit and internal habit, respectively.

Table 2 and Table 3 show that the resource allocations as well as prices associated with capital controls are more stable than those associated with no in-

Figure 11: Impulse Response to a Positive Domestic Productivity Shock in a Sticky Price Model: External Habit $(\sigma = 1, \eta = 1)$




tervention in capital flows: The standard deviations of the terms of trade and net exports decrease from 1.77 and 0.44 to 1.47 and 0.29 in the external habit case, while the standard deviations of the corresponding variables decrease from 2.79 and 0.79 to 1.47, 0.29 in the internal habit case.

Finally, note that the optimal labor income taxation moves procyclically over business cycles to stabilize the economy. The procyclical capital control taxes are complementary to countercyclical nominal interest rates in stabilizing the economy and moderating international capital movements aggravated by the externality of the terms of trade associated with habit persistence.[7]

[7] In the closed economy with external habit, the correlation between the optimal tax rate and output is equal to the negative value of the correlation between the nominal interest rate with output. See Jung (2015) in detail.

Figure 12: Impulse Response to a Positive Domestic Productivity Shock in a Sticky Price Model: Internal Habit ($\sigma = 1, \eta = 1$)

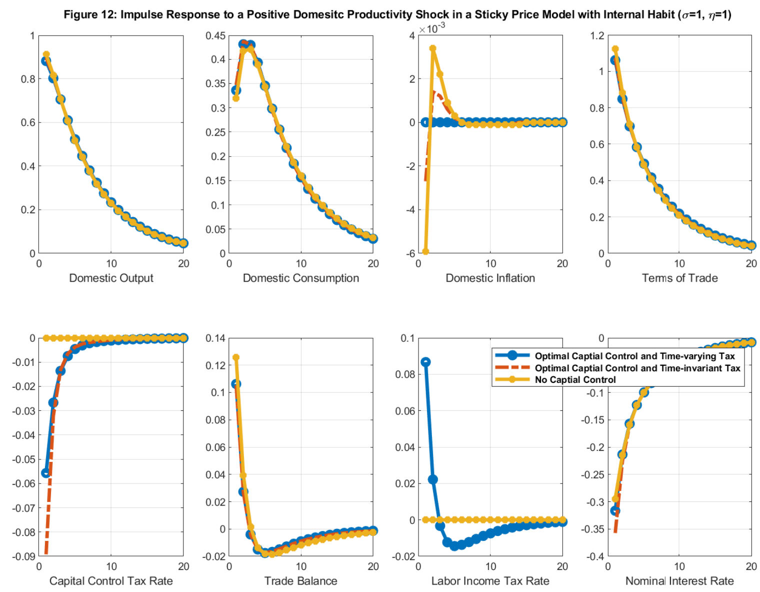


Figure 13: Impulse Response to a Positive Risk Premium Shock in a Sticky Price Model with External Habit $(\sigma = 1, \eta = 1)$

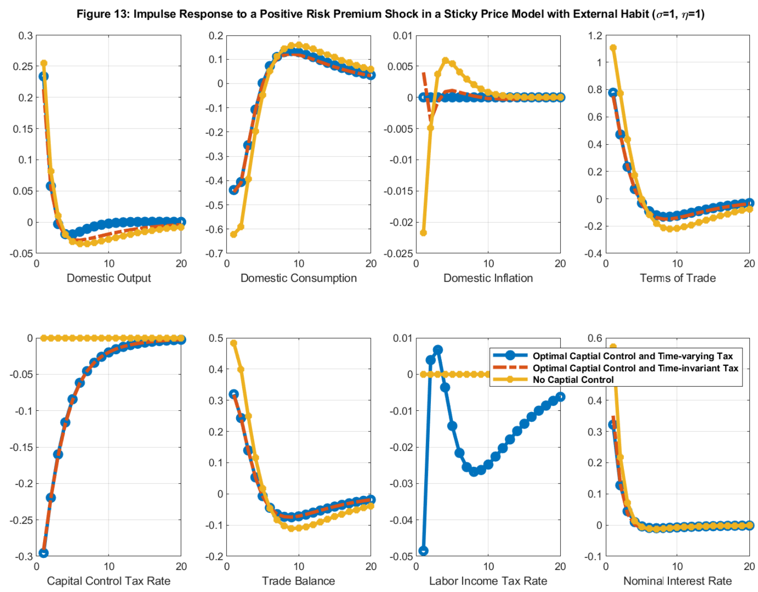


Figure 14: Impulse Response to a Positive Risk Premium Shock in a Sticky Price Model with Internal Habit $(\sigma = 1, \eta = 1)$

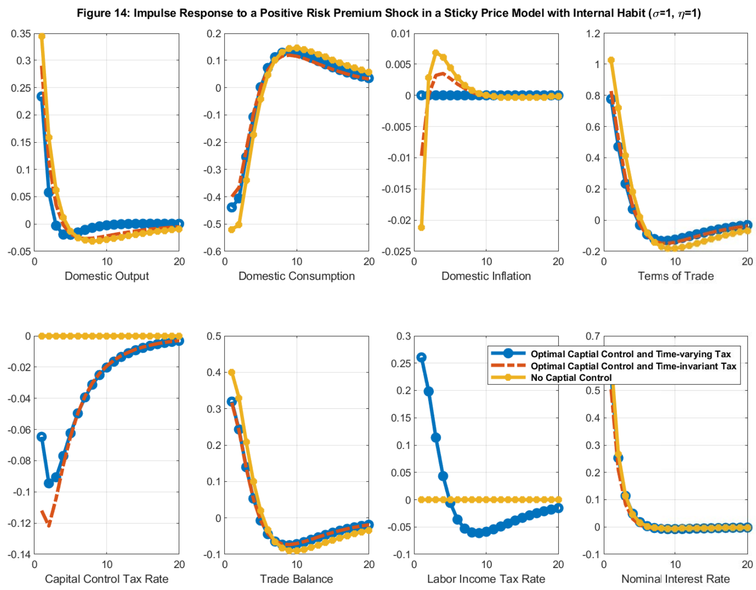


Figure 15: Welfare Gain from Capital Controls in Flexible Price Equilibrium with Productivity Shocks Only $(\sigma = 1, \eta = 1, \alpha = 0, \mathbf{b} = 0.5)$

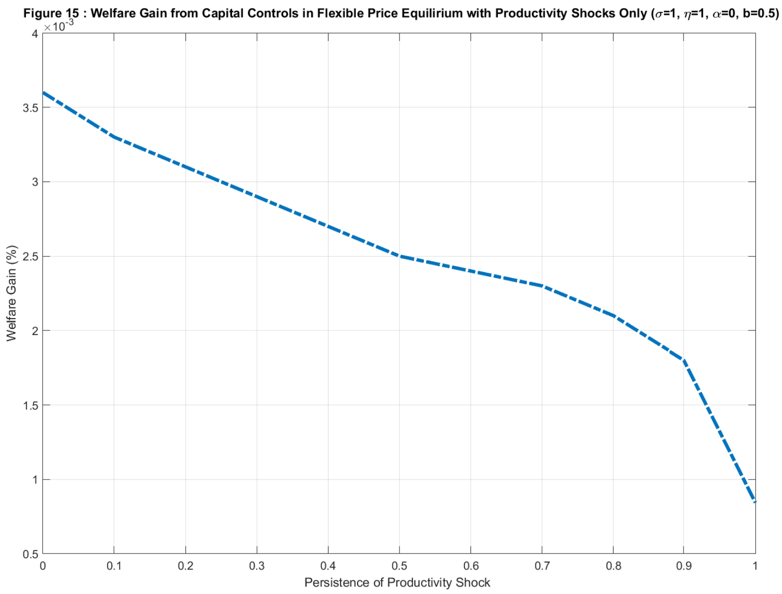


Table 2: Dynamic Properties of the Resource Allocations in a **Flexible Price Model with** External Habit under Alternative Tax Regimes ($\sigma = \eta = 1,\ \nu = 3,\ \alpha = 0$)

| Variable | Mean | Std. Dev. | Auto. Corr | $Corr(x,y)$ |
|---|---|---|---|---|
| Optimal Labor | Income | and Capital | Control | Tax |
| $\mathscr{W}_{C1} = 0$ | $\mathscr{W}_{C2} = 0$ | | | |
| $\tau$ | 63.6500 | 0.0900 | 0.5672 | 0.4967 |
| $\tau_B$ | 0.0500 | 0.7400 | 0.1217 | -0.0475 |
| $\mathscr{T}$ | 1.0000 | 1.4700 | 0.8011 | 0.7280 |
| $TB$ | 0.0000 | 0.2900 | 0.6718 | 0.1621 |
| $C$ | 0.8800 | 0.7500 | 0.8830 | 0.6437 |
| $Y$ | 0.8800 | 0.9800 | 0.8412 | 1 |
| Optimal Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -0.0044\%$ | $\mathscr{W}_{C2} = -1.8214 \times 10^{-5}\%$ | | | |
| $\tau$ | 63.6500 | 0 | - | - |
| $\tau_B$ | 0.1100 | 1.2970 | 0.8263 | -0.0140 |
| $\mathscr{T}$ | 1.0000 | 1.4865 | 0.8020 | 0.7333 |
| $TB$ | 0.0000 | 0.2957 | 0.6720 | 0.1815 |
| $C$ | 0.8800 | 0.7670 | 0.8778 | 0.6592 |
| $Y$ | 0.8800 | 1.0098 | 0.8371 | 1 |
| Non-Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -0.0094\%$ | $\mathscr{W}_{C2} = -0.0013\%$ | | | |
| $\tau$ | 63.6500 | 0 | - | - |
| $\tau_B$ | 0 | 0 | - | - |
| $\mathscr{T}$ | 1.0000 | 1.7685 | 0.7131 | 0.6918 |
| $TB$ | 0.0001 | 0.4356 | 0.6937 | 0.2277 |
| $C$ | 0.8821 | 0.9847 | 0.8112 | 0.4275 |
| $Y$ | 0.8822 | 1.0312 | 0.8175 | 1 |

Note: $\tau$ and $\tau_B$ are expressed in percentage points and $Y$, $N$, $\mathscr{T}$, $TB$ and $C$ in levels. $\mathscr{W}_{C1}$ and $\mathscr{W}_{C2}$ represent 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 in terms of the steady state consumption under two productivity shocks and risk premium shock and the corresponding welfare difference under only two productivity shocks, respectively. 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 Model with** Internal Habit under Alternative Tax Regimes ($\sigma = \eta = 1,\ \nu = 3,\ \alpha = 0$)

| Variable | Mean | Std. Dev. | Auto. Corr | $Corr(x,y)$ |
|---|---|---|---|---|
| Optimal Labor | Income | and Capital | Control | Tax |
| $\mathscr{W}_{C1} = 0$ | $\mathscr{W}_{C2} = 0$ | | | |
| $\tau$ | 28.0000 | 0.2400 | 0.6710 | 0.1634 |
| $\tau_B$ | -0.1500 | 1.3000 | 0.4616 | -0.0244 |
| $\mathscr{T}$ | 1.0000 | 1.4700 | 0.8008 | 0.7270 |
| $TB$ | 0.0000 | 0.2900 | 0.6710 | 0.1634 |
| $C$ | 0.8800 | 0.7600 | 0.8839 | 0.6465 |
| $Y$ | 0.8800 | 0.9800 | 0.8433 | 1 |
| Optimal Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -0.0044\%$ | $\mathscr{W}_{C2} = -6.8809 \times 10^{-6}\%$ | | | |
| $\tau$ | 28.0000 | 0 | - | - |
| $\tau_B$ | 0.0200 | 1.2868 | 0.4720 | -0.0473 |
| $\mathscr{T}$ | 1.0000 | 1.4812 | 0.7934 | 0.7392 |
| $TB$ | 0.0000 | 0.2916 | 0.6720 | 0.2365 |
| $C$ | 0.8818 | 1.5899 | 0.8769 | -0.0443 |
| $Y$ | 0.8822 | 1.0973 | 0.7883 | 1 |
| Non-Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -0.0302\%$ | $\mathscr{W}_{C2} = -0.0298\%$ | | | |
| $\tau$ | 28.0000 | 0 | - | - |
| $\tau_B$ | 0 | 0 | - | - |
| $\mathscr{T}$ | 1.0003 | 2.7977 | 0.7892 | 0.6965 |
| $TB$ | 0.0003 | 0.7951 | 0.8369 | 0.4181 |
| $C$ | 0.8800 | 2.8850 | 0.9022 | -0.6045 |
| $Y$ | 0.8800 | 1.1963 | 0.6802 | 1 |

Note: $\tau$ and $\tau_B$ are expressed in percentage points and $Y$, $N$, $\mathscr{T}$, $TB$ and $C$ in levels. $\mathscr{W}_{C1}$ and $\mathscr{W}_{C2}$ represent 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 in terms of the steady state consumption under two productivity shocks and risk premium shock and the corresponding welfare difference under only two productivity shocks, respectively. The parameter values are $\beta = (1.04)^{-1/4}$, $T = 200$, and $J = 1000$.

Table 4: Dynamic Properties of the Resource Allocations in a Sticky **Price Model with** External Habit under Alternative Tax Regimes ($\sigma = \eta = 1,\ \nu = 3,\ \alpha = 2/3$)

| Variable | Mean | Std. Dev. | Auto. Corr | $Corr(x,y)$ |
|---|---|---|---|---|
| Optimal Capital | Control and | Time-varying | Labor Income | Tax |
| $\mathscr{W}_{C1} = 0$ | | | | |
| $\tau$ | 63.6500 | 0.0900 | 0.5600 | 0.4900 |
| $\tau_B$ | 0.0200 | 1.3000 | 0.8200 | -0.0400 |
| $\pi_H$ | 0 | 0 | - | - |
| $R$ | 3.9700 | 0.3000 | 0.5800 | -0.6200 |
| $TB$ | 0.0000 | 0.3000 | 0.6700 | 0.1700 |
| $\mathscr{T}$ | 1.0000 | 1.4700 | 0.8000 | 0.7300 |
| $C$ | 0.8800 | 0.7500 | 0.8800 | 0.6400 |
| $Y$ | 0.8800 | 0.9700 | 0.8400 | 1 |
| Optimal Capital | | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -9.2344 \times 10^{-6}\%$ | $\mathscr{W}_{C2} = -1.5182 \times 10^{-5}\%$ | | | |
| $\tau$ | 63.6500 | 0 | - | - |
| $\tau_B$ | 0.1500 | 1.2900 | 0.8200 | 0.0029 |
| $\pi_H$ | 0.0000 | 0.0100 | -0.1500 | -0.0702 |
| $R$ | 3.9900 | 0.3200 | 0.8300 | 0.5500 |
| $TB$ | 0.0000 | 0.2900 | 0.6700 | 0.1789 |
| $\mathscr{T}$ | 1.0000 | 1.4600 | 0.8000 | 0.7266 |
| $C$ | 0.8800 | 0.7700 | 0.8800 | 0.6632 |
| $Y$ | 0.8800 | 1.0000 | 0.8400 | 1 |
| No Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -0.0592\%$ | $\mathscr{W}_{C2} = -0.0554\%$ | | | |
| $\tau$ | 63.6500 | 0 | - | - |
| $\tau_B$ | 0 | 0 | - | - |
| $\pi_H$ | 0.0000 | 0.1100 | 0.1889 | -0.2469 |
| $R$ | 3.9800 | 0.8000 | 0.4238 | 0.0182 |
| $TB$ | 0.0000 | 1.000 | 0.8452 | 0.3161 |
| $\mathscr{T}$ | 1.0000 | 3.1700 | 0.8087 | 0.5801 |
| $C$ | 0.8800 | 0.3200 | 0.5900 | 0.2883 |
| $Y$ | 0.8800 | 0.9400 | 0.8185 | 1 |

Note: $\tau$ and $\tau_B$ are expressed in percentage points and $Y$, $N$, $\mathscr{T}$, $TB$ and $C$ in levels. $\mathscr{W}_{C1}$ and $\mathscr{W}_{C2}$ represent 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 in terms of the steady state consumption percent under two productivity shocks and the corresponding welfare difference under two productivity shocks and risk premium shock, respectively. The parameter values are $\beta = (1.04)^{-1/4}$, $T = 200$, and $J = 1000$.

Table 5: Dynamic Properties of the Resource Allocations in a Sticky **Price Model with** Internal Habit under Alternative Tax Regimes ($\sigma = \eta = 1,\ \nu = 3,\ \alpha = 2/3$)

| Variable | Mean | Std. Dev. | Auto. Corr | $Corr(x,y)$ |
|---|---|---|---|---|
| Optimal Capital | Control and | Time-varying | Labor Income | Tax |
| $\mathscr{W}_{C1} = 0$ | $\mathscr{W}_{C2} = 0$ | | | |
| $\tau$ | 28.0000 | 0.2400 | 0.6700 | 0.1600 |
| $\tau_B$ | 0.1200 | 1.2900 | 0.4600 | -0.0300 |
| $\pi_H$ | 0 | 0 | - | - |
| $R$ | 3.9700 | 0.4300 | 0.5400 | -0.4600 |
| $TB$ | 0 | 0.2900 | 0.6700 | 0.1600 |
| $\mathscr{T}$ | 1.0000 | 1.4600 | 0.8000 | 0.7300 |
| $C$ | 0.8800 | 0.7500 | 0.8800 | 0.6500 |
| $Y$ | 0.8800 | 0.9800 | 0.8400 | 1 |
| Optimal Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = 3.2107 \times 10^{-5}\%$ | $\mathscr{W}_{C2} = 6.1757 \times 10^{-6}\%$ | | | |
| $\tau$ | 28.0000 | 0 | - | - |
| $\tau_B$ | 0.1100 | 1.2900 | 0.4700 | -0.0426 |
| $\pi_H$ | 0.0000 | 0.0100 | 0.1700 | -0.1306 |
| $R$ | 3.9800 | 0.4100 | 0.5200 | -0.4815 |
| $TB$ | 0 | 0.2900 | 0.6700 | 0.2305 |
| $\mathscr{T}$ | 1.0000 | 1.4900 | 0.8000 | 0.7347 |
| $C$ | 0.8800 | 0.7300 | 0.8900 | 0.6339 |
| $Y$ | 0.8800 | 0.9900 | 0.8300 | 1 |
| No Capital | Control and | Time-invariant | Labor | Income Tax |
| $\mathscr{W}_{C1} = -0.0468\%$ | $\mathscr{W}_{C2} = -0.0465\%$ | | | |
| $\tau$ | 28.0000 | 0 | - | - |
| $\tau_B$ | 0 | 0 | - | - |
| $\pi_H$ | 0.0000 | 0.0500 | 0.2663 | -0.1245 |
| $R$ | 3.9700 | 0.6700 | 0.3523 | -0.0221 |
| $TB$ | 0 | 1.1500 | 0.8691 | 0.4418 |
| $\mathscr{T}$ | 1.0000 | 2.1000 | 0.8464 | 0.7833 |
| $C$ | 0.8800 | 0.4800 | 0.7514 | 0.3604 |
| $Y$ | 0.8800 | 1.0800 | 0.8274 | 1 |

Note: $\tau$ and $\tau_B$ are expressed in percentage points and $Y$, $N$, $\mathscr{T}$, $TB$ and $C$ in levels. $\mathscr{W}_{C1}$ and $\mathscr{W}_{C2}$ represent 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 in terms of the steady state consumption percent under two productivity shocks and risk premium shock and the corresponding welfare difference under only two productivity shocks, respectively. The parameter values are $\beta = (1.04)^{-1/4}$, $T$ = 200, and $J = 1000$.

## 5. CONCLUSION

In the present paper, we have extended the existing literature on optimal capitals in a small economy framework by incorporating habit persistence 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 a unitary inter- and intra-temporal elasticity of substitution, i.e. in the Cole-Obstfeld preference case if households have habit persistence in consumption, irrespective of nominal price rigidities There is a substantial difference between the welfare associated with capital controls and the welfare associated without capital controls in the economy with efficient productivity shocks.

Domestic price stability is optimal only if the fiscal authority implements an optimal time-varying labor income tax to completely eliminate distortions associated with habit persistence. Otherwise, monetary authority should deviate from price stability to improve the welfare. Finally, we have shown that the optimal capital control tax leans against the wind less under an optimal time-varying labor income tax regime than under a time-invariant labor income tax regime.

In the future, it is necessary to introduce some financial frictions and discuss the implications on the capital controls.

## APPENDIX

**Proof of Proposition 2**

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

$$\max_{\{C_t, N_t, \mathscr{T}_t, \mathscr{B}_{Ft}, , \tau_{B_t}\}} . E_t \sum_{i=0}^{\infty} \beta^{t+i} \left( \log(C_{t+i} - bC_{t+i-1}) - \frac{N_{t+i}^{1+v}}{1+v} \right)$$

subject to

$$A_t N_t = (1-\theta)\mathscr{T}_t^{\theta} C_t + \theta \mathscr{T}_t C_t^* \quad (40)$$

$$MU_{C_t}^{-1} N_t^{\nu} = \mathscr{M}^{-1}(1-\tau_t) A_t \mathscr{T}_t^{-\theta} \quad (41)$$

$$E_t[\left(\frac{\mathscr{T}_{t+1}}{\mathscr{T}_t}\right)^{1-\theta} \frac{MU_{C_{t+1}}}{MU_{C_t}} \frac{P_t^*}{P_{t+1}^*}] \exp(-\chi \mathscr{B}_{Ft})(1+\tau_{B_t}) = E_t[\frac{MU_{C_{t+1}^*}}{MU_{C_t^*}} \frac{P_t^*}{P_{t+1}^*}] \quad (42)$$

$$\mathscr{T}_t^{-\theta} A_t N_t = C_t - \exp(-\chi \mathscr{B}_{Ft-1}) \left(\frac{\mathscr{T}_t}{\mathscr{T}_{t-1}}\right)^{1-\theta} \frac{P_{t-1}^*}{P_t^*} R_{t-1}^* \mathscr{B}_{Ft-1} + \mathscr{B}_{Ft}. \quad (43)$$

Since the first order condition with respect to $\tau_{B_t}$ implies the Lagrange multiplier associated with (42) is zero, the first order conditions can be written as

$$C_t : 0 = \frac{1}{C_t - bC_{t-1}} - b\beta E_t[\frac{1}{C_{t+1} - bC_t}] - \widetilde{\lambda}_{1,t}(1-\theta)\mathscr{T}_t^{\theta} + \widetilde{\lambda}_{2,t} N_t^{\nu} - b\beta E_t \lambda_{2,t+1} N_{t+1}^{\nu} - \widetilde{\lambda}_{4,t},$$

$$N_t : 0 = -N_t^{\nu} + \widetilde{\lambda}_{1,t} A_t + \widetilde{\lambda}_{2,t}(C_t - bC_{t-1}) N_t^{\nu} + \widetilde{\lambda}_{4,t} \mathscr{T}_t^{-\theta} A_t,$$

$$\begin{aligned} \mathscr{T}_t \quad : \quad & 0 = -\theta[(1-\theta)\mathscr{T}_t^{\theta-1} C_t - C_t^*]\widetilde{\lambda}_{1,t} + \theta \mathscr{M}^{-1} A_t \mathscr{T}_t^{-\theta-1} \widetilde{\lambda}_{2,t} \\ & -\widetilde{\lambda}_{4,t}[\theta \mathscr{T}_t^{-\theta-1} A_t N_t - (1-\theta)\exp(-\chi \mathscr{B}_{Ft-1}) \left(\frac{\mathscr{T}_t}{\mathscr{T}_{t-1}}\right)^{1-\theta} \mathscr{T}_t^{-1} \frac{P_{t-1}^*}{P_t^*} R_{t-1}^* \mathscr{B}_{Ft-1}] \\ & +(1-\theta)\beta E_t[\widetilde{\lambda}_{4,t+1} \left(\frac{\mathscr{T}_{t+1}}{\mathscr{T}_t}\right)^{1-\theta} \exp(-\chi \mathscr{B}_{Ft}) \mathscr{T}_t^{-1} \frac{P_t^*}{P_{t+1}^*} R_t^* \mathscr{B}_{Ft}], \end{aligned}$$

$$\mathscr{B}_{Ft}:\widetilde{\lambda}_{4,t}=\beta E_t[\widetilde{\lambda}_{4,t+1}\left(\frac{\mathscr{T}_{t+1}}{\mathscr{T}_t}\right)^{1-\theta}\exp(-\chi\mathscr{B}_{Ft})\frac{P_t^*}{P_{t+1}^*}R_t^*(1-\eta\mathscr{B}_{Ft})],$$

and (40) ~(43). Here $\widetilde{\lambda}_{i,t}$ $(i=1,2,3,4)$ is the Lagrange multiplier associated with (40) ~(43).

If households do not have habit persistence, then $MU_{C_t}\mathscr{T}_t^{1-\theta}=MU_{C_t^*}$ for the Cole-Obstfeld preference. Hence, $\mathscr{T}_t^{1-\theta}C_t^*=C_t$, implying that $\mathscr{B}_{Ft}=0$. Hence, (42) implies that $\tau_{Bt}=0$.

If households have habit persistence in consumption for the unitary elasticity of substitution, the marginal utility of consumption is given by

$$MU_{C_t}=\begin{cases}(C_t-bC_{t-1})^{-1} & \text{for external habit}\\ (C_t-bC_{t-1})^{-1}-b\beta E_t(C_{t+1}-bC_t)^{-1} & \text{for internal habit}\end{cases}.$$

Hence,

$$\mathscr{T}_t^{1-\theta}\neq\frac{MU_{C_t^*}}{MU_{C_t}}.$$

implying that $\mathscr{B}_{Ft}\neq 0$.

**Proof of Proposition 3**

It is obvious that (42) implies that $\tau_{B,t}\neq 0$ since $\mathscr{B}_{Ft}\neq 0$.

Next, note that the modified uncovered interest parity condition

$$(1+\tau_{Bt})\exp(-\chi\mathscr{B}_{Ft})R_t^{-1}E_t\left[\left(\frac{\mathscr{T}_{t+1}}{\mathscr{T}_t}\right)^{1-\theta}\frac{P_t^*}{P_{t+1}^*}\right]=R_{t+1}^{*-1}E_t\left[\frac{P_t^*}{P_{t+1}^*}\right]$$

can be log-linearized as

$$\tau_{B,t}=\chi\mathscr{B}_{Ft}+\widehat{R}_t-(1-\theta)E_t[\Delta\widehat{\mathscr{T}_{t+1}}]-\widehat{R}_t^*,$$

where $R_t^*$ is the nominal interest rate of the rest of the world. Here a hat variable represents the log-deviation from the steady-state of the corresponding variable. Households with habit persistence sluggishly increase their consumption to the positive domestic productivity shock, while the interest rate decreases and the terms of trade overshoots to the positive domestic productivity shock. Hence, for a moderate degree of openness, $\tau_{B,t}$ tends to decrease to an increase of $a_t$.

Next, note that the modified uncovered interest parity condition with the labor market equilibrium conditions can be rewritten as

$$(1+\tau_{Bt})\Psi_t \exp(-\chi\mathscr{B}_{Ft})E_t\left[\left(\frac{N_{t+1}}{N_t}\right)^{\nu}\left(\frac{\mathscr{T}_{t+1}}{\mathscr{T}_t}\right)\frac{A_{t+1}}{A_t}\frac{P_t^*}{P_{t+1}^*}\right] = E_t\left[\beta^{-1}R_{t+1}^{*-1}\frac{P_t^*}{P_{t+1}^*}\right]. \tag{44}$$

Let $\mu_{A,t} \equiv \frac{A_{t+1}}{A_t}$ denote the gross growth rate of the domestic productivity shock. It is assumed that $\log(\mu_{A,t}/\mu_A) = \varepsilon_{\mu_A,t}$, where $\varepsilon_{\mu_A,t} \sim i.i.d.(0,\sigma^2_{\mu_A})$. Then, the log-linearization of equation (44) can be written as

$$\tau_{B,t} = \chi\mathscr{B}_{Ft} - E_t[\Delta\widehat{\mathscr{T}}_{t+1}] - \nu E_t[\Delta\widehat{N}_{t+1}]. \tag{45}$$

In the absence of habit persistence, the terms of trade immediately jumps to the new equilibrium value and labor hours do not respond at all to the domestic permanent productivity shock, i.e. $E_t[\Delta\widehat{\mathscr{T}}_{t+1}] = E_t[\Delta\widehat{N}_{t+1}] = 0$. Trade account always balances to the domestic permanent productivity shock. Hence, $\tau_{B,t} = 0$.

Since households with habit persistence in consumption slowly adjust their consumption and labor hours to the permanent shock, the terms of trade sluggishly adjusts to the new equilibrium values, i.e. $E_t[\Delta\widehat{\mathscr{T}}_{t+1}] \neq 0$, and there occurs a trade account adjustment to the permanent domestic productivity shock. Hence, $\tau_{B,t} \neq 0$.

■

**Proof of Proposition 4**

The Ramsey problem can be formulated as the Lagrangian:

$$
\begin{aligned}
\mathscr{L} \;=\; & E_t \sum_{i=0}^{\infty} \beta^{t+i} \{ \left( \frac{(C_t - bC_{t-1})^{1-\sigma}}{1-\sigma} - \frac{N_{t+i}^{1+v}}{1+v} \right) \\
& + \lambda_{1,t+i} [\frac{A_{t+i} N_{t+i}}{\Delta_{H,t+i}} - (1-\theta) \mathscr{H}^{\eta}(\mathscr{T}_{t+i}) C_{t+i} - \theta \mathscr{T}_{t+i}^{\eta} C_{t+i}^{*}] \\
& + \lambda_{2,t+i} [\frac{\Lambda_{t+i+1}^{*}}{\Lambda_{t+i}^{*}} \frac{P_{t+i}^{*}}{P_{t+i+1}^{*}} - (1+\tau_{B,t+i}) \Psi_{t+i} \Xi(\mathscr{B}_{Ft+i}) \frac{\Lambda_{t+i+1}}{\Lambda_{t+i}} \frac{\mathscr{J}(\mathscr{T}_{t+i+1}) P_{t+i}^{*}}{\mathscr{J}(\mathscr{T}_{t+i}) P_{t+i+1}^{*}}] \\
& + \lambda_{3,t+i} [1 - (1-\alpha) \widetilde{p}_{H,t+i}^{1-\varepsilon} - \alpha (1+\pi_{H,t+i})^{\varepsilon - 1}] \\
& + \lambda_{4,t+i} [\Delta_{H,t+i} - (1-\alpha) \widetilde{p}_{H,t+i}^{-\varepsilon} - \alpha (1+\pi_{H,t+i})^{\varepsilon} \Delta_{H,t+i-1}] \\
& + \lambda_{5,t+i} [A_{t+i} (1-\tau_t) \mathrm{mc}_{t+i} - \mathscr{H}(\mathscr{T}_{t+i}) N_{t+i}^{v} \Lambda_{t+i}^{-1}] \\
& + \lambda_{6,t+i} [\frac{\varepsilon}{\varepsilon - 1} \mathscr{X}_{t+i} - \mathscr{Y}_{t+i}] \\
& + \lambda_{7,t+i} [\mathscr{X}_{t+i} - \widetilde{p}_{H,t+i}^{-1-\varepsilon} \frac{A_{t+i} N_{t+i}}{\Delta_{H,t+i}} \mathrm{mc}_{t+i} - \alpha [(1+\pi_{H,t+i+1})^{1+\varepsilon} (1+\pi_{t+i+1})^{-1} \\
& \times Q_{t+i,t+i+1} \left( \frac{\widetilde{p}_{H,t+i}}{\widetilde{p}_{H,t+i+1}} \right)^{-1-\varepsilon} \mathscr{X}_{t+i+1}] \\
& + \lambda_{8,t+i} [\mathscr{Y}_{t+i} - \widetilde{p}_{H,t+i}^{-\varepsilon} \frac{A_{t+i} N_{t+i}}{\Delta_{Ht+i}} - \alpha E_t [Q_{t+i,t+i+1} (1+\pi_{H,t+i+1})^{\varepsilon} (1+\pi_{t+i+1})^{-1} \\
& \times \left( \frac{\widetilde{p}_{H,t+i}}{\widetilde{p}_{H,t+i+1}} \right)^{-\varepsilon} \mathscr{Y}_{t+i+1}] \\
& + \lambda_{9,t+i} [1 - \beta \frac{\Lambda_{t+i+1}}{\Lambda_{t+i}} \frac{R_{t+i}}{1+\pi_{t+i+1}}] \\
& + \lambda_{10,t+i} [\frac{1+\pi_{t+i}}{1+\pi_{H,t+i}} - \frac{\mathscr{H}(\mathscr{T}_{t+i})}{\mathscr{H}(\mathscr{T}_{t+i-1})}] \\
& + \lambda_{11,t+i} [\mathscr{H}^{-1}(\mathscr{T}_{t+i}) \frac{A_{t+i} N_{t+i}}{\Delta_{H,t+i}} - C_{t+i} + \Psi_{t+i-1} \frac{\mathscr{J}(\mathscr{T}_{t+i}) P_{t+i-1}^{*}}{\mathscr{J}(\mathscr{T}_{t+i-1}) P_{t+i}^{*}} \Xi(\mathscr{B}_{Ft+i-1}) \\
& \times R_{t+i-1}^{*} \mathscr{B}_{Ft+i-1} - \mathscr{B}_{Ft+i}] \}.
\end{aligned}
$$

The first order conditions with respect to $\tau_t$, $\tau_{Bt}$, $\mathrm{mc}_t$, $\mathscr{X}_t$, $\mathscr{Y}_t$, $R_t$, $\pi_t$, and $\mathscr{B}_{Ft}$ imply that $\lambda_{2,t} = \lambda_{5,t} = \lambda_{6,t} = \lambda_{7,t} = \lambda_{8,t} = \lambda_{9,t} = \lambda_{10,t} = \lambda_{11,t} = 0$.

Hence, the Ramsey problem can be reformulated as

$$\begin{aligned}\mathscr{L} &= E_t \sum_{i=0}^{\infty} \beta^{t+i} \{ \left( \frac{(C_{t+i} - bC_{t+i-1})^{1-\sigma}}{1-\sigma} - \frac{{N_{t+i}}^{1+\nu}}{1+\nu} \right) \\ &+ \lambda_{1,t+i} [\frac{A_{t+i} N_{t+i}}{\Delta_{Ht+i}} - (1-\theta)\mathscr{H}^{\eta}(\mathscr{T}_{t+i}) C_{t+i} - \theta \mathscr{T}_{t+i}^{\eta} C_{t+i}^{*}] \\ &+ \lambda_{3,t+i} [1 - (1-\alpha)\widetilde{p}_{Ht+i}^{1-\varepsilon} - \alpha(1+\pi_{Ht+i})^{\varepsilon-1}] \\ &+ \lambda_{4,t+i} [\Delta_{Ht+i} - (1-\alpha)\widetilde{p}_{Ht+i}^{-\varepsilon} - \alpha(1+\pi_{Ht+i})^{\varepsilon} \Delta_{Ht+i-1}] \} \end{aligned} \quad \blacksquare$$

**Proof of Proposition 5**
The first order conditions with respect to $\widetilde{p}_{H,t}$, $\pi_{H,t}$ are given by

$$(1-\alpha)(\varepsilon-1)\widetilde{p}_{H,t}^{-\varepsilon}\lambda_{3,t} + (1-\alpha)\varepsilon\lambda_{4,t}\widetilde{p}_{H,t}^{-\varepsilon-1} = 0, \tag{46}$$

$$\alpha(\varepsilon-1)(1+\pi_{H,t})^{\varepsilon-2}\lambda_{3,t} + \alpha\varepsilon\lambda_{4,t}(1+\pi_{H,t})^{\varepsilon-1}\Delta_{H,t-1} = 0, \tag{47}$$

From (46) and (47),

$$\widetilde{p}_{H,t}(1+\pi_{H,t})\Delta_{H,t-1} = 1. \tag{48}$$

$$1 = (1-\alpha)\widetilde{p}_{H,t}^{1-\varepsilon} + \alpha(1+\pi_{H,t})^{\varepsilon-1} \tag{49}$$

$$\Delta_{H,t} = (1-\alpha)\widetilde{p}_{H,t}^{-\varepsilon} + \alpha(1+\pi_{H,t})^{\varepsilon}\Delta_{H,t-1} \tag{50}$$

Plugging (48) into (49) leads to

$$1 = (1-\alpha)(1+\pi_{H,t})^{\varepsilon-1}\Delta_{H,t-1}^{\varepsilon-1} + \alpha(1+\pi_{H,t})^{\varepsilon-1}$$

I.e.

$$1+\pi_{H,t} = [\alpha + (1-\alpha)\Delta_{H,t-1}^{\varepsilon-1}]^{\frac{1}{1-\varepsilon}}. \tag{51}$$

Next, plugging (48) and (51) into (50) leads to

$$\Delta_{H,t} = \Delta_{H,t-1}(\alpha + (1-\alpha)\Delta_{H,t-1}^{\varepsilon-1})^{\frac{1}{1-\varepsilon}}. \tag{52}$$

Next, (51) and (52) imply that

$$\pi_{H,t} = \frac{\Delta_{H,t}}{\Delta_{H,t-1}} - 1, \tag{53}$$

Finally, plugging (53) into (48) yields

$$\widetilde{p}_{H,t} = \Delta_{H,t}^{-1}.$$

The optimal monetary policy prescription to respond to relative price dispersion according to (53): It is optimal to maintain the flexible price equilibrium output if there is no relative price distortion, i.e. if $\Delta_{H,t} = \Delta_{H,t-1} = 1$.

Finally, the Ramsey optimal resource allocations and the terms of trade $\{C_t, N_t, \mathscr{T}_t, \mathscr{B}_{F,t}\}_{t=0}^{\infty}$ are determined by the first order conditions with respect to $C_t, N_t, \mathscr{T}_t, \mathscr{B}_{F,t}$, and the associated constraints. The CPI inflation rate and nominal interest rate are determined by

$$\frac{1+\pi_t}{1+\pi_{H,t}} = \frac{\mathscr{H}(\mathscr{T}_t)}{\mathscr{H}(\mathscr{T}_{t-1})} \tag{54}$$

$$\beta E_t[\frac{\Lambda_{t+1}}{\Lambda_t}\frac{R_t}{1+\pi_{t+1}}] = 1, \tag{55}$$

Also note that (17), (18) and (19) yield the real marginal cost as

$$\text{mc}_t = \frac{\varepsilon - 1}{\varepsilon}\frac{1}{\Delta_{H,t}}.$$

■

## REFERENCES

Abel, Andrew. B. (1990). "Asset Prices under Habit Formation and Catching Up with the Joneses," *American Economic Review Papers and Proceedings,* 80, 38–42.

Abel, Andrew. B. (1999). "Risk Premia and Term Premia in General Equilibrium," *Journal of Monetary Economics,* 43, 3–33.

Adolfson, Malin, Stefan Laséen, Jesper Lindé, Mattias Villani (2007). "Bayesian estimation of an open economy DSGE model with incomplete pass-through," Journal of International Economics, 72(2), 481–511.

Benigno, Gianluca, Huigang Chen, and Christopher Otrok, Alessandro Rebucci, and Eric R. Young (2016). "Optimal Capital Controls and Real Exchange Policies: A Pecuniary Externality Perspective," *Journal of Monetary Economics,* Forthcoming.

Benigno, Gianluca, Huigang Chen, and Christopher Otrok, Alessandro Rebucci, and Eric R. Young (2016). "Financial Crisis and Macro-Prudential Policies," *Journal of International Economics,* 89(2), 453–470.

Bianchi, Javier (2011). "Overborrowing and Systemic Externalities in the Business Cycle," *American Economic Review,* 101, pp. 3400–3426.

Bils, Mark and Pete Knelow (2004). "Some Evidence on the Importance of Sticky Prices," *Journal of Political Economy,* 112 (5), 947–985.

Calvo, Guillermo A. (1983). "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics,* 12, 383–398.

Christiano, Lawrence J. and Martin Eichenbaum and Charles L. Evans (2005). "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy,* 113(1), 1–45.

Benigno, Gianluca, Huigang Chen, and Christopher Otrok, Alessandro Rebucci, and Eric R. Young (2010). "Financial Crisis and Macro-Prudential Policies," *Handbook on Monetary Economics, Vol. III*, Chapter 7, 285–367.

Christiano, J. Lawrence, Martin Eichenbaum and Charles L. Evans (2016). "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy,* 124, 1–45.

Cole, Harold, L. and Maurice Obstfeld (1991). "Commodity Trade and International Risk Sharing: How Much Do Financial Markets Matter?," *Journal of Monetary Economics,* 28, 3–24.

Corsetti, Giancarlo, Luca Dedola, Sylvain Leduc (2010). "Optimal Monetary Policy in Open Economies," *Handbook of Monetary Economics,* 3, 861–933.

Cole, Harold, L. and Maurice Obstfeld (1991). "Commodity Trade and International Risk Sharing: How Much Do Financial Markets Matter?," *Journal of Monetary Economics,* 28, 3–24.

De Paoli, Bianca (2009). "Monetary Policy and Welfare in a Small Open Economy," *Journal of International Economics,* 77, 11–22.

Dixit, Avinash K., and Joseph E. Stiglitz (1977). "Monopolistic Competition and Optimum Product Diversity," *American Economic Review,* 67, 297–308.

Faia Ester and Tommaso Monacelli (2008). "Optimal Monetary Policy in a Small Open Economy with Home Bias," *Journal of Money, Credit and Banking,* 40 (4), 721–750.

Faia, Ester and Monacelli, Tommaso (2008). "Optimal Monetary Policy in a Small Open Economy with Home Bias," *Journal of Money, Credit and Banking,* 40(4), 721–750.

Farhi, Emmanuel and Iván Werning (2014). "Dilemma not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows," *IMF Economic Review,* 62, 569-605.

Farhi, Emmanuel and Iván Werning (2012). "Dealing with Trilemma: Optimal Capital Controls with Fixed Exchange Rates," *NBER Working Papers,* 18199

Galí, Jordi, and Tommaso Monacelli (2005). "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies,* 72, 707–734.

Korinek, Anton (2011). "The New Economics of Prudential Capital Controls," *IMF Review,* 59(3), 523–561.

Jung, Yongseung (2015). "Price Stability in Economies with Habit Persistence," *Journal of Money, Credit and Banking,* 47(4), 517–549.

Ljungqvist, Lars and Uhlig Harold (2000). "Tax Policy and Aggregate Demand Management under Catching Up with the Joneses," *American Economic Review,* 90, 356–366.

Ravn, Morten O., Stephanie Schmitt-Grohé, and Martín Uribe (2012). "Consumption, Government Spending, and Real Exchange Rate," *Journal of Monetary Economics,* 59, 215–234.

Smets, Frank and Rafael Wouters (2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *American Economic Review,* 97(3), 586–606.

Schmitt-Grohé , Stephanie and Martin Uribe (2004). "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function," *Journal of Economic Dynamics and Control,* 28(1), 755–775.

Schmitt-Grohé , Stephanie and Martin Uribe (2016). "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment," *Journal of Political Economy,* 124, 1466–1514.

Woodford, Michael (2003). "Interest and Prices," *Princeton University Press, New Jersey.*

Yun, Tack (1996). "Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles," *Journal of Monetary Economics,* 37, 345–370.

Yun, Tack (2005). "Optimal Monetary Policy with Relative Price Distortions," *American Economic Review,* 95(1), 89–108.