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Capital control and exchange rate volatility

Shikuan Chen[a,1], Ming-Jen Chang[b,*]

[a] National Taiwan University, Taiwan
[b] National Dong Hwa University, Taiwan

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ABSTRACT

The study offers one conceptual and theoretical framework for evaluating the economic effects of a trading tax on foreign exchange transactions. Taxes and the price stickiness mechanism are taken into account in the model. When prices are flexible, full monetary neutrality can be obtained even in the short-term. Intuitively, taxes on foreign exchange transactions discourage speculation by rising currency trading costs, and, thus, increase the stability of the exchange rate. Finally, the results show that not only the exchange rate but consumption, investment and employment will become less volatile by imposing trading taxes on foreign exchange transactions.

1. Introduction

The debate on capital controls has been argued by a number of economists in the aftermath of the currency crises of Mexico in 1995, East Asia in 1997, Russia in 1998, Brazil in 1999, and Argentina in 2001. The general view of such crises is that they are caused by some fundamental economic weakness, such as excessive external borrowing, over-investment and current account deficits. However, a significant part of the problem is that there is no explicit regulation governing excessive international capital movements in these economies. Controls on capital flows are expected to protect

* Corresponding author at: Department of Economics, National Dong Hwa University, Hualien 97401, Taiwan. Tel.: +886 3 863 5551; fax: +886 3 863 5551.
E-mail address: mjchang@mail.ndhu.edu.tw (M.-J. Chang).
[1] Address: Department of International Business, National Taiwan University, Taiwan.

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countries, especially in developing economies, from speculative attacks.[2] In fact, using capital mobility as a policy instrument in order to reduce macroeconomic volatility is not new. Date back to Tobin (1974) and Eichengreen, Tobin, and Wyplosz (1995), for example, argue that a tax on foreign exchange (henceforth, FX) transactions might reduce speculative capital flows in the international currency market.

As a consequence, a number of studies has analyzed and evaluated the effects of capital controls on short-term and long-term inflows (see, for example, Forbes, 2007). In the mid-1990s, Eichengreen and Wyplosz (1993) and Eichengreen et al. (1995), for instance, discuss that taxes would discourage short-run speculators from betting against several major currencies if they were implemented by all countries at the same time. Recently, Binici, Hutchison, and Schindler (2010) find that capital controls may affect the volume and composition of capital flows by using 74 countries' data. On the contrary, Glick and Hutchison (2011) investigate the effectiveness of capital control from currency crises by a panel data set comprised of 69 emerging/developing economies. Glick and Hutchison conclude that capital controls have not effectively insulated economies from currency crises at any time. Additionally, some studies, such as Aliber, Chowdhry, and Yan (2003), Valdés-Prieto and Soto (1998), and Edwards and Rigobon (2009), argue that a tightening of capital control would increase the volatility of exchange rate. To utilize a vector autoregressive analysis, De Gregorio, Edwards, and Valdes (1998) confirm that a tax on capital movements, indeed, discourage Chile's inflows. Edwards (1999) captures the relationship between stock market variability and capital flows. His investigation shows that Chile's capital controls policy helped reduce stock market instability.

Using micro-level data on capital flows in Brazil, Jinjarak, Noy, and Zheng (2013) find no evidence that any tightening of controls is effective in reducing inflows. Of interest, Hanke, Huber, Kirchler, and Sutter (2010) utilize an experimental analysis to explore a Tobin tax on FX markets. They confirm that a tax on FX market reduces short-term speculation. Korinek (2011) builds a simple model to analyze the capital control and find prudential capital controls can induce agents to internalize their externalities and thereby increase macro stability and welfare. One recent survey paper on capital flow by Magud et al. (2011) concludes that the empirical studies on the impacts of capital controls is still debated. In addition, most existing studies on capital controls are focusing on empirical evidence. Different from those existing works, this study offers a theoretical framework based on a dynamic general equilibrium model setup for analyzing the relationship between capital control and macroeconomic stability. More specifically, the dynamic model with micro-foundation presented assumes a uniform, internationally levied tax payable on FX transactions and analyze the tax impacts on this economy.[3]

The study is based on microfoundations in which consumers maximize utility from three alternative sources, i.e., consumption, real balances and leisure. Both *un*anticipated monetary and technological disturbances at home and abroad introduce uncertainty into this model. Of important, this work explicitly considers a trading tax on FX transactions in the money supply process. In a flexible price economy, country specific productivity and demand disturbances influence the terms of trade, but monetary innovation has no effect on any real variables. That is, monetary neutrality does hold in this model, when prices are entirely flexible. Furthermore, imperfectly competitive producers are then assumed to choose optimal prices before realizing money disturbances, and prices can be adjusted completely after a period. With sticky prices, the exchange rate must fluctuate to achieve a change in terms of trade. Consequently, this paper extends the standard dynamic general equilibrium framework developed by Devereux (2004) and Chang, Chang, and Shieh (2014).

In this framework, a tax on FX transactions, extending from Devereux and Engel (2003), would be effective in stabilizing nominal exchange rate variability.[4] The model also shows that increasing the tax can be effective in protecting a country against economic instability. Specifically, the economy will remain more stable in terms of consumption, investment and employment. However, when monetary

[2] Magud, Reinhart, and Rogoff (2011) summarize some of the key reasons why capital controls, i.e., four fears: fear of appreciation, fear of hot money, fear of large inflows and fear of loss of monetary autonomy.

[3] The basic idea of trading tax on the FX markets is similar to the an *unremunerated reserve requirement* (hereafter, URR) adopted by Chile in the 1990s. For more details, see Gallego, Hernández, and Schmidt-Hebbel (2003).

[4] Nominal or real exchange rate volatility always attract much attention in empiric or theory (see, for example, Bailliu, Dib, Kano, & Schembri, 2014; Chao, Hu, Lai, Tai, & Wang, 2013).

authorities employ this policy instrument, the economic performance will drop into a relatively lower level. That is, the conclusions imply that there is a trade-off between economic growth and stability. The rest of this paper is structured as follows. Section 2 designs a two-country general equilibrium monetary model with uncertainty arising from monetary and technological shocks. Solutions for the flexible price economy are derived in Section 3. Section 4 shows the results of theory. Finally, we conclude.

2. The model

This section describes a two-country (home and foreign) general equilibrium monetary model for analyzing the properties of nominal exchange rate in a stochastic economy (see also, Chang et al., 2014; Devereux, 2004). In each country, agent is populated by a continuum of yeomen-farmers (consumers–producers) and is presumed to produce differentiated goods (home agents are indexed by numbers in the interval $[0, n]$, while foreign agents are located in $(n, 1]$).

During each period t, the world experiences one of a finite number of states z^t. Let z^t denote the history of states up to and including period t, i.e., $z^t = \{z_0, z_1, \ldots, z_t\}$. The probability in period t of any history, z_t, having occurred is denoted by $\pi(z^t)$.

2.1. Preferences

All agents in the home country are assumed to have utility functions of the same form. In the home country, the lifetime utility of the home agent is given by:

$$EU = \sum_{t=0}^{\infty}\sum_{z^t}\beta^t\pi(z^t)\left[\ln c(z^t) + \chi\ln\frac{m(z^t)}{P(z^t)} - \eta\frac{h^2(z^t)}{2}\right], \tag{1}$$

where

$$c(z^t) \equiv c_h(z^t)^n c_f(z^t)^{1-n}, \quad 0 < n < 1,$$

where $\beta < 1$ denotes the discount rate; $c(z^t)$ represents a consumption index; $m(z^t)/P(z^t)$ is the end-of-period actual money balances, and h denotes the amount of labor supplied by the agents. Additionally, $c_h(z^t)$ and $c_f(z^t)$ are the domestic consumption of goods produced at home and in the foreign country, respectively.

The consumption index is defined as:

$$c_h(z^t) \equiv \left[n^{-1/\lambda}\int_0^n c(i, z^t)^{(\lambda-1)/\lambda}di\right]^{\lambda/(\lambda-1)},$$

$$c_f(z^t) \equiv \left[(1-n)^{-1/\lambda}\int_n^1 c(i, z^t)^{(\lambda-1)/\lambda}di\right]^{\lambda/(\lambda-1)},$$

where $\lambda > 1$. The parameter λ measures the unit elasticity of substitution between the two. The overall consumer price index follows as:

$$P(z^t) \equiv P_h(z^t)^n[S(z^t)P_f(z^t)]^{1-n},$$

where $S(z^t)$ denotes the nominal exchange rate, defined as the domestic currency price of foreign currency, while $P_h(z^t)$ and $P_f(z^t)$ represent the price indices of home and foreign goods in the domestic and local currency, respectively. Written in terms of the home currency, the budget constraint for the representative home agent is given by:

$$P(z^t)c(z^t) + m(z^t) + B(z^t) + P(z^t)\nu(z^t) \leq (1-\tau_W)W(z^t)h(z^t) + (1-\tau_R)R(z^t)\nu(z^{t-1}) + \aleph(z^t) + m(z^{t-1}) + [1 + (1-\tau_B)i(z^{t-1})]B(z^{t-1}) + TR(z^t), \tag{2}$$

where $B(z^t)$ represents the nominal bond portfolio. The investment good, $v(z^t)$, is constructed using the same basket of goods as the consumer goods. Furthermore, $W(z^t)$ denotes the wage rate; $R(z^t)$ represents nominal rental return on capital; $\aleph(z^t)$ is the agent's share of profits from home firms; $i(z^t)$ denotes the nominal interest rate; and $TR(z^t)$ represents any transfer from monetary or fiscal authorities. The government imposes taxes τ_W, τ_R and τ_B, on wage income, return on capital holdings and the interest income for each unit of output lent.

A typical home agent maximizes the lifetime utility function in Eq. (1), subject to the budget constraint in Eq. (2) with respect to $B(z^t)$, $m(z^t)$, $h(z^t)$ and $v(z^t)$. The four resulting first-order conditions are:

$$[1+(1-\tau_B)i(z^t)]^{-1}c(z^t)^{-1} = \beta\sum_{z^{t+1}}\pi(z^{t+1})\frac{P(z^t)}{P(z^{t+1})c(z^{t+1})}, \tag{3}$$

$$\frac{m(z^t)}{P(z^t)} = \chi\left[\frac{1+(1-\tau_B)i(z^t)}{(1-\tau_B)i(z^t)}\right]c(z^t), \tag{4}$$

$$h(z^t) = \frac{1}{\eta}\frac{(1-\tau_W)W(z^t)}{P(z^t)c(z^t)}, \tag{5}$$

$$c(z^t)^{-1} = \sum_{z^{t+1}}\beta\pi(z^{t+1})\frac{(1-\tau_R)R(z^{t+1})}{P(z^{t+1})c(z^{t+1})}. \tag{6}$$

Eq. (3) represents the standard Euler equation for optimal intertemporal consumption smoothing for goods. When τ_B increases, the cost of bond holding will be higher, and hence the agent tends to consume more at time t. Expression (4) equates the marginal rate of substitution of composite consumption to the consumption opportunity cost of holding real balances. Additionally, Eq. (5) gives the optimal trade-off between consumption and leisure. When the tax on wage income is higher, the amount of labor supplied is lower. Finally, Eq. (6) describes the choice of investment goods. In practice, however, imposing a tax on the return to investments will increase the users' cost of capital and reduce firms' desired capital stocks. However, the tax tends to increase consumption at time t. In a symmetric economy, all households in each country obtain the same optimal consumption, real money balances, investment and labor supplied. Consequently, the following indicates these variables with upper case letters. In addition, the current account in symmetric equilibrium is zero and the consumption across countries are full insurance so as to have (see Devereux, 2004):

$$C(z^t) = C^*(z^t). \tag{7}$$

2.2. Government

The government composite good is produced in the same way as private consumption and investment. Without loss of generality, this work assumes that all government purchases are financed by taxes' revenues and seigniorage.

$$\begin{aligned} &M(z^t) - M(z^{t-1}) + \tau_T\zeta_t(z^t) + \tau_W W(z^t)H(z^t) + \tau_R R(z^t)V(z^{t-1}) + \tau_B i(z^{t-1})B(z^{t-1}) \\ &\quad \geq P(z^t)G(z^t) + TR(z^t), \end{aligned}$$

where τ_T is the trading tax on FX markets, $\zeta_t(z^t)$ represents the FX reserve changes and $G(z^t)$ denotes a composite good of government consumption.

2.3. Producers

For producers, we assume that there is a Cobb–Douglas production technology. For a variety (i.e., firm) i, the production function is given by:

$$y(i,z^t) = A(i,z^t)k(i,z^t)^{\alpha}h(i,z^t)^{1-\alpha},$$

where the capital holding is known as $k(i, z^t)$ and $A(i, z^t)$ is a productivity parameter. The number of firms within each variety is sufficiently large that each firm ignores the impact of its pricing decisions on the aggregate price index. For the production function, assume that an externality exists at the aggregate level. Following Romer (1986), this study supposes that the aggregate production function for variety i exhibits linear returns in the accumulated factor:

$$A(i, z^t) = A(z^t)k(i, z^t)^{1-\alpha}.$$

In a symmetric economy, all producers in the same country will have the same production function. Accordingly the following equation denotes the representative firm as follows:

$$y(i, z^t) = A(z^t)k(i, z^t)h(i, z^t)^{1-\alpha}.$$

The law of motion for such capital in the home country is given by:

$$k(i, z^{t+1}) = v(i, z^t). \tag{8}$$

For simplicity, we assume full depreciation. Then, cost minimizing behavior implies the following factor prices representation:

$$W(z^t) = (1-\alpha)MC(z^t)\frac{y(i, z^t)}{h(i, z^t)}, \tag{9}$$

$$R(z^t) = MC(z^t)\frac{y(i, z^t)}{k(i, z^t)}. \tag{10}$$

where $MC(z^t)$ denotes the marginal production cost for a typical firm in the home country. Firms must set nominal prices in advance. This study assumes that the firm sets prices so as to maximize profits using the marginal utility of money of the entrepreneur. Consequently, the firm's objective function becomes:

$$\sum_{z^t} \beta\pi(z^t)\frac{P(z^{t-1})C(z^{t-1})}{P(z^t)C(z^t)}[p_h(i, z^t)x(i, z^t) - MC(z^t)x(i, z^t)].$$

Here $x(i, z^t)$ denotes the demand for the good of the representative producer. In a symmetric equilibrium economy, the optimal price charged by the home producer to home residents will be identified by:

$$P_h(z^{t-1}) = \frac{\lambda}{\lambda-1}\frac{\sum_{z^t}\pi(z^t)[((C(z^t)+nV(z^t)+(1-n)V^*(z^t))/C(z^t))MC(z^t)]}{\sum_{z^t}\pi(z^t)[(C(z^t)+nV(z^t)+(1-n)V^*(z^t))/C(z^t)]}. \tag{11}$$

Similarly, the price charged by foreign firms will be analogous.

Finally, production must be equal to total demand (consumption and investment) in symmetric equilibrium within a country, so that the good market is clear in home country as:

$$A(z^t)K(z^t)H(z^t)^{1-\alpha} = n\left(\frac{P_h(z^{t-1})}{P(z^t)}\right)^{-1}[C(z^t)+nV(z^t)+(1-n)V^*(z^t)]. \tag{12}$$

Analogously, the foreign country good market clearing condition holds.

2.4. Shocks, taxes on capital flows and equilibrium

In equilibrium, monetary authorities may help stabilize the economy in response to unanticipated shocks. However, an explicit description is necessary to clarify the structure of the external disturbances. For example, suppose that the economy is exposed to two types of shocks (domestic and foreign): disturbances to money supply (nominal shocks) and disturbances to technology (real shocks).[5] That's:

$$\Psi_t = \{M_t, M_t^*; A_t, A_t^*\}.$$

In the model, the monetary rules are assumed to permit the authorities to react to (1) unanticipated disturbances of FX reserves, (2) other shocks.[6] For this reason, the log money supply for the domestic economy, m_t, is assumed to be governed by:

$$M_t = \exp(m_t), \quad m_t = m_{t-1} + d_1\zeta_t + d_2u_t,$$

where ζ_t represents the unanticipated disturbances of FX reserves originating from the home country, u_t denotes other shocks and u_t is distributed *iid* with mean 0 and variance σ_u^2. Since this study treats movements in FX reserves as exogenous, we make direct assumptions regarding its process in our setup.[7] FX reserves are defined as:

$$Q_t = \exp(q_t), \quad q_t = q_{t-1} + \zeta_t,$$

where Q_t denotes the stock of FX reserves held by the central bank and ζ_t is distributed *iid* with mean 0 and variance σ_ζ^2.[8]

For simplicity, this work assumes $d_1 = 1 - \tau_T$, and $d_2 = 1$.[9] Then Eq. (13) can be rewritten as:

$$m_t = m_{t-1} + (1 - \tau_T)\zeta_t + u_t, \tag{13}$$

where τ_T is a small *ad valorem* tax on any FX transaction, $0 \le \tau_T \le 1$.[10] When τ_T is equal to zero, the money supply includes the money stock one period in advance as well as all nominal shocks (the conventional stochastic monetary shocks). Therefore, the money supply process in Eq. (13), is just a general monetary form. In this environment, taxes on capital flows allow domestic policymakers to break the direct links between money supply and FX reserve, with higher τ_T raising the cost of capital mobility. It is simple to show that stochastic technological shocks follow the process:

$$A_t = \exp(a_t), \quad a_t = \rho a_{t-1} + \varepsilon_t, \tag{14}$$

where ε_t is distributed *iid* with mean 0 and variance σ_ε^2. A similar equation holds for the foreign money supply and technological shock processes.

The dynamic system in equilibrium can be solved by the current model setup. The endogenous variables in equilibrium $\{C(z^t), C^*(z^t), H(z^t), H^*(z^t), i(z^t), i^*(z^t), K(z^t), K^*(z^t), P_h(z^t), P_f(z^t), MC(z^t), MC^*(z^t), W(z^t), W^*(z^t), R(z^t), R^*(z^t), S(z^t); M(z^t), M^*(z^t), A(z^t), A^*(z^t)\}$ can be obtained by Eqs. (3)–(6) and (9)–(14), as well as their foreign counterparts, and Eq. (7).

3. Exchange rate and economic dynamics

This section clarifies that the nominal price of each firm is set one period in advance and is fixed for the duration of the price contract. This modification increases the impact of unanticipated money

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[5] For more details about the description of exogenous shocks, see, Obstfeld and Rogoff (2002).

[6] The monetary policy rules used here are similar to those developed by Devereux and Engel (2003). In their case, the home monetary policy is allowed to react directly to movements in the exchange rate and productivity disturbances from each country.

[7] For instance, the FX reserve was \$80 at period $t-1$, but it is \$100 at times t. Thus, there is \$20 net capital inflow during the period t, but it is exogenously given; see also the discussion in Forbes (2007).

[8] Because the stochastic processes, ζ_t and u_t, are mean-zero, independent and identically distributed random variables, it follows that $E(\zeta_t|\Omega_{t-1}) = 0$, $E(u_t|\Omega_{t-1}) = 0$, and $E(\zeta_t u_t|\Omega_{t-1}) = 0$ for all t, where Ω_{t-1} denotes the expectation based on information available at the end of period $t-1$. Since the representative agents are assumed to be rational, they are assumed to know the underlying money supply process in Eq. (13), and thus take this information into account when forming their expectations. Given this assumption, the agents are still unable to predict any change in money supply at time $t-1$, because an unanticipated change in the level of money supply in the present model is described by two white noise processes (ζ_t and u_t) and displays no serial correlation.

[9] Accordingly, net capital inflows influence the money supply in the present model setting.

[10] This transaction tax on capital flows was first proposed by James Tobin (1974). We assume that the government imposes tax on cross-border trading and then distributes as lump-sum transfers back to the agent.

shocks on real variables which imply the *non*neutrality of money. Therefore, this study then introduces one-period price stickiness into the basic money in the utility model.

To understand the logic of the case for floating exchange rates, the model must be extended to incorporate money supply shocks. Thus, in the domestic economy, the money market equilibrium condition in Eq. (4) is substituted into the choice of investment goods in Eq. (6). To obtain the optimal nominal interest rate, the money supply is assumed to follow a random walk in logs in Eq. (13), thus, producing:

$$\frac{1}{1+(1-\tau_B)i_t} = \frac{\beta}{\mu}, \tag{15}$$

where

$$\mu = E_t[\exp((1-\tau_T)\zeta_{t+1} + u_{t+1})].$$

In equilibrium the optimal nominal interest rate is constant and does not depend on money disturbances. The nominal exchange rate can now be determined by combining the money market equilibrium condition in Eq. (4) (and its foreign country counterpart), the optimal nominal interest rate in Eq. (15) and the purchasing power parity condition. It follows:

$$S_t = \frac{M_t}{M_t^*} \frac{\mu^*(\mu-\beta)}{\mu(\mu^*-\beta)}. \tag{16}$$

Therefore, the nominal exchange rate generally depends on the response to home and foreign money supply shocks.[11] The logic behind Eq. (16) is that nominal exchange rate depreciation causes an increase in relative money shocks. To maintain nominal exchange rate, S_t, as fixed, the home money supply must move in proportion to the foreign money supply. Changes in the technological disturbances (both home and foreign) do not affect the nominal exchange rate.

To determine the equilibrium consumption given a floating exchange rate, recall the money market condition in Eq. (4). It can be stated as:

$$C_t = \frac{1}{\chi} \frac{M_t^n M_t^{*1-n}}{P_{ht}^n P_{ft}^{1-n}} \frac{(\mu-\beta)^n (\mu^*-\beta)^{1-n}}{\mu^n \mu^{*1-n}}. \tag{17}$$

Using this result, consumption is completely insulated from technological disturbances, but is positively correlated with the influence of unanticipated money shocks from home and abroad.[12] Thus, the level of consumption increases with home money supply.

Because the law of motion of capital in Eq. (8) is assumed to have no adjustment costs and full depreciation, it can be established:

$$K_{t+1} = \frac{\beta(1-\tau_R)\tilde{\lambda}}{1-\beta(1-\tau_R)\tilde{\lambda}} C_t. \tag{18}$$

Consumption and investment increase following an unanticipated monetary expansion in each country.[13] Intuitively, the domestic CPI tends to increase with domestic currency depreciation and enables a reduction in home consumption and investment via the money market equilibrium. Since home residents save some of their excess income for future consumption the fall in the τ_R encourages them to reduce present consumption. Using Eqs. (4), (15), and (18), equilibrium employment level is:

$$H_t = \left[\frac{\mu-\beta}{(1-\beta(1-\tau_R)\tilde{\lambda})\chi\mu} \frac{M_t}{P_{ht} A_t K_t} \right]^{1/(1-\alpha)}. \tag{19}$$

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[11] One can now deduce that in the preset price model, the nominal exchange rate model must follow a stochastic rule. That is no nominal exchange rate overshooting in response to monetary disturbances. The result is the same as Devereux and Engel (1998).

[12] Because, the prices, P_{ht} and P_{ft}, are entirely predetermined and do not adjust for the duration of the price contract.

[13] In the present case an unanticipated disturbance in the money supply does not guarantee that prices will change, since the prices are sticky. Therefore, an interaction exists between nominal money and consumption (investment).

Table 1
Conditional variances.

	Conditional variances
Exchange rate	$(1-\tau_T)^2[\sigma_\zeta^2+\sigma_{\zeta*}^2]+\sigma_u^2+\sigma_{u*}^2$
Consumption (investment)	$n^2[(1-\tau_T)^2\sigma_\zeta^2+\sigma_u^2]+(1-n)^2[(1-\tau_T)^2\sigma_{\zeta*}^2+\sigma_{u*}^2]$
Employment	$\frac{(1-\tau_T)^2\sigma_\zeta^2+\sigma_u^2+\sigma_\varepsilon^2}{(1-\alpha)^2}$

Consequently, current domestic consumption and investment are nondecreasing functions of both home and foreign monetary policy shocks, while employment is only a function of a home money shock.[14] Additionally, a home technology disturbance expansion reduces the equilibrium employment level (see Galí, 1999). For a home monetary shock, depreciation in the home currency generates expenditure substitution away from foreign goods. This raises output at home but reduces foreign output. Consequently, while positive international consumption and investment transmission of money shocks exist, negative international output transmission persists as well.

Since money supply and technology shocks are assumed to follow random walk processes in logs in Eqs. (13) and (14), one can obtain conditional variances, shown in Table 1, which indicates how the conditional variance of the nominal exchange rate is related to both home and foreign monetary volatility. In addition, changes in domestic and foreign technology shocks cannot influence nominal exchange rate variability at all. The interesting question is whether the τ_T can constrain speculative capital movements or not. With respect to Table 1, the conditional variance of the nominal exchange rate decreases when the trading tax, τ_T, increases. That is, a trading tax on FX transaction might be implemented to stabilize the exchange rate.[15] The results of Table 1 are confirmed by the Chilean data, see Table A1. The findings also support Hanke, Huber, Kirchler, and Sutter's (2010) conclusions.

Of course, conditional variance of both consumption and investment depends ultimately on home and foreign monetary variability. Restated, consumption and investment variance are independent of technological shocks. When τ_T is lower, the volatility of consumption (investment) is explicitly higher (see Table 1). One crucial reason for this phenomenon might be that a too low τ_T is frequently associated with reduced foreign borrowing and lending costs providing firms with an excessive incentive to borrow internationally. In such a case, the tax can even became a subsidy in some countries. The country will accumulate excess borrowing and go through a faster boom-recession business cycle accompanied by a *capital flow reversal* (Eicher, Turnovsky, & Walz, 2000, 2001).[16] Therefore, the economy will become more volatile in terms of output, investment, consumption and employment if the country levies a too low tax on FX transactions. So, it is not surprising to find that the employment variability will be high, if τ_T is low (see Table 1). Thus, these levels, not only consumption (investment) but also employment, are relatively low as well (see, Eqs. (17)–(19)), when their variabilities are low.

[14] In contrast, if the model maintained the assumption of price flexibility, an unanticipated change in domestic money would simply cause a proportionate change in the home price, P_{ht}, and the aggregate employment level would remain unaffected. In this subsection, since firms are assumed to set prices in period $t-1$, an unanticipated increase in money in period t will disturb real employment (see Eq. (19)).

[15] A good example of levying trading tax on FX transaction is the discouraging foreign borrowing policy of the Banco Central de Chile in 1990s. After a growing wave of capital inflows during 1988–1990, the Banco Central de Chile imposed some new restrictions in the form of an URR on inflows from June 1991 to September 1998. In order to discourage speculative capital inflow, the Chilean monetary authority imposed an URR of 10–30 percent on new foreign loans (see, Gallego et al., 2003). In other words, local companies in Chile, which borrow abroad must keep at least 10 percent of that loan as a deposit at the central bank, without interest for one year. Therefore, the URR, which is substantially a price-based mechanism, acted as an implicit tax on the FX market, similar to τ_T in the study. However, the nominal exchange rate variability (standard deviation) fell sharply as a consequence of the price mechanisms adopted in the 1991 and low volatility remained until 1998 (see, the Banco Central de Chile).

[16] Eicher et al. (2001) recognize that *capital flow reversal* can be separated into three stages. First is the borrowing boom, which occurs with capital accumulation and economic growth. The second is the interest crunch, where the increase in the level of debt raises the cost of foreign borrowing, and eventually reduces capital expenditures to finance a reduction in foreign debt. Finally the economy approaches a *capital flow reversal*.

It implies that trade-off relationships do exist between economic performance and stability in the model.[17]

On the other hand, this work derives the equilibrium consumption, investment and employment from the preset prices, P_{ht} and P_{ft}. However, these prices are optimally preset by using Eq. (11). The optimally preset prices can be expressed as the following equation:

$$P_{ht-1} = \frac{\eta(1-\beta(1-\tau_R)\tilde{\lambda})}{\tilde{\lambda}(1-\alpha)(1-\tau_W)} E_{t-1}(H_t^2 P_{ht-1}).$$

Using the equilibrium employment level from Eq. (19), then:

$$1 = \frac{\eta(1-\beta(1-\tau_R)\tilde{\lambda})}{\tilde{\lambda}(1-\alpha)(1-\tau_W)} E_{t-1}\left[\varphi \frac{M_{t-1}\exp[(1-\tau_T)\zeta_t + u_t]}{A_{t-1}^{\rho}\exp(\varepsilon_t)P_{ht}K_t}\right]^{2/(1-\alpha)}, \tag{20}$$

where

$$\varphi = \frac{\mu-\beta}{\chi\mu(1-\beta(1-\tau_R)\tilde{\lambda})}.$$

The question then arises of whether P_{ht} can include the time $t-1$ information set in this environment. Clearly, using the previous Eq. (20), the preset price, P_{ht}, can be evaluated from $[\frac{\varphi M_{t-1}}{A_{t-1}^{\rho}K_t}]$. Thus, the predetermined price can be expressed as:

$$P_{ht} = \Theta\left[\frac{\varphi M_{t-1}}{A_{t-1}^{\rho}K_t}\right], \tag{21}$$

where, Θ must satisfy the following condition:

$$1 = \frac{\eta(1-\beta(1-\tau_R)\tilde{\lambda})}{\tilde{\lambda}(1-\alpha)(1-\tau_W)} E_{t-1}\left[\frac{\exp[(1-\tau_T)\zeta_t + u_t - \varepsilon_t]}{\Theta}\right]^{2/(1-\alpha)}. \tag{22}$$

If $\sigma_\zeta = \sigma_u = \sigma_\varepsilon = 0$, then Θ is equal to $H_t^{-(1-\alpha)}$, indicating that a negative relationship exists between the Θ and H_t. Consequently, Eq. (22) implies how the domestic firm determines the expected employment level given floating exchange rates. Clearly, when $\exp[(1-\tau_T)\zeta_t + u_t - \varepsilon_t]$ is high (low), then Θ tends to be high (low).

The following can be understood intuitively. Eqs. (21) and (22) show that the expected marginal cost increase with the variability of the employment level. As a result, the preset prices will become higher conditional to the predicted values of money, technology and capital stocks. Therefore, this captures the fact that higher P_{ht} will reduce the mean employment level. An analogous expression can be derived for foreign employment and the predetermined price level, P_{ft}, for the foreign firm.

Using the pre-determined price level P_{ht} and its foreign counterpart P_{ft} and the relationship between investment and consumption in Eq. (18), a full dynamic path of consumption and investment can be derived as:

$$K_{t+1} = \beta(1-\tau_R)\tilde{\lambda}\exp[n((1-\tau_T)\zeta_t + u_t)]\exp[(1-n)((1-\tau_T)\zeta_t^* + u_t^*)]A_{t-1}^{n\rho}A_{t-1}^{*(1-n)\rho}\frac{1}{\Theta}K_t.$$

Since investment at time t is determined by technology shocks at time $t-1$, a current technology improvement does not influence consumption, investment, or output during the same time period.[18] However, the fact that P_{ht} is affected by technology shocks at time $t-1$ can be used to reduce the home country prices in the next period, leading to an increase in consumption and investment.

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[17] Clearly, recalling Table 1, imposing a higher τ_T may somehow reduces the returns on domestic (foreign) investment, providing an appropriate means of correcting the myopic expectations of private investors and discouraging investment. Therefore, the levels associated with conditional variance of consumption, investment, and employment should decrease with increasing τ_T.

[18] The foreign pre-determined price can be written as

Table A1
The volatilities of macroeconomic variables in Chile.

	Exchange rate	Consumption	Investment	Employment
St.Dev. all samples	177.79	6464.5	2545.2	1.915
St.Dev. between 91 and 98	34.12	2808.5	1268.4	0.909

Sources: International Monetary Fund's *International Financial Statistics*, and the Banco Central de Chile. St.Dev. is standard deviation; See data appendix.

4. Conclusions and policy implications

This paper explores a classic theme in open economy macroeconomics: capital controls and exchange rate volatility. Additionally, this work demonstrates that a tax on all FX transactions can reduce excessive volatility of nominal exchange rates. The present analysis contains trade-offs between economic performance and macroeconomic instability for an economy facing disturbances both domestically and abroad. More generally, the results have implications for the debate on the consequences of the costs and benefits of exchange rate flexibility. This work shows that, under a sticky price regime, a tax on international currency transactions could curb speculative hot money flows, and thus help stabilize exchange rate fluctuations. In future research and by extending our work, the *ad valorem* tax on FX trading can be designed as a two-tier tax (Spahn, 1996); specifically, a lower tax rate for normal transactions and a higher tax rate for short-term speculative trading.

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Appendix A.

See Table A1.

Data appendix

The Chilean data used to compute level and volatility statistics are from the International Monetary Fund's *International Financial Statistics* and the Banco Central de Chile. All data except exchange rates are annual; the exchange rates are weekly. The measure of foreign exchange reserves is foreign exchange (U.S. dollars, billion); consumption level aggregates both household consumption expenditure and consumption of fixed capital (Chilean pesos, billions); investment data is the gross fixed capital formation (Chilean pesos, billions); employment is computed as 100% less unemployment rate. Both consumption and investment are transformed to per capita quantities using the population numbers.

The variables are as follows. The measure of the nominal exchange rate is weekly Chilean pesos per U.S. dollar (end-of-period rate). The remaining economic aggregates, consumption and investment, are in current national currencies and were converted into real terms using the consumer price index (2005 = 100). The sample periods are: 1982/06/07–2008/12/31 for nominal exchange rate; 1970–2009

$$P_{ft} = \Theta\left[\frac{\varphi^* M^*_{t-1}}{A^{*\rho}_{t-1} K^*_t}\right].$$

for foreign exchange reserves; 1981–2008 for consumption; 1981–2009 for investment; 1985–2009 for employment.

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