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Input substitution, export pricing, and exchange rate policy☆

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ABSTRACT

This paper develops a small open economy model with sticky prices to show why a flexible exchange rate policy is not desirable in East Asian emerging market economies. We argue that weak input substitution between local labor and import intermediates in traded good production and extensive use of foreign currency in export pricing in these economies can help to explain this puzzle. In the presence of these two trade features, the adjustment role of the exchange rate is inhibited, so even a flexible exchange rate cannot stabilize the real economy in face of external shocks. Instead, due to the high exchange rate pass-through, exchange rate changes will lead to instability in domestic inflation. As a result, a flexible exchange rate regime becomes less desirable. In a very limited parameter space, a fixed exchange rate can be superior to monetary policy rules with high exchange rate flexibility, such as non-traded good price targeting. In most cases, however, non-traded good price targeting still delivers higher welfare.

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1. Introduction

The purpose of this paper is to explain why exchange rates in East Asian economies are usually not as flexible as those in developed countries, i.e., why these economies usually adopt fixed or less flexible exchange rate policies. We argue that this phenomenon can be attributed to two features in trade structures of these economies: weak input substitution between local labor and import intermediates in traded goods production and extensive use of foreign currency in export pricing.

The debate on fixed versus flexible exchange rates has been at the heart of international monetary economics for many years. Friedman (1953) and later Mundell (1961) made the case for flexible exchange rates as an efficient adjustment mechanism, cushioning the economy against external shocks when domestic price levels could not change quickly enough. The implication is that for a small economy buffeted by external disturbances from the rest of the world, it is better to allow the exchange rate to adjust.

Recently, a large number of papers have examined business cycle stabilization and welfare properties of simple monetary rules in dynamic, sticky-price, general equilibrium small open economy models.[1] An especially pertinent example is Schmitt-Grohe and Uribe (2001), who examined a small open economy model and compare welfare properties of a number of monetary policy rules allowing for exchange rate movement with a fixed nominal exchange rate rule. They found that the stabilization properties of each of monetary rules with exchange rate flexibility are superior to a fixed exchange rate rule. Recently, in a prominent paper, Engel (2011) shows explicitly in a two-country model that when firms price to market, the optimal monetary policy involves a trade-off among inflation, output gap, and currency misalignment objective. So policy makers will put some weight on exchange rate stability, and CPI inflation is the relevant inflation target for policy makers.

In reality, however, many East Asian economies, such as Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand, pegged their currencies to the US dollar, either explicitly or implicitly. Before the 1997 financial crisis, exchange rate regimes in these economies ranged from a currency board hard peg in Hong Kong to a sliding or crawling peg in Indonesia. After 1997, some of these economies have gradually switched to CPI inflation targeting. However, the volatilities of East Asian currencies are still usually much lower than those of major currencies.[2]

Thus, it remains a challenge for economists to explain exchange rate regime choices or the inflexibility of exchange rates in these economies. Calvo and Reinhart (2002) argue that this is because of the “fear of floating”, which is due to financial fragility or the presence of foreign currency debt or currency mismatch in these economies. Cespedes et al. (2004) and Calvo (2000) show that, with high foreign currency debt ratios in emerging market economies, a balance sheet effect may lead to a real contraction when the exchange rate devalues. This will force central banks to stabilize their exchange rates. In emerging market economies, the desirability of a flexible exchange rate is subject to financial conditions.

Nevertheless, recent literature finds that, for a small open economy, a fixed exchange rate is still dominated by a flexible exchange rate in terms of welfare, even when financial friction or potentially large balance-sheet effects are taken into consideration. For example, Gertler et al. (2007) show that fixed exchange rates exacerbate financial crises by tying the hands of the monetary authorities, so that the welfare loss following a financial crisis is significantly larger under fixed exchange rates relative to flexible exchange rates. Chang and Velasco (2006) find that “fear of floating” may emerge endogenously when there is a currency mismatch between assets and liabilities, but floating exchange rate regimes always Pareto dominates fixed exchange rate regimes. Devereux et al. (2006) show that financial frictions magnify the volatility of economies but they do not affect the ranking of alterative policy rules. So policy makers would always choose a flexible exchange rate regime.[3]

[1] See for example, Devereux et al. (2006) and Gali and Monacelli (2005) for details.

[2] See Park et al. (2001) for details.

[3] Choi and Cook (2004) find that a fixed exchange rate stabilizes banks' balance sheets and leads to greater business cycle stability than does an inflation-targeting interest rate rule. This comparison is not based on welfare metric, however.

In this paper, we re-examine the issue of exchange rate policies in emerging market economies. In particular, we focus on how trade structure features in East Asian economies, instead of financial conditions, affect the choices of exchange rate policies. Our research is motivated by two well-observed facts in trade sectors of these economies. First, it is noted that more and more intermediate goods and raw materials are imported by East Asian economies for the re-exporting of finished products to other countries. For example, more than 50 percent of trade in East Asian economies is processing trade.[4] Secondly, most export goods in these economies are priced in foreign currencies, especially in US dollars. Cook and Devereux (2006) document that about 90 percent of export goods in Thailand and Korea are preset in US dollars. They refer to this as external currency pricing.

Why are these two features important for the choice of exchange rate policies? This is because they both limit the adjustment role of exchange rates, which in turn reduces the desirability of flexible exchange rates. Given high percentage of processing trade in the total trade, the elasticity of substitution between imported intermediates and local labor will be low in the production of traded goods. In some cases, these two inputs are even complementary.

In general, the expenditure-switching role of exchange rate adjustments depends critically on the substitutability of inputs of production. When the substitutability is low, then the expenditure-switching effect is less important. Therefore, on the production side, if imported inputs and domestic inputs have low substitutability or are complementary, the benefits of flexible exchange rates under price rigidity are limited as the expenditure-switching effect in input substitution is small or disappears. Meanwhile, when most export goods are priced in foreign currency, in the short run, export prices are fixed in terms of the foreign currency and the exchange rate movements cannot help export firms to stabilize export demands or improve their export competitiveness. Therefore, this feature also reduces the incentive of these economies to increase their exchange rate flexibility.

Furthermore, as emphasized by Calvo and Reinhart (2002), exchange rate shocks in emerging market economies tend to feed into aggregate inflation at a much faster rate than in industrialized economies (also see Choudhri and Hakura, 2006; Devereux and Yetman, 2010). In an economy with high exchange rate pass-through to consumption goods, there is a clear trade-off between output stability and inflationary stability. However, due to the absence of expenditure-switching effects in both the production side and the market demand side, the function of exchange rate changes in stabilizing the real economy disappears. The only benefit of having exchange rate movement is to adjust the relative prices between domestic goods and imported foreign goods in the consumption basket. Nevertheless, as noted by Fraga et al. (2003), in emerging market economies, consumption goods represented only 21.3% of total imports, whereas capital goods and intermediate goods shares are 29.5% and 46.2%, respectively. This implies that, in these economies, the expenditure-switching effect on the consumption side might be quite small and may be welfare-dominated by the inflation nonstability caused by flexible exchange rates. That is, under such conditions a flexible exchange rate does not help to stabilize output, but leads to inflation instability. Therefore, a fixed exchange rate may be superior to a flexible exchange rate for a small open economy characterized by weak input substitution and foreign currency export pricing. Thus, besides financial fragility, the trade structure of emerging market economies may also cause the “fear of floating”.

To explore our explanation, we develop a small open economy stochastic general equilibrium model with sticky prices, where there is vertical trade. Export firms produce differentiated finished goods using imported intermediate and local labor. Meanwhile, export goods prices are set in the foreign currency and firms need to pay a menu cost to adjust their prices. The monetary authority is assumed to choose a simple interest-rate targeting rule, which represents different exchange rate regimes. Therefore, we can investigate welfare properties of different monetary policy rules when the economy faces external shocks.

Our welfare analysis shows that the presence of low input substitution and foreign currency pricing can affect welfare ranking between flexible exchange rates and fixed exchange rates. There

[4] Processing trade refers to the business activity of importing all or part of the raw and auxiliary materials, parts and components, accessories, and packaging materials from abroad in bond, and re-exporting the finished products after processing or assembly by enterprizes within the domestic economy.

are cases where a fixed exchange rate can dominate a flexible exchange rate in terms of welfare, although the parameter space that supports this result is very limited. Both low input substitution and foreign currency pricing are essential in generating this result. In most cases, a non-traded good price targeting (hereafter, NPT) rule delivers higher welfare than the fixed exchange rate rule. We also introduce an intermediate regime between the two, a CPI inflation targeting rule. In the extreme cases where fixed exchange rate rule dominates the NPT rule, the CPI inflation targeting rule is superior to both NPT or fixed exchange rate regime. This is because the CPI rule stabilizes exchange rate fluctuations, but meanwhile allows for some exchange rate flexibility to respond to external shocks. Also, this result is consistent with Engel (2011)'s finding, although our model focuses on small open economy.

Our results are robust when we introduce technology shocks in the export sector or consider different ownership structure of the export sector. Hence, our findings suggest a fixed exchange rate regime may be a rational policy choice for a small open economy characterized by weak input substitution in the traded goods sector and foreign currency pricing of export goods.

Our research is closely related to Devereux et al. (2006). They emphasize the impact of financial friction on the choice of monetary policy rules for a small open economy. Our paper is different in that we focus on how the trade structure of East Asian emerging market economies affects the transmission mechanism of shocks and the exchange rate policy. Meanwhile, since this paper focuses the welfare ranking between exchange rate stability and domestic price targeting, it is also related to Engel (2011). Specifically, our paper pursues Engel (2011)'s logic in a setting where Asian exports are prices in USD and domestic goods are priced in local currency, which also implies currency misalignment in the goods market. Nevertheless, in this paper we explore the degree to which certain sensible limitations on the ability of exchange rates to reallocate expenditure can affect the relative ranking between NPT, CPI and fixed exchange rate regime, which is different from Engel (2011). In other words, we focus on quantitatively how the LCP in export pricing and the low elasticity implied by processing trade in Asia reduces the relative benefits of exchange rate flexibility.

Finally, to our knowledge, this paper is the first to explore the implication of input substitution for exchange rate policy choice in the literature. There is a large literature that incorporates import intermediate goods in open economy models. For example, see Neumeyer and Perri (2005) and Mendoza and Yue (2012). However, they focus on imported materials as a channel for interest rate and financial shocks and their implications for business cycles in open economies.

This paper is organized as follows. Section 2 presents the basic setup of the model. Section 3 reports the dynamics of model when the economy is buffeted by shocks. Section 4 compares the welfare properties of different exchange rate regimes and discusses relevant implications. Section 5 presents some discussion on technology shocks and robustness checks. Section 6 concludes the paper.

2. Basic model

We construct a small open economy two-sector model. Two types of goods are produced: non-traded goods and traded goods. Domestic agents consume non-traded goods and import foreign goods. The model exhibits the following three features: a) nominal rigidities, in the form of costs of price adjustment for non-traded goods and export goods firms; b) vertical trade, where export firms have to import intermediate goods to produce export goods[5]; and c) foreign currency pricing of export goods, i.e., export goods are priced in the foreign currency.

There are three types of domestic agents in the model: households, firms, and monetary authority. In addition, there is a 'rest of world' economy where foreign-currency prices of import goods are set, and where the interest rates of foreign currency bonds are determined. Domestic households determined their consumption, labor supply and how much to borrow or lend on domestic and international financial markets. Production firms in two sectors hire labor from households, and sell goods to

[5] In East Asian economies, most of vertical trade is in the form of processing trade, so the feature of vertical trade also implies weak input substitution of import intermediate goods and local labor in the traded sector.

domestic residents and foreign markets. Monetary policy (or exchange rate regime) is represented by a domestic interest-rate targeting rule set by the monetary authority.

The economy is subjected to three shocks: foreign demand shocks, world interest rate shocks, and technology shocks in the export sector. The detailed structure of the economy is described below. Where appropriate, foreign currency (dollar) prices are indicated with an asterisk.

2.1. Households

The preference of the representative household is given by:

$$\mathrm{EU} = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{C_s^{1-\rho}}{1-\rho} - \eta \frac{L_s^{1+\psi}}{1+\psi} \right] \tag{2.1}$$

where C_t is an aggregate consumption index defined across domestic non-traded goods and foreign goods; E_t is the expectation operator conditional on information at time t; β is the discount factor; ρ is the inverse of the elasticity of intertemporal substitution; η is a scale parameter for the disutility of the labor supply.

The consumption index, C, is defined as $C_t = \left(C_{Nt}^{1-\alpha} C_{Ft}^{\alpha}\right) / \left(\alpha^{\alpha}(1-\alpha)^{1-\alpha}\right)$, where C_N is the aggregate non-traded goods, C_F is the consumption of foreign goods, and α is the share of imported foreign goods in the total consumption expenditure of domestic households. Given the consumption index, the consumer price index for domestic households can be derived as $P_t = P_{Nt}^{1-\alpha} P_{Ft}^{\alpha}$, where P_N and P_F are the prices of domestic non-traded goods and imported foreign goods, respectively.

Households may borrow or lend in domestic or foreign bonds. Trade in foreign bonds is subject to small portfolio adjustment costs. If the household borrows an amount, D_{t+1}, then the adjustment cost will be $(\psi_D/2)\left(D_{t+1} - \overline{D}\right)^2$ (denominated in the composite good), where $\overline{D}$ is an exogenous steady state level of net foreign debt.[6] The household can borrow in foreign currency bonds at a world given interest rate i_t^* , or in domestic currency bonds at an interest rate i_t.

Households own all domestic firms and therefore receive the profits on non-traded and traded firms. A household's revenue flow in any period then comes from the wage income, $W_t L_t$, transfers T_t, from the government, profits from both the non-traded sector and the traded sector, Π_t, less debt repayments from the last period, $(1+i_t^*)S_t D_t + (1+i_t)B_t$, as well as portfolio adjustment costs. The household then obtains new loans from the domestic and/or international capital market, and uses all the revenue to finance consumption. The budget constraint is thus:

$$P_t C_t = W_t L_t + T_t + \Pi_t + S_t D_{t+1} + B_{t+1} - P_t \frac{\psi_D}{2}\left(D_{t+1} - \overline{D}\right)^2 - \left(1 + i_t^*\right) S_t D_t - (1+i_t) B_t. \tag{2.2}$$

where S_t is the nominal exchange rate of the dollar in terms of domestic currency, D_t is the outstanding amount of foreign-currency debt, and B_t is the stock of domestic currency debt.

The household chooses how much non-traded and imported consumption goods to consume to minimize expenditure conditional on total composite demand. Demand for non-traded and imported goods is then $C_{Nt} = (1-\alpha)(P_t C_t / P_{Nt})$, and $C_{Ft} = \alpha(P_t C_t / P_{Ft})$. The household optimal conditions can be characterized by the following conditions:

$$\frac{1}{1+i_{t+1}^*}\left[1 - \frac{\psi_D P_t}{S_t}\left(D_{t+1} - \overline{D}\right)\right] = \beta E_t \left[\frac{C_t^{\rho} P_t}{C_{t+1}^{\rho} P_{t+1}} \frac{S_{t+1}}{S_t}\right] \tag{2.3}$$

$$\frac{1}{1+i_{t+1}} = \beta E_t \left(\frac{C_t^{\rho} P_t}{C_{t+1}^{\rho} P_{t+1}}\right) \tag{2.4}$$

[6] As pointed out by Schmitt-Grohe and Uribe (2003), these portfolio adjustment costs eliminate the unit root problem in net foreign assets.

$$W_t = \eta L_t^{\psi} P_t C_t^{\rho}. \tag{2.5}$$

Equations (2.3) and (2.4) represent the Euler equation for the foreign and domestic bond holdings. Equation (2.5) is the labor supply equation. Combining (2.3) and (2.4) gives interest rate parity condition for this economy.

We assume that the price of imported foreign goods in terms of the domestic currency is simply $P_{Ft} = S_t$. As a result, the domestic CPI price index is $P_t = P_{Nt}^{1-\alpha} S_t^{\alpha}$, which implies that exchange rate changes will fully pass through into import prices and then to the domestic CPI.

2.2. Firms

There are two sectors: the non-traded goods sector and the traded goods sector. Firms in these two sectors produce differentiated goods and therefore have monopolistic power. Also, all firms face costs of price adjustments. The two sectors differ in their production technologies. Non-traded firms produce output using only labor while export goods are produced by combining labor and import intermediates (or capital goods).

2.2.1. Non-traded goods sector

The non-traded sector is monopolistic competitive and contains a unit interval [0,1] of firms indexed by j. Each firm j produces a differentiated non-traded good, which is imperfect substitute for each other in the production of composite goods, Y_N, produced by a representative competitive firm. Aggregate non-traded output is defined using the Dixit and Stiglitz function, $Y_{Nt} = (\int_0^1 Y_{Nt}(j)^{\frac{\lambda-1}{\lambda}} \mathrm{d}j)^{\frac{\lambda}{\lambda-1}}$, where λ is the elasticity of substitution between differentiated non-traded goods. Given the above aggregation, the demand for each individual non-traded good j can be derived as:

$$Y_{Nt}(j) = \left(\frac{P_{Nt}(j)}{P_{Nt}}\right)^{-\lambda} Y_{Nt}, \tag{2.6}$$

where the price index for composite non-traded goods, P_{Nt}, is given by $P_{Nt} = \left(\int_0^1 P_{Nt}(j)^{1-\lambda}\right)^{1/(1-\lambda)}$. Each monopolistically competitive firm has a linear production technology, $Y_{Nt}(j) = L_{Nt}(j)$.

Following Rotemberg (1982), we assume that each firm bears a small direct cost of price adjustments. As a result, firms will only adjust prices gradually. Non-traded firms are owned by domestic households. Thus, a firm will maximize its expected profit stream, using the household's marginal utility as the discount factor. We may define the objective function of the non-traded firm, j, as:

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[P_{Nt+l}(j) Y_{Nt+l}(j) - \mathrm{MC}_{Nt+l} Y_{Nt+l}(j) - \frac{\psi_{P_N}}{2} P_{t+l} \left(\frac{P_{Nt+l}(j) - P_{Nt+l-1}(j)}{P_{Nt+l-1}(j)} \right)^2 \right], \tag{2.7}$$

where $\Gamma_{t+l} = 1/(P_{t+l} C_{t+l}^{\sigma})$ is the marginal utility of wealth for a representative household, and $\mathrm{MC}_{Nt} = W_t$ represents marginal cost for non-traded firm j, and the third term inside parentheses describes the cost of price adjustment incurred by firm j.

Each firm chooses a sequence of prices, $P_{Nt+l}(j)\big|_{l=0,\ldots,\infty}$ to maximize (2.7). Since all non-traded goods firms face the same downward-sloping demand function and price adjustment cost and they have the same production technology, we may write the optimal price-setting equation in a symmetric manner as[7]:

$$P_{Nt} = \frac{\lambda}{\lambda-1} \mathrm{MC}_{Nt} - \frac{\psi_{P_N}}{\lambda-1} \frac{P_t}{Y_{Nt}} \frac{P_{Nt}}{P_{Nt-1}} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right) + \frac{\psi_{P_N}}{\lambda-1} E_t \left[\beta \frac{\Gamma_{t+1}}{\Gamma_t} \frac{P_{t+1}}{Y_{Nt}} \frac{P_{Nt+1}}{P_{Nt}} \left(\frac{P_{Nt+1}}{P_{Nt}} - 1 \right) \right]. \tag{2.8}$$

[7] This Rotemberg-type pricing is equivalent to the standard Calvo-type pricing, as we can choose the value of ψ_{P_N} to match the dynamic of prices under Calvo pricing.

When the parameter ψ_{P_N} is zero, firms simply set prices as a markup over marginal cost. In general, however, the non-traded goods price follows a dynamic adjustment process.

2.2.2. Traded goods sector

It is assumed that there is a unit interval [0,1] of firms indexed by i in the traded goods sector. They solve a similar maximization problem as firms in the non-traded goods sector do. Each firm, i, in this sector sells a differentiated export good[8] and the aggregate traded good is given by:

$$Y_{Tt} = \left(\int_0^1 Y_{Tt}(i)^{\frac{\lambda-1}{\lambda}} \mathrm{d}i \right)^{\frac{\lambda}{\lambda-1}}. \tag{2.9}$$

Export firms, however, face the world market and use different production technologies. Each monopolistically competitive firm i imports intermediate goods to produce differentiated good, and re-exports their output to the world market. Thus, there exists the so-called “vertical trade” in this small open economy. The production function of the export firm, i is given as follows:

$$Y_{Tt}(i) = A_t \left[\alpha_T{}^{\frac{1}{\theta}} L_{Tt}(i)^{\frac{\theta-1}{\theta}} + (1-\alpha_T)^{\frac{1}{\theta}} IM_t(i)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{2.10}$$

where A_t is the technology in export sector, α_T is the share of labor in the traded goods firms' production, $\theta \geq 0$ is the elasticity of substitution between local labor and import intermediate. When $\theta = 0$, the imported intermediate goods are complementary to local labor in the production of traded goods. In this paper, we are interested in the case where θ is very small or close to zero, so that we can examine how weak input substitution or complementary input substitution implied by the processing trade affects the desirability of exchange rate flexibility in East Asian economies. The marginal cost, MC_{Tt}, is given by:

$$\mathrm{MC}_{Tt} = \frac{1}{A_t} \left[\alpha_T W_t^{1-\theta} + (1-\alpha_T) \left(S_t P_m^* \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}, \tag{2.11}$$

where P_m^* is the world price of intermediate goods and is assumed to be constant and equal to unity over time.

Since the traded goods sector is monopolistically competitive, each traded firm, i, sets prices in a way similar to the non-traded goods firms, but the export prices can be set either in terms of the foreign currency or in the domestic currency. We assume that of one unit of traded goods firms, $(1-\kappa)$ are priced in domestic currency and κ units are price in the foreign currency.

Therefore, if a firm i chooses its price in the foreign currency, then its profit maximization problem is given by:

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[S_t P_{TFt+l}^*(i) Y_{TFt+l}(i) - \mathrm{MC}_{Tt+l} Y_{TFt+l}(i) - \frac{\psi_{P_T}}{2} P_{t+l} \left(\frac{P_{TFt+l}^*(i) - P_{TFt+l-1}^*(i)}{P_{TFt+l-1}^*(i)} \right)^2 \right], \tag{2.12}$$

subject to

$$Y_{TFt}(i) = \left(\frac{P_{TFt}^*(i)}{P_{Tt}^*} \right)^{-\lambda} Y_{Tt} = \left(\frac{P_{TFt}^*(i)}{P_{Tt}^*} \right)^{-\lambda} \left(\frac{P_{T_t}^*}{P^*} \right)^{-\mu} X_t, \tag{2.13}$$

where $P_{TFt+l}^*(i)$ and $Y_{TFt+l}(i)$ represent the foreign currency price and the output of traded goods firm, i, which sets its price in the foreign currency. Y_{Tt} represents the aggregate output of domestically

[8] In this model we assume that these firms produce traded goods for exports only. If the traded goods are also consumed by domestic consumers, then the role of CPI targeting might be strengthened as it addresses the price rigidity in both traded and non-traded sectors. Nevertheless, this paper focuses on the exchange rate policy, so we will leave this topic for future research.

produced traded goods; P^*_{Tt} is the price index for all domestically produced export goods sold in the world market; P^* is the price level of final goods in the world market.[9] The demand structure implies that the elasticity of demand for export firms is λ, where $\lambda > 1$. The elasticity of substitution between aggregate domestically-produced traded goods and foreign goods is μ. Finally, X_t is the foreign demand shock, following stochastic process.

If a firm i sets its prices in the domestic currency, then its profit maximization problem is given by.

$$E_t\sum_{l=0}^{\infty}\beta^l\Gamma_{t+l}\left[P_{TDt+l}(i)Y_{TDt+l}(i)-\mathrm{MC}_{Tt+l}Y_{TDt+l}(i)-\frac{\psi_{P_T}}{2}P_{t+l}\left(\frac{P_{TDt+l}(i)-P_{TDt+l-1}(i)}{P_{TDt+l-1}(i)}\right)^2\right], \tag{2.14}$$

subject to

$$Y_{TDt}(i)=\left(\frac{P_{TDt}(i)}{S_tP^*_{Tt}}\right)^{-\lambda}Y_{Tt}=\left(\frac{P_{TDt}(i)}{S_tP^*_{Tt}}\right)^{-\lambda}\left(\frac{P^*_{T_t}}{P^*}\right)^{-\mu}X_t, \tag{2.15}$$

where $P_{TDt+l}(i)$ and $Y_{TDt+l}(i)$ represent the domestic currency price and the output of traded goods firm i which sets its price in the domestic currency.

Imposing symmetry, we may get the optimal price setting equation for P^*_{TFt} as:

$$\begin{aligned}P^*_{TFt}=&\frac{\lambda}{\lambda-1}\frac{\mathrm{MC}_{Tt}}{S_t}-\frac{\psi_{P_T}}{\lambda-1}\frac{1}{S_t}\frac{P_t}{Y_{TFt}}\frac{P_{TFt}}{P_{TFt-1}}\left(\frac{P_{TFt}}{P_{TFt-1}}-1\right)\\&+\frac{\psi_{P_T}}{\lambda-1}E_t\left[\beta\frac{1}{S_t}\frac{C_t^{\rho}P_t}{C_{t+1}^{\rho}P_{t+1}}\frac{P_{t+1}}{Y_{TFt}}\frac{P_{TFt+1}}{P_{TFt}}\left(\frac{P_{TFt+1}}{P_{TFt}}-1\right)\right].\end{aligned} \tag{2.16}$$

Similarly, we establish the optimal price setting equation for P_{TDt} as:

$$\begin{aligned}P_{TDt}=&\frac{\lambda}{\lambda-1}\mathrm{MC}_{Tt}-\frac{\psi_{P_T}}{\lambda-1}\frac{P_t}{Y_{TDt}}\frac{P_{TDt}}{P_{TDt-1}}\left(\frac{P_{TDt}}{P_{Tt-1}}-1\right)\\&+\frac{\psi_{P_T}}{\lambda-1}E_t\left[\beta\frac{C_t^{\rho}P_t}{C_{t+1}^{\rho}P_{t+1}}\frac{P_{t+1}}{Y_{TDt}}\frac{P_{TDt+1}}{P_{TDt}}\left(\frac{P_{TDt+1}}{P_{TDt}}-1\right)\right],\end{aligned} \tag{2.17}$$

where Y_{TFt} and Y_{TDt} are given as below:

$$Y_{TFt}=\left(\frac{P^*_{TFt}}{P^*_{Tt}}\right)^{-\lambda}\left(\frac{P^*_{T_t}}{P^*}\right)^{-\mu}X_t,Y_{TDt}=\left(\frac{P_{TDt}}{S_tP^*_{Tt}}\right)^{-\lambda}\left(\frac{P^*_{T_t}}{P^*}\right)^{-\mu}X_t, \tag{2.18}$$

and P^*_{Tt} represents the price index of these goods, which is given by

$$P^*_{T_t}=\left[\kappa P^{*1-\lambda}_{TFt}+(1-\kappa)\left(\frac{P_{TDt}}{S_t}\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}}. \tag{2.19}$$

2.3. Monetary policy rules

Monetary authority uses a short-term domestic interest rate as its monetary instrument. The general form of the interest rate rule may be written as:

$$1+i_{t+1}=\left(\frac{P_t}{P_{t-1}}\frac{1}{\overline{\pi}}\right)^{\mu_\pi}\left(\frac{P_{Nt}}{P_{Nt-1}}\frac{1}{\overline{\pi}n}\right)^{\mu_{\pi n}}\left(\frac{S_t}{\overline{S}}\right)^{\mu_S}(1+\overline{\mathrm{i}}). \tag{2.20}$$

[9] Without loss of generality, let P^*_{Tt} and P^* be denominated in dollars.

The parameters μ_π and μ_{π_n} allow monetary authority to control the inflation rate in the domestic CPI and the non-traded goods sector around a target rate of $\overline{\pi}$ and $\overline{\pi}_n$, respectively. μ_S controls the degree to which monetary authority attempts to control variations in the exchange rate, around a target level of $\overline{S}$. $\overline{i}$ is the steady state nominal interest rate and equals to $1/\beta$. The general form of the interest rate rule (20) allows for three types of monetary policy stances. The first rule is the one whereby the monetary authority targets CPI inflation rate (CPI rule), so that $\mu_\pi \to \infty$; The second rule is the one whereby the monetary authority targets the inflation rate of non-traded goods (NPT rule), so that $\mu_{\pi_N} \to \infty$. This is analogous to a domestic inflation targeting rule. The exchange rate is flexible under such a rule, so this rule implies a flexible exchange rate regime. The third rule we analyze is a simple fixed exchange rate rule (FER rule) by setting $\mu_s \to \infty$, whereby the monetary authority adjusts interest rates to keep the nominal exchange rate fixed at the target level of $\overline{S}$.[10]

Since the domestic CPI inflation is affected by changes in both the non-traded goods prices and the exchange rate, the CPI rule can be considered as an intermediate regime between the second rule (the flexible exchange rate one) and the third one (fixed exchange rate rule).

2.4. Shocks

There are three shocks in this economy, a world interest rate shock, i_t^*, a foreign demand shock X_t, a technology shock in the export sector, A_t. We assume that the log of gross world interest rate, $1+i_t^*$, follows an AR(1) stochastic process given by:

$$\log\left(1+i_{t+1}^*\right) = (1-\rho_R)\log(1+\overline{r}) + \rho_R \log\left(1+i_t^*\right) + \varepsilon_{R^*t}, \tag{2.21}$$

with $0 < \rho_R < 1$ and the serially uncorrelated shock ε_{R^*t} is normally distributed with mean zero and variance $\sigma_{i^*}^2$. The foreign demand, X_t, is also assumed to follow a stochastic process:

$$\log(X_t) = (1-\rho_X)\log\left(\overline{X} + \rho_X \log(X_{t-1}) + \varepsilon_{Xt}, \right. \tag{2.22}$$

where $0 < \rho_x < 1$ and the serially uncorrelated shock ε_{Xt} is normally distributed with mean zero and variance σ_X^2. Finally, the technology shock, A_t, is assumed to follow a stochastic process:

$$\log(A_t) = (1-\rho_A)\log\left(\overline{A} + \rho_A \log(A_{t-1}) + \varepsilon_{At}, \right. \tag{2.23}$$

where $0 < \rho_A < 1$ and the serially uncorrelated shock ε_{At} is normally distributed with mean zero and variance σ_A^2.

2.5. Equilibrium

In equilibrium, besides the optimal conditions for firms and households, we have the following labor market, goods market, and bonds market clearing conditions[11]:

$$L_{Nt} + L_{Tt} = L_t, \tag{2.24}$$

where $L_{Tt} = \alpha_T (W_t/\mathrm{MC}_{Tt})^{-\theta} Y_{Tt}$.

The non-traded goods market clearing condition is given by:

$$Y_{Nt} = (1-\alpha)\frac{P_t Z_t}{P_{Nt}}, \tag{2.25}$$

where Z_t is the aggregate expenditure, including consumption, the foreign bond adjustment cost, and the price adjustment cost for traded and non-traded firms.

[10] In a numerical exercise, we set $\mu_\pi = 9000$, $\mu_{\pi_N} = 9000$, and $\mu_s = 9000$ for the CPI, NPT, and FER rule, respectively. In each case, we set the policy so that the equilibrium is determinate.

[11] The details of the equilibrium conditions are given in the Technical Appendix. It is available upon request.

Table 1
Calibration parameters.

Parameters	Value	Parameters	Value	Parameters	Value
ρ	2	β	0.99	α	0.4
λ	11	α_T	0.3	κ	[0,1]
ψ	1	ϕ_D	0.0007	μ	1
ϕ_{P_N}	120	θ	[0,2]	ϕ_{P_T}	105

$$Z_t = C_t + \frac{1}{2}\psi_{p_N}\left(\frac{P_{Nt}}{P_{Nt-1}} - 1\right)^2 + \frac{\kappa}{2}\psi_{p_T}\left(\frac{P^*_{TFt}}{P^*_{TFt-1}} - 1\right)^2 + \frac{1-\kappa}{2}\psi_{p_T}\left(\frac{P_{TDt}}{P_{TDt-1}} - 1\right)^2 + \frac{1}{2}\psi_D\left(D_{t+1} - \overline{D}\right)^2 \tag{2.26}$$

For traded goods, we have $Y_{Tt} = (P^*_{T_t}/P^*)^{-\mu}X_t$, which implies that the aggregate output in the traded goods sector is determined by the foreign demand, X_t, and the relative prices of the domestic export goods.

In a symmetric equilibrium, the representative household's domestic bond holding is $B_t = 0$. Therefore, using Equation (2.26), we can rewrite the household's budget constraint as:

$$S_t P^*_{Tt} Y_{T_t} - \alpha P_t Z_t - S_t P^*_m IM_t + S_t D_{t+1} - (1 + i^*_t) S_t D_t = 0. \tag{2.27}$$

This is a balance of payment condition, where trade surplus will be affected by imports for both consumption goods, $\alpha P_t Z_t$, and intermediate inputs, $S_t P^*_m IM_t$.

3. Model dynamics

This section discusses impulse responses of key aggregate variables to external shocks $\{i^*_t, X_t, A_t\}$. This can help to highlight the transmission mechanisms of shocks in a small open economy characterized by two features we emphasized, weak input substitution and extensive use of foreign currency pricing.

3.1. Calibration

The parameters that need to be calibrated in our model are listed in Table 1. The coefficient of risk aversion, ρ, is set to 2 as is commonly assumed in the literature. The discount factor, β, is calibrated at 0.99, so that the steady state annual real interest rate is 4%. The elasticity of labor supply, $1/\psi$, is set to unity, following Christiano et al. (1997). The elasticity of substitution across individual export goods λ is chosen to be 11, which implies a steady state markup of 10%. This is equal to the common value found by Basu and Fernald (1997).[12] The elasticity of substitution between aggregate domestically-produced traded goods and foreign goods, μ, is set to unity. We set $\alpha_T = 0.3$, so that the share of labor in the production of trade goods is equal to that estimated by Cook and Devereux (2006) for Malaysia and Thailand. α is set to 0.4, which implies that the share of non-traded goods in the consumer price index equals 0.6. This is close to the evidence cited by Schmitt-Grohe and Uribe (2001) for Mexico and by Cook and Devereux (2006) for Malaysia and Thailand. With $\alpha = 0.4$ and $\alpha_T = 0.3$, the total expenditure on imported goods (including imported consumption goods and intermediate inputs) is about half of GDP.[13]

[12] As pointed out by Cook and Devereux (2001), markups are usually higher in emerging markets, so they choose $\lambda = 6$. In the processing trade firms the profit margin is usually lower, therefore, we still choose $\lambda = 11$ in this model.
[13] We set $\eta = 1$ as it is only a scale parameter in our model.

Ortega and Rebei (2006) show that price rigidity differs in different sectors. Prices are more rigid in the non-traded goods sector than in the traded goods sector. Therefore, we set the parameters governing the cost of price adjustment in the non-traded goods sector and the traded goods sector as $\phi_{P_N} = 120$ and $\phi_{P_T} = 105$, respectively, which give us an implied Calvo price adjustment probability of approximately 0.80 and 0.70, respectively.[14] This is consistent with the standard estimates used in the literature that prices usually adjust on average after four quarters. Regarding the parameter related to the bond adjustment cost, we follow Schmitt-Grohe and Uribe (2003) and set $\phi_D = 0.0007$.

The elasticity of substitution between local labor and imported intermediate inputs in the traded goods sector (θ) and the degree of foreign currency pricing (κ) are important in determining the dynamics of the model. In our benchmark model, we set $\theta = 0.01$ and $\kappa = 1$.[15] The values of these parameters capture the facts in East Asian emerging market economies, that is, low elasticity of input substitution in the traded goods sector and the wide use of foreign currency pricing in export pricing. Later, in welfare analysis, we will consider a wide range of values of these two parameters and highlight their importance in determining the desirability of exchange rate flexibility.

For the parameters related to shocks, we set $\rho_x = 0.75$ and $\sigma_x = 0.012$, and $\rho_A = 0.58$ and $\sigma_A = 0.015$, following Ortega and Rebei (2006). And we set $\rho_R = 0.46$ and $\sigma_R = 0.012$, following Devereux et al. (2006).[16]

3.2. Impulse response functions

Now we analyze the impact of shocks under different monetary rules in our benchmark model ($\theta = 0.01$ and $\kappa = 1$). The illustrations are divided into categories of real variables (namely, consumption, C; employment, L; non-traded goods employment, L_N; and traded output, Y_T) and those of nominal variables (namely, CPI price, P; exchange rate, S; marginal cost of traded goods, MC_T; price for export goods in dollars, P_T^*; non-traded price, P_N). Figs. 1–3 illustrates the effects of a world interest rate shock, a foreign demand shock, and a technology shock in the export sector, respectively. The responses of variables are in terms of the percentage deviation from their steady sate values to a 1% standard deviation of exogenous shocks.

3.2.1. Interest rate shocks

The NPT rule allows for exchange rate movement. When the foreign interest rate increases, the nominal exchange rate depreciates. Due to full exchange rate pass-though into consumer prices and traded goods firms' marginal costs, this depreciation generates a large initial burst of inflation and a sharp increase in traded goods firms' marginal costs. The aggregate inflation rises, as a result, the aggregate demand (consumption) decreases, which in turn decreases the demand for non-traded goods. Nevertheless, because of the expenditure-switching effect of exchange rates, the substitution between non-traded goods and imported consumption goods will lead to an increase in the demand for non-traded goods. In total, the substitution effect dominates the income effect, so the output of the non-traded goods sector rises. In the traded goods sector, since the traded good are priced in the foreign currency, the nominal exchange rate depreciation does not cause large changes in export volume and prices. Meanwhile, given the low input substitution in the traded goods sector, the increase in traded goods labor is small, though total labor increases sharply.

The interest rate shock tends to be contractionary under the FER rule. As the FER rule prevents nominal exchange rate depreciation, the domestic nominal and real interest rate becomes the shock-absorber and increases, which leads to contraction of the real variables. Consumption falls more than under the NPT rule, and now the non-traded goods sector output decreases as well, because there is no

[14] That is, if the model is interpreted as being governed by the dynamics of the standard Calvo price adjustment process, firms in the non-traded sector will adjust prices on average after five quarters.

[15] The case with $\theta = 0.01$ is close to the one with fixed proportional (Leontief) technology, where local labor is complementary to the imported intermediate goods. Later, when we set $\theta = 0.99$, this will be close to the case that represents a standard Cobb–Douglas technology with unitary input substitution elasticity.

[16] In Uribe and Yue (2006), they use a higher persistence and a smaller volatility for the world interest rate shock, $\rho_R = 0.83$ and $\sigma_R = 0.007$.

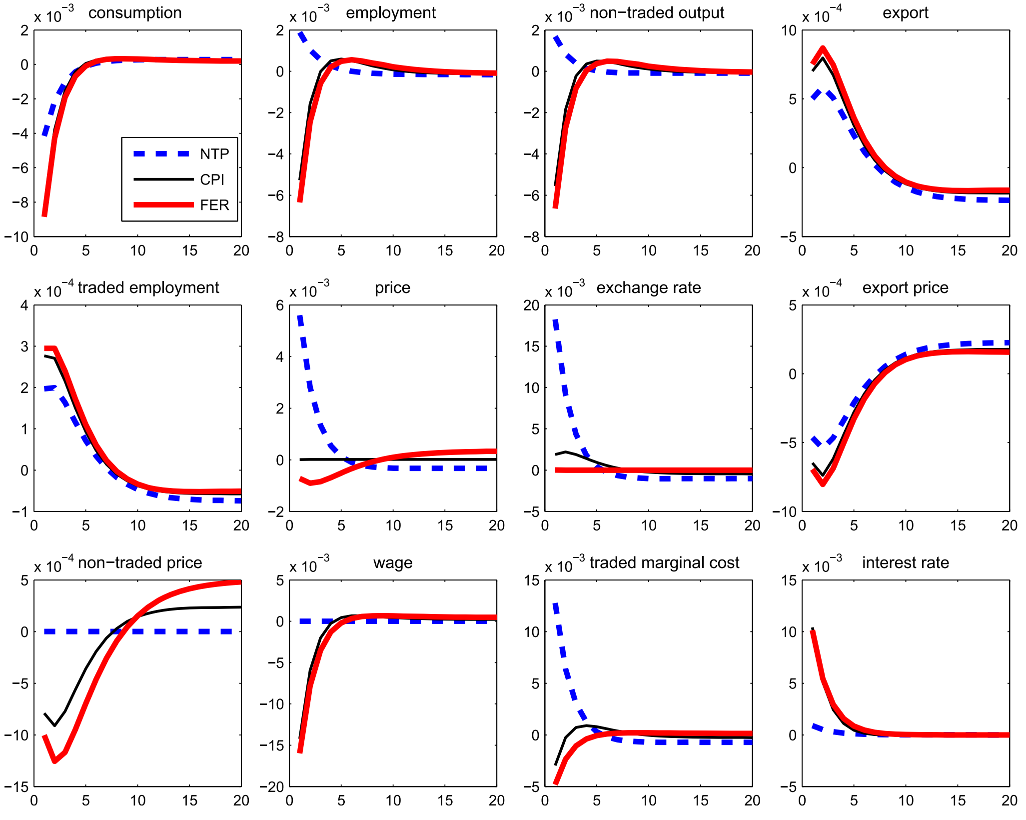

Fig. 1. Responses of economies to a positive foreign interest rate shock under different rules.

expenditure-switching effect. Therefore, the prices of non-traded good will decrease and so will wages. In the traded goods sector, the response of output, prices, and labor are similar to those under the NPT rule except for the change in the marginal cost of traded goods. Under the NPT rule, MC_T increases since the nominal exchange rate depreciates. However, under the FER rule, MC_T decreases because wages decrease.

The response of economy under a CPI rule is very similar to that under a FER rule. There are only two slight differences. First, the price level is unchanged under CPI rule while the price declines under a fixed exchange rate. Second, the non-traded good price declines less under the CPI rule than under the FER rule. The impulse responses of real variables under a CPI rule lie between those under the FER rule and the NPT rule. This is because the CPI rule represents an intermediate regime between the NPT rule and the FER rule.

In Fig. 1, we can see that, when the economy is constrained by weak input substitution and foreign currency pricing of export goods, allowing for exchange rate movement cannot stabilize the real variables, such as consumption and employment. Instead, it generates large fluctuation in the nominal variables, especially in inflation.

3.2.2. Foreign demand shocks

Fig. 2 illustrates the effects of a positive shock to the foreign demand. Under the NPT rule, the shock will lead to nominal exchange rate appreciation. Since the export goods are priced in the foreign currency, an exchange rate adjustment cannot help to stabilize the demand. The aggregate output in the traded goods sector will thus bear the foreign demand shock fully. With low input substitution in

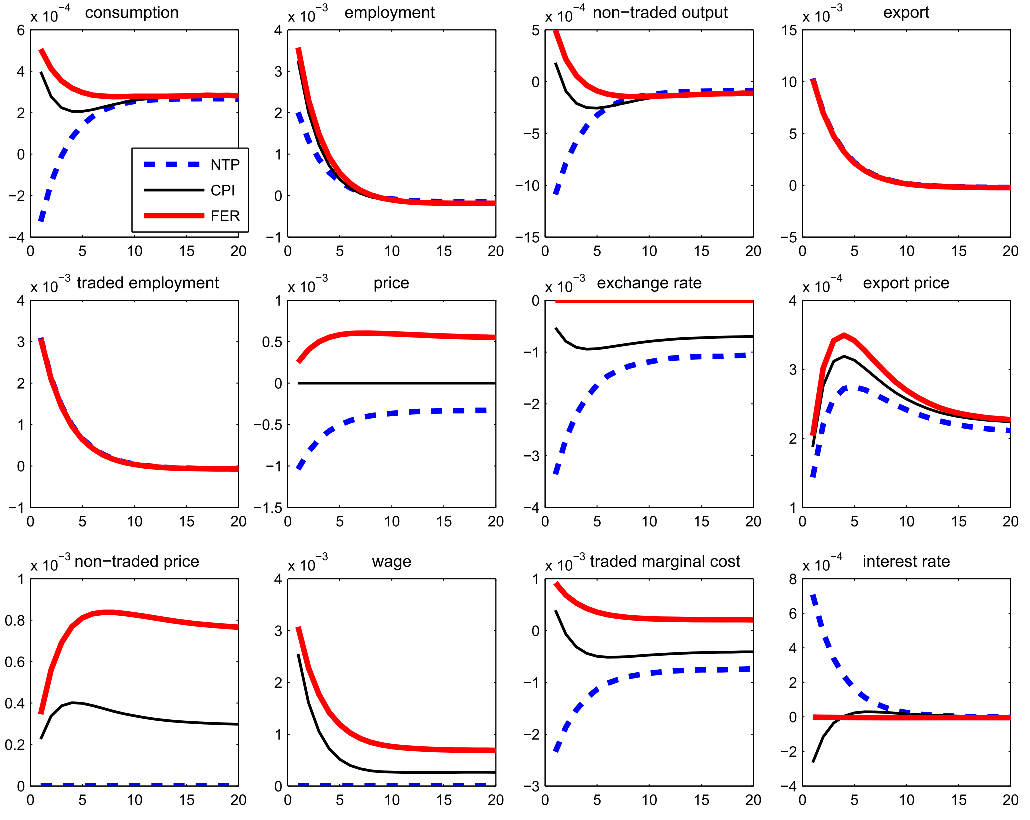

Fig. 2. Responses of economies to a positive demand shock under different rules.

the traded goods sector, the traded goods sector labor increases sharply as well. The expansion in the traded goods sector generates a persistent increase in aggregate consumption followed by an initial fall, though these changes are very small. To respond to the expansion in the traded goods sector, non-traded sector shrinks, and output and employment decline. Nevertheless, the total labor still increases, since the impact of the shock on the traded goods sector is much larger than that on non-traded goods sector. Regarding the nominal variables, the exchange rate appreciation leads to decreases in inflation and marginal cost of traded goods.

Under the FER rule, the response of traded goods output and traded goods price are exactly the same as under the NPT rule. Because there is no exchange rate movement, the responses of aggregate consumption and employment are different from those under the NPT rule. They both increase sharply and then return to their initial levels quickly. Also, both the price and the marginal cost of traded goods increase, opposite to the NPT rule. This is because the nominal wage (non-traded good price) increases.

In face of the demand shock, the response of real variables under the CPI rule is still similar to that under the FER rule, but the magnitude is relatively smaller. For example, the consumption also rises under the CPI rule, but lower than that under the FER rule. Meanwhile, the exchange rate appreciates and the interest rate declines under the CPI rule while they both remain unchanged under the FER rule.

In summary, the effects of foreign demand shocks are different from those of interest rate shocks. However, similar to the interest rate shock case, we find that given weak input substitution and foreign currency pricing of export goods, the adjustment role of exchange rate movement is inhibited. Comparing to the FER rule, allowing for exchange rate fluctuation cannot stabilize real variables, such as consumption and employment, but causes larger fluctuation in nominal variables, especially inflation.

3.2.3. Technology shocks

Fig. 3 reports the response of economy to an internal shock, technology shock in the export sector. When the technology in traded goods sector increases, output and employment in the tradable sector increase. Therefore, to induce an increase in the foreign demand, the export price must decline. Under the NPT rule, the exchange rate is flexible, so the exchange rate will depreciate. This causes an increase in prices. It will also lead the domestic demand to shift from import goods to non-traded goods. Since the export price falls down, the export revenue will fall in the short run. This will generate a negative income effect and reduce aggregate consumption. In the first period, the substitution effect dominates the income effect. As a result, non-traded goods sector expands first and then declines. When the exchange rate is fixed, the decrease in export price can only be achieved through the decline in the nominal wage. So the non-traded goods price and the CPI price fall. Decrease in non-traded good price will shift the domestic demand to non-traded goods. But in this case, there is still a negative income effect due to the decrease of export, and it is actually larger than that under the NPT rule. Therefore, aggregate consumption declines sharply in the first period, so the non-traded goods output decrease and then increases. Similarly, the responses of real variables under a CPI rule are close to those under a fixed exchange rate, but responses of prices, the exchange rate, and the interest rate are slightly different.

It should be noted that, in the presence of technology shocks, real variables such as consumption and labor are much more volatile under a fixed exchange rate regime than under a NPT rule. This implies that a flexible exchange rate rule may be more desirable in dealing with internal shocks.

In the next section, we investigate the implication of weak input substitution and foreign currency pricing for welfare ranking between NPT, FER, and CPI rules and check if there is a case where a FER rule can dominate a NPT rule in terms of welfare.

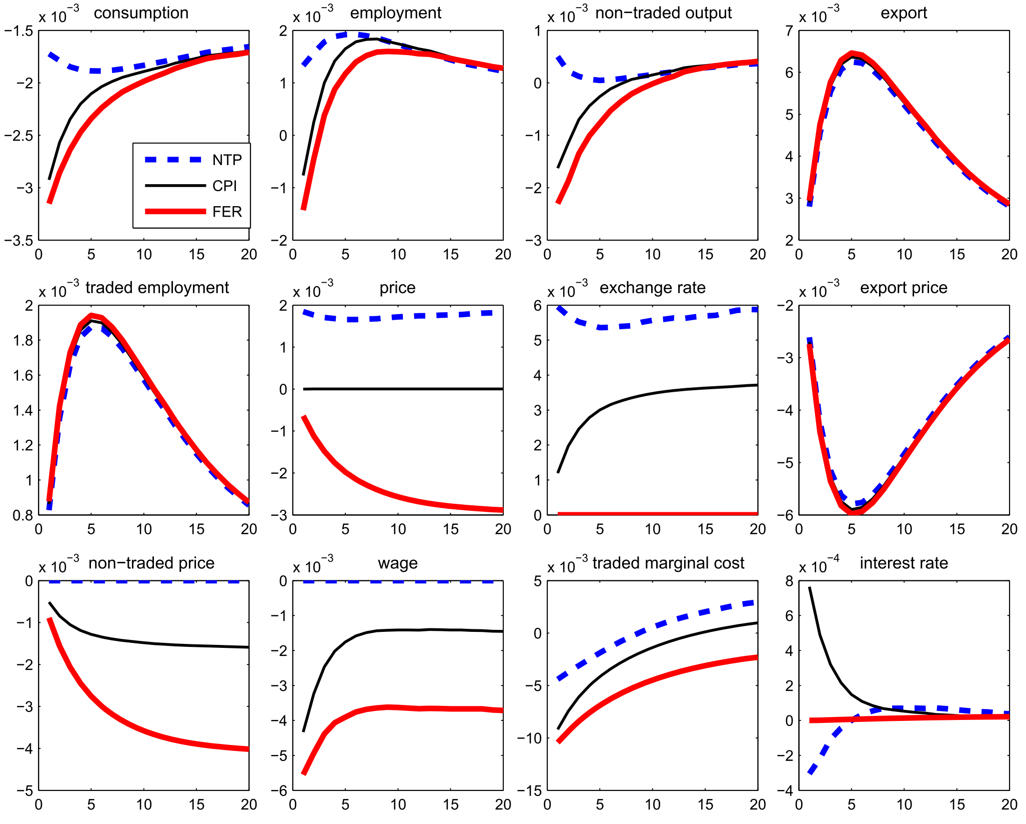

Fig. 3. Responses of economies to a technology shock under different rules.

4. Welfare analysis

4.1. Welfare measure

In this section, we discuss welfare properties of different monetary rules in the economy. Welfare measurement we use here is conditional expected lifetime utility of the representative household at time zero. Following Schmitt-Grohe and Uribe (2004), we use a perturbation method to calculate welfare. The expected lifetime utility is computed conditional on the initial state being the deterministic steady state, which is the same for all policy regimes.[17] To measure the magnitude of welfare differential across regimes, we define ζ_k as the percentage change in the deterministic steady state consumption that will give the same conditional expected utility, EU, under policy regime k. That is, ζ_k is given implicitly by:

$$\frac{\frac{1}{1-\rho}\left[(1+\zeta_k)\overline{C}\right]^{1-\rho}-\frac{\eta}{1+\psi}\overline{L}^{1+\psi}}{1-\beta}=\mathrm{EU}_k, \tag{4.1}$$

where $\overline{X}$ denotes the deterministic steady state of variable X. If $\zeta_k>0(<0)$, the welfare under regime k is implied to be higher (lower) than that of the steady state case. Higher value of ζ_k corresponds to higher welfare.

The expected utility, EU_k, is computed by taking second order Taylor approximations of the structural equations around the deterministic steady state. The model is solved using Dynare. The values of structural parameters are those used in Section 3.1.

4.2. Results

In Table 2, we present welfare results for four different cases when the model dynamics is only driven by two external shocks usually disturbing the small open economy, a foreign demand shock and a world interest rate shock as specified in Section 3.1. The internal technology shock will be discussed later. We find that in an extreme case, ($\theta\rightarrow 0$, $\kappa=1$), the FER rule marginally dominates the NPT rule in terms of welfare, although the welfare differential is small, at about 0.003% steady state consumption.[18] Also, in this case, the CPI rule delivers the highest welfare. This is perhaps because the CPI rule, as an intermediate regime between the FER and NPT rules (more close to the FER rule from the impulse response functions), can stabilize the exchange rate fluctuations, but meanwhile allow for some flexibility of exchange rates to respond external shocks. Since the responses of real variables under the CPI rule is very similar to those under the FER rules, the fact that CPI rule delivers the highest welfare also indicates fixed exchange rate rules welfare-dominate the flexible exchange rate rules in this case. This result is also consistent with Engel (2011)'s finding.

Moreover, this parameter combination shows that both trade features, the low elasticity of input substitution and the foreign current pricing of export goods are important in generating this welfare ranking. From Table 2 we can see that when the elasticity of input substitution (θ) increases or the degree of foreign currency pricing (κ) decreases, the welfare ranking between the NPT, FER and CPI rules is reversed. The NPT rule gives the highest welfare and dominates the FER and CPI rules in all other three cases. Also, in these cases, the welfare under the CPI rule is between the NPT rule and the FER rule.

To highlight the importance of both factors in determining the welfare ranking between the NPT rule and the FER rule, we do two welfare experiments. The results are given in Figs. 4 and 5.

Fig. 4 describes welfare changes when the degree of foreign currency pricing, κ, increases, given $\theta=0.01$.[19] This figure shows that welfare under the NPT (CPI) rule decreases with κ, while welfare

[17] This choice of the initial state has the advantage of ensuring that the economy starts from the same initial point for all policy regimes considered.
[18] Note that different θ implies different steady states, so welfare under different θ is not comparable.
[19] Changes in κ only do not affect the steady state, so the welfare results are comparable even when κ changes in this experiment.

Table 2
Welfare comparison under external shocks (%).

	$\kappa = 1$	$\kappa = 0$
$\theta = 0.01$	$(\xi_{NPT} = 1.847, \xi_{FER} = 1.850, \xi_{CPI} = 1.859)$	$(\xi_{NPT} = 2.199, \xi_{FER} = 1.850, \xi_{CPI} = 1.928)$
$\theta = 0.99$	$(\xi_{NPT} = 0.691, \xi_{FER} = 0.666, \xi_{CPI} = 0.674)$	$(\xi_{NPT} = 0.733, \xi_{FER} = 0.666, \xi_{CPI} = 0.685)$

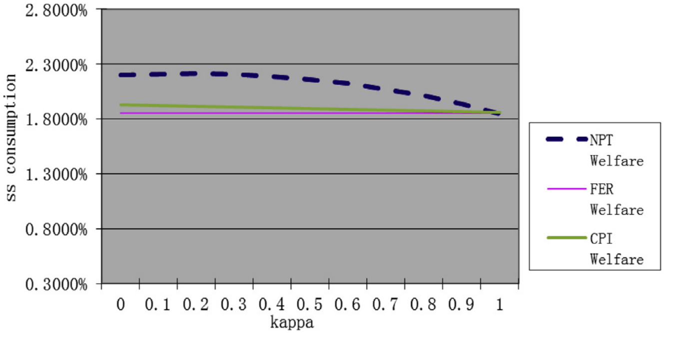

Fig. 4. Welfare change with the degree of foreign currency pricing under external shocks.

under the FER rule does not change with κ. The intuition is as follows: when κ increases, the degree of foreign currency pricing increases, which reduces the role of exchange rate adjustment in stabilizing export demand under the flexible exchange rate rules. The welfare under the NPT(CPI) rule thus decreases with κ. Under the FER rule, pricing in terms of foreign or domestic currency does not matter, so that the welfare under the FER rule will not change when κ increases. That is, the impact of changes in κ on welfare under the NPT(CPI) rule and the FER rule is asymmetric. Given low input substitution ($\theta = 0.01$), if κ is not too big, the NPT rule delivers higher welfare than does the FER rule. However, when κ is big enough, the welfare ranking between them is reversed and the FER rule dominates. Fig. 4 also shows that welfare under the CPI rule is always higher than that under the FER rule, but lower than that under the NPT rule, except when κ approaches 1. When κ is close to 1, the CPI rule delivers the highest welfare among the three rules.

Fig. 5 show that how welfare differentials between the NPT (CPI) rule and the FER rule change with θ, given $\kappa = 1$. Since the steady state also changes when θ increases, we can only compare the welfare differential between the two rules, but not the welfare level for different values of θ directly. In Fig. 5, there are no monotonic relationships between welfare differentials and θ. A low θ corresponds to a

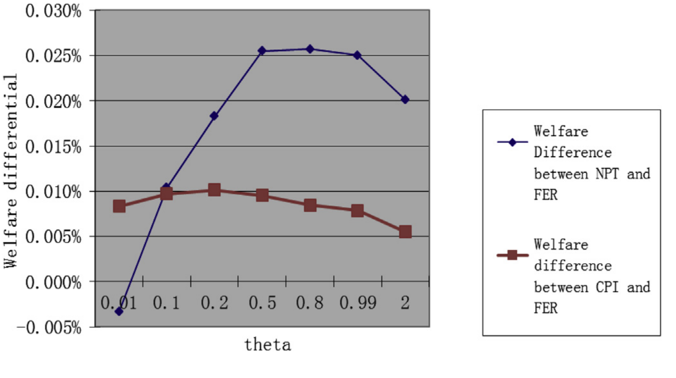

Fig. 5. Welfare differential under different rules under external shocks.

negative welfare differential between the NPT and the FER rule, implying that the FER rule dominates the NPT rule in terms of welfare. When θ increases, the welfare differential between the NPT rule and FER rule first increases and then decreases. This is because when the elasticity of input substitution becomes too high, the exchange rate changes will lead to excessive fluctuations of real variables, which also reduces the desirability of exchange rate flexibility. Nevertheless, for empirically relevant calibration ($\theta \in [0, 2]$), we get a negative welfare differential only when θ is quite small. For other reasonable values of θ, the welfare differential is still positive.[20] The welfare differential between CPI and FER rule also exhibits a non-monotonic relationship with θ. However, for any θ, the welfare differential is always positive, implying that CPI rule is always superior to a fixed exchange rate in terms of welfare.

Why are these two parameters important for the choice of exchange rate policy? This is because they both limit the adjustment role of exchange rates, which in turn reduces the desirability of exchange rate flexibility. In general, the expenditure-switching role of exchange rate changes depends critically on the substitution of domestic goods and foreign goods in the consumption basket. But in emerging market economies, due to the presence of vertical trade, the exchange rate movement also affects the relative price between domestic input and foreign input in the traded goods sector. When imported inputs and domestic inputs have low substitutability or are even complementary, the benefit of flexible exchange rates in dealing with price rigidity is limited as the expenditure-switching effect in input substitution is small or even disappears. Meanwhile, when most export goods are priced in the foreign currency, export prices are fixed in terms of the foreign currency in the short run. Hence, the exchange rate movement cannot help export firms to stabilize the foreign demand or to improve their export competitiveness by adjusting the relative prices of export goods. Thus, the extensive use of foreign currency pricing reduces the incentive of these economies to increase exchange rate flexibility.

As a result, when a small open economy is characterized by low elasticity of input substitution and high degree of foreign currency pricing of export goods, flexible exchange rate regime might not be the optimal policy. Actually, exchange rate fluctuations may lead to inflation volatility in these small open economies since exchange rate pass-through to import prices are higher in these countries. Finally, as illustrated in the Introduction, the expenditure-switching effect in consumption goods is also smaller in these countries because of the low percentage of consumption goods in imports. In other words, under such conditions a flexible exchange rate does not help to stabilize output, but leads to inflation instability. Hence, controlling the fluctuation of the nominal exchange rates might be the optimal policy. That is, the “fear of floating” is not because of the “fear”. It might be a rational reaction of central banks in these small open economies.

From the above analysis, we can see that for empirically relevant parameterization, both low input substitution and extensive foreign currency pricing are essential in producing this welfare result. This may because one single effect, either the lack of expenditure-switching in input substitution or the lack of export demand stabilization, is not sufficient to generate enough real variable fluctuation under the NPT rule, and the welfare ranking reversal.

5. Discussion

In the above section, we only investigate how input substitution and export pricing affect welfare ranking of different monetary policy rules under two external shocks. For robustness check, we also discuss the case with an internal shock, technology shock in the export sector.

Fig. 6 depicts welfare changes when κ increases from 0 to 1, given $\theta = 0.01$. It shows that, when the economy is affected by only technology shocks in the export sector, both NPT rule and CPI rule dominate the fixed exchange rate even when all the export goods are priced in the foreign currency and the elasticity of input substitution is close to zero. Similarly, Fig. 7 gives the relationship between welfare differential between the three rules and θ, given $\kappa = 1$. It shows that when the elasticity of input substitution decreases, welfare differential between the NPT and FER rules becomes small but is

[20] Note that when a specific value of θ delivers the highest welfare differential, it does not imply that this value also delivers the highest welfare under the NPT rule. This is because the steady state changes when θ changes and welfare under the two rules changes as well.

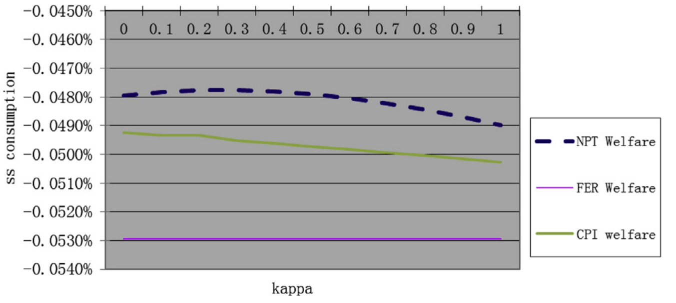

Fig. 6. Welfare change with the degree of foreign currency pricing with tech shocks only.

always positive (NPT rule is always better). Similarly, welfare differential between the CPI and the FER rule is also always positive. But the relationship between these welfare differentials and θ, the elasticity of input substitution is non-monotonic, as in the external shock case. Compared to welfare results in the benchmark case with external shocks, welfare differentials under technology shock are quite small relatively.

Since NPT rule always dominates the other two rules when the economy is disturbed by technology shocks only, what will be the welfare ranking if all three shocks are considered? We reported the welfare result when both external shocks and internal shocks are considered in Table 3. It can be seen that the introduction of technology shocks makes the NPT rule marginally dominates the FER rule by 0.001% steady state consumption in the extreme case ($\theta = 0.01, \kappa = 1$). But it does not affect the welfare ranking between NPT and CPI rules in this case. The CPI rule still dominates the NPT rule, implying stabilizing the exchange rate fluctuation is still very important even when technology shocks are considered. The reversal between FER and NPT rules after the introduction of technology shock is not surprising, since the welfare differential is very small in the benchmark case anyway. Also, flexible exchange rate rule is much more efficient in dealing with domestic shocks then fixed exchange rate rules. The dominance of CPI rule still indicates importance of exchange rate stabilization when economy is characterized by the two trade structure features.

For the other three cases, from Table 3 we can see that the introduction of technology shocks does not affect the welfare ranking of monetary rules.

In Section 4, we find that, when the elasticity of input substitution is close to zero and the export prices are set in the foreign currency, a CPI rule is superior to a fixed exchange rate, although the desirability of flexible exchange rate is reduced. A CPI rule is simply a convex combination of a NPT rule and a fixed exchange rate rule. The fact that the CPI rule delivers the highest welfare shows that a

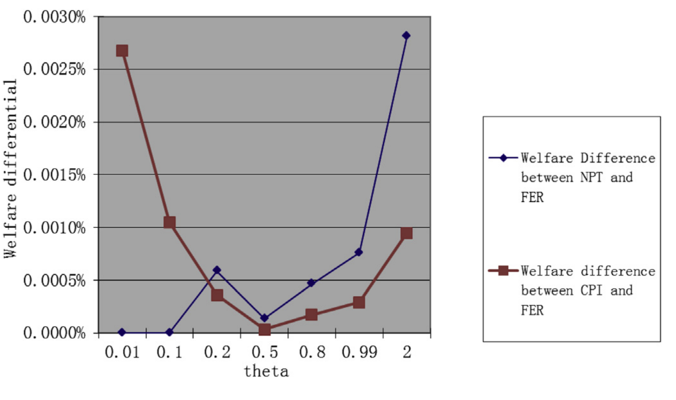

Fig. 7. Welfare differential under different rules with tech shocks only.

Table 3
Welfare comparison under both external and internal shocks (%).

	$\kappa = 1$	$\kappa = 0$
$\theta = 0.01$	$(\xi_{NPT} = 1.796, \xi_{FER} = 1.795, \xi_{CPI} = 1.806)$	$(\xi_{NPT} = 2.149, \xi_{FER} = 1.795, \xi_{CPI} = 1.877)$
$\theta = 0.99$	$(\xi_{NPT} = 0.661, \xi_{FER} = 0.635, \xi_{CPI} = 0.644)$	$(\xi_{NPT} = 0.707, \xi_{FER} = 0.635, \xi_{CPI} = 0.655)$

Table 4
Optimal weighting scheme under external shocks.

	$\kappa = 1$	$\kappa = 0$
$\theta = 0.01$	$a^* = 0.92$	$a^* = 1$
$\theta = 0.99$	$a^* = 0.99$	$a^* = 1$

combination of NPT and FER rules might be the optimal policy, but the combination implied by the CPI rule is not necessarily the optimal one. So we consider the following interest rate rule:

$$1 + i_{t+1} = \left[\left(\frac{P_{Nt}}{P_{Nt-1}} \frac{1}{\overline{\pi}_n} \right)^{a^*} \left(\frac{S_t}{\overline{S}} \right)^{1-a^*} \right]^{\pi_a} (1 + \overline{\imath}), \tag{5.1}$$

where π_a represents a large positive number. This rule can be considered as a combination of the NPT rule and the FER rule. And we can choose the weight a^* to see which combination gives the highest welfare. In Table 4, we report the weight scheme in terms of a^* that delivers the highest welfare for given calibration of θ and κ. Since welfare measure under technology shocks are quite small, we focus on the exogenous shocks only in Tables 4 and 5.

Table 4 shows that, only in the extreme case where fixed exchange rate may dominate the NPT rule, the optimal rule is the one with $a^* = 0.92$. That is, the monetary authority should put 92 percent weight on non-traded goods price to get an optimal combination of NPT and FER rule, whereas in a CPI rule the weight on non-traded goods price is 60%. In the other three cases, the optimal weight is almost 1, implying NTP rule is almost the optimal monetary rule even if we consider weighted combination of the NPT rule and the FER rule.

In the extreme case where flexible exchange rate rules are suboptimal, domestic exporters have little scope for adjustment to exchange rate changes. This implies that profits of export firms bear the brunt of exchange rate fluctuations. In our model, the representative household is the recipient of these profits. However, this may not be entirely true. In reality there is considerable multinational company ownership in East Asian exporters. Therefore, it would be interesting to see what will happen if we change the model and consider foreign ownership of export sectors. As an experiment, we assume a fraction (χ) of export firms are owned by foreign companies. Therefore, the profit included in the households' budget constraint is simply $\Pi_t^{NT} + (1 - \chi)\Pi_t^{EX}$. If χ is sufficiently large, then the domestic economy would be affected by the export sector mainly through the labor and wage channel. For simplicity, we only study how the change in ownership structure affects welfare results in the extreme case where $\theta = 0.01$ and $\kappa = 1$. Again, we only consider external shocks since the ownership changes are in the export sector.

Table 5
Welfare under different ownership structure of export sector ($\theta = 0.01$ and.$\kappa = 1$).

	$\chi = 0$	$\chi = 0.2$	$\chi = 0.5$
C_{ss}	0.8926	0.8400	0.7295
ξ_{NPT}	1.847%	2.81%	7.33%
ξ_{FER}	1.850%	2.87%	7.68%
ξ_{CPI}	1.859%	2.87%	7.62%

Table 5 shows that the higher percentage of export profits are owned by foreign firms, the lower the household's consumption (at the steady state) will be. More interestingly, same sizes of external shocks generate larger welfare changes and larger welfare differential between different monetary policy rules. Nevertheless, changes in ownership structure do not affect the welfare ranking between the NPT rule and FER rule. This implies that the welfare dominance of fixed exchange rate rule over flexible one is not due to its role in stabilizing export sector profits. Instead, it is due to its role in stabilizing labor supply and consumption of domestic households.[21]

In summary, our paper shows that the trade structure features matter for the desirability of flexible exchange rate regimes. This also implies that trade structure should be taken into consideration when monetary authorities choose exchange rate policies.

6. Conclusion

Most East Asian economies choose pegged exchange rate regimes or control the movement of the exchange rate. The literature usually attributes this ”fear of floating” to the balance-sheet effect or financial fragility in these economies. In this paper, we provide a new explanation for this phenomenon. We argue that two trade structure features in these economies can help to explain the lack of exchange rate flexibility. Specifically, weak input substitution in traded goods production and extensive use of foreign currency in export pricing inhibit the adjustment role of exchange rate changes in face of external shocks. A flexible exchange rate regime cannot help to stabilize the real variables, but leads to more fluctuations in the nominal variables, especially inflation. Allowing the exchange rates to float thus may not be desirable in these economies. To explore our explanation, we develop a small open economy stochastic general equilibrium model with sticky prices. We compare the welfare of alternative monetary policy rules and show that a fixed exchange rate rule can welfare-dominate a flexible exchange rate rule, although the parameter space is very limited. Therefore, we argue that ”fear of floating” in emerging market economies might be the central banks' optimal reaction when these economies are constrained by the above-mentioned trade structures.

References

Basu, Susanto, Fernald, John G., 1997. Returns to scale in U.S. manufacturing: estimates and implications. J. Polit. Econ. 105 (2), 249–283.

Calvo, Guillermo, 2000. Notes on Price Stickiness: with Special Reference to Liability Dollarization and Credibility. Mimeo, University of Maryland.

Calvo, Guillermo, Reinhart, Carmen, 2002. Fear of floating. Q. J. Econ. 117, 379–408.

Cespedes, Luis Felips, Chang, Robert, Velasco, Andres, 2004. Balance sheets and exchange rate policy. Am. Econ. Rev. 94 (4), 1183–1193.

Chang, Robert, Velasco, Andres, 2006. Currency mismatches and monetary policy: a tale of two equilibria. J. Int. Econ. 69 (1), 150–175.

Choi, Woon Gyu, Cook, David, 2004. Liability dollarization and the bank balance channel. J. Int. Econ. 64, 247–275.

Choudhri, Ehsan, Hakura, Dalia, 2006. Exchange rate pass-through to domestic prices: does the inflationary environment matter. J. Int. Money Finance 25, 614–639.

Christiano, Lawrence J., Eichembaum, Martin, Evans, Charles L., 1997. Monetary Policy Shocks: What Have We Learned and to What End?. In: Handbook of Macroeconomics North-Holland Pub. Co.

Cook, David, Devereux, Michael B., 2001. The Macroeconomics of International Financial Panics. Mimeo, Hong Kong University of Science and Technology.

Cook, David, Devereux, Michael B., 2006. External currency pricing and the East Asian Crisis. J. Int. Econ. 69 (1), 37–63.

Devereux, Michael, Lane, Philip, Xu, Juanyi, 2006. Exchange rates and monetary policy in emerging market economies. Econ. J. 116, 478–506.

Devereux, Michael, Yetman, James, 2010. Price adjustment and exchange rate pass-through. J. Int. Money Finance 29, 181–200.

Engel, Charles, 2011. Currency misalignments and optimal monetary policy: a reexamination. Am. Econ. Rev. 101 (6), 2796–2822.

Friedman, Milton, 1953. The case for flexible exchange rates. In: Essays in Positive Economics. Chicago University Press, Chicago.

Fraga, Arminio, Goldfajn, Ilan, Minella, Andre, 2003. Inflation targeting in emerging market economies. In: Gertler, Mark, Rogoff, Kenneth (Eds.), NBER Macroeconomic Annual 2003.

[21] If $\chi = 1$, all export sector profits are owned by foreigners. The system becomes instable in face of external shocks. Therefore, we do not consider the case where $\chi = 1$. Also, it should be noted that different χ implies different steady states.

Gertler, Mark, Gilchrist, Simon, Natalucci, Fabio, 2007. External constraint on monetary policy and financial accelerator. J. Money Credit Bank. 39, 295–330.
Gali, Jordi, Monacelli, Tommaso, 2005. Monetary policy and exchange rate volatility in a small open economy. Rev. Econ. Stud. 72, 707–734.
Mendoza, Enrique G., Yue, Vivian Z., 2012. A general equilibrium model of sovereign default and business cycles. Q. J. Econ. 127 (2), 889–946.
Mundell, Robert A., 1961. A theory of optimum currency areas. Am. Econ. Rev. 51, 657–665.
Neumeyer, Pablo A., Perri, Fabrizio, 2005. Business cycles in emerging economies: the role of interest rates. J. Monet. Econ. 52 (2), 345–380.
Ortega, Eva, Rebei, Nooman, 2006. The Welfare Implications of Inflation versus Price-Level Targeting in a Two-sector, Small Open Economy. Working Papers, Bank of Canada.
Park, Yung Chul, Chung, Chae-Shick, Wang, Yunjong, 2001. Fear of floating: Korea's exchange rate policy after the crisis. J. Jpn. Int. Econ. 15, 225–251.
Rotemberg, Julio J., 1982. Monopolistic price adjustment and aggregate output. Rev. Econ. Stud. 49 (4), 517–531.
Schmitt-Grohe, Stephanie, Uribe, Martin, 2001. Stabilizing policy and the cost of dollarization. J. Money Credit Bank. 33, 482–509.
Schmitt-Grohe, Stephanie, Uribe, Martin, 2003. Closing small open economy models. J. Int. Econ. 61, 163–185.
Schmitt-Grohe, Stephanie, Uribe, Martin, 2004. Solving dynamic general equilibrium models using a second-order approximation to the policy function. J. Econ. Dyn. Control 28, 755–775.
Uribe, Martin, Yue, Vivien Z., 2006. Country spreads and emerging markets: who drives whom? J. Int. Econ. 69, 6–36.