

Input Substitution, Export Pricing, and Exchange Rate Policy

Kang Shi*

Chinese University of Hong Kong

Juanyi Xu

Hong Kong University of Science and Technology

Xiaopeng Yin

University of International Business and Economics

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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 goods 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 fixed exchange rate may dominate monetary policy rules with high exchange rate flexibility in terms of welfare. In a sense, our finding provides a rationale for the “fear of floating” phenomenon in these economies. That is, “fear of floating” may be central banks’ rational reaction when these economies are constrained by the trade features mentioned above.

JEL classification: F3, F4

Keywords: Input substitution, Export pricing, Exchange rate flexibility, Welfare

*Shi: Department of Economics, Chinese University of Hong Kong, Shatin, New Territories, Hong Kong; Tel (852)2609-8194; Email: kangshi@cuhk.edu.hk. Xu: Department of Economics, Hong Kong University of Science and Technology. Email: jennyxu@ust.hk. Yin: School of International Trade and Economics, University of International Business and Economics. Email: xyin@uibe.edu.cn. We thank Michael B. Devereux, Hafedh Bouakez, Hongbin Li, and the seminar participants at the 2006 Annual Meeting of the Canadian Economics Association, and 2007 Far Eastern Meeting of the Econometric Society for comments and helpful discussions. Part of this research was conducted while Juanyi Xu and Kang Shi were visiting the Hong Kong Institute for Monetary Research as Research Fellows. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Hong Kong Institute for Monetary Research, its Council of Advisors, or the Board of Directors.

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 the 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 the welfare properties of simple monetary rules in dynamic, general equilibrium, sticky-price, small open economy models. (See Devereux, Lane and Xu, 2006; and Gali and Monsacelli, 2005). An especially pertinent example is Schmitt-Grohe and Uribe (2001), who examined a small open economy model and compare the welfare properties of a number of interventionist monetary policy rules¹ 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.

However, in reality, 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. The exchange rate regimes in these economies ranged from a currency board hard peg in Hong Kong to a sliding or crawling peg in Indonesia.² The

¹All these rules allow for exchange rate movement.

²Although these pegs were often not openly admitted or were disguised as currency baskets, the common adherence to the dollar is easy to recognize. For example, Singapore follows an exchange-rate-centered monetary policy, targeting a trade-weighted exchange rate index. Thailand has followed a managed floating system since the 1997 Asian financial crisis. Park et al. (2001) shows that Korea is still fearful of floating although it claims to have a flexible exchange rate regime.

volatilities of East Asian currencies were usually much lower than those of major currencies.

Thus, it remains a challenge for economists to explain the 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 to the presence of foreign currency debt or currency mismatch in these economies. Cespedes, Chang, and Velasco (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 the 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, Gilchrist, and Natalucci (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) study the simultaneous determination of exchange rate regimes and portfolio choices between domestic and foreign currency bonds. They 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, Lane, and Xu (2006) show that financial frictions magnify the volatility of economies but they do not affect the ranking of alternative policy rules. Given the structure of their model, they find that the policy maker would always choose a flexible exchange rate.³

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 policy. Our research is

³Choi 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.

motivated by two well-observed facts in the 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 trade⁴. Secondly, most export goods in these economies are priced in foreign currencies, especially in US dollar. 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 the high percentage of processing trade in the total trade, the elasticity of substitution between imported intermediates and local labor will be very small 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 not 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 2003, and Devereux and Yetman 2005). In an economy with high exchange rate pass-through to consumption goods, there

⁴Processing 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 enterprises within the domestic economy.

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 to stabilize 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, Goldfajn and Minella (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, since, under such conditions a flexible exchange rate does not help to stabilize output, but leads to inflation instability. Therefore, a fixed exchange rate regime may be the optimal monetary policy for a small open economy characterized by weak traded goods 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”. Even without considering the balance sheet effect, in a small open economy with the two features mentioned above, a fixed exchange rate may be superior to a flexible exchange rate in terms of welfare.

To explore our explanation, we develop a small open economy stochastic general equilibrium model with sticky prices, where there is vertical trade. Export firms are monopolistic competitive, and they 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. In this economy, we assume that central bank chooses a simple interest rate targeting rule, which can represent different exchange rate regimes. Therefore, we can investigate welfare properties of different monetary policy rules when the economy faces external shocks.

Following Schmitt-Grohe and Uribe (2004), we use a perturbation method to calculate welfare. We show that the presence of low input substitution (or input complementarities) and foreign currency pricing can affect the welfare ranking between flexible exchange rates and fixed exchange rates. That is, a fixed exchange rate can dominate a flexible exchange

rate in terms of welfare. In particular, we find that both low input substitution and foreign currency pricing are essential in producing this result. To our knowledge, this paper is the first to show that a fixed exchange rate can be superior to a flexible exchange rate in terms of welfare. Therefore, 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. In a sense, our finding also provides a rationale for the “fear of floating” phenomenon in East Asian economies. That is, controlling exchange rate fluctuation or “fear of floating” in these economies might be central banks’ rational reactions when they are constrained by these trade structure features.

Our research is closely related to Devereux, Lane, and Xu (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 monetary transmission mechanism and the exchange rate policy. To our knowledge, this paper is the first to explore the implication of input substitution on exchange rate policy choice in the literature.

Regarding the discussion of the “fear of floating” phenomenon, our paper’s major contribution is that we focus on how the trade structure features in East Asian economies, instead of the financial condition, affect the choice of the exchange rate policy. In particular, we show how weak input substitution in the trade sector and foreign currency pricing affect the exchange rate policy regimes in these economies. We argue that “fear of floating” in emerging market economies might be central banks’ optimal reaction when they are constrained by these trade structure features.

This paper is organized as follows. Section 2 presents the basic setup of the model. Section 3 reports the dynamic results of our model when the economy is buffeted by different external shocks. Section 4 compares the welfare properties of different exchange rate regimes and discusses relevant implications. Section 5 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 foreign currency (we will simply call it dollars in the later discussion).

There are three types of domestic agents in the model: consumers, firms, and the 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 determine 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 domestic residents and foreign markets. The monetary policy (or the exchange rate regime) is represented by a domestic interest rate targeting rule set by the monetary authority.

The economy is subjected to two types of external shocks: foreign demand shocks and world interest rate shocks. 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:

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

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

⁵In 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.

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 follows

$$C_t = \frac{1}{\alpha^\alpha(1-\alpha)^{1-\alpha}} C_{Nt}^{1-\alpha} C_{Ft}^\alpha, \quad (2.2)$$

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. The Cobb-Douglas form of equation (2.2) implies a unit elasticity of substitution between domestic goods and foreign goods in consumption. Given the consumption index, the consumer price index for domestic households can be derived as

$$P_t = P_{Nt}^{1-\alpha} P_{Ft}^\alpha, \quad (2.3)$$

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 non state-contingent 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 $\frac{\psi_D}{2}(D_{t+1} - \bar{D})^2$ (denominated in the composite good), where \bar{D} is an exogenous steady state level of net foreign debt.⁶ The household can borrow in foreign currency bonds at a 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 consumer'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

$$P_t C_t = W_t L_t + T_t + \Pi_t + S_t D_{t+1} + B_{t+1} - P_t \frac{\psi_D}{2} (D_{t+1} - \bar{D})^2 - (1 + i_t^*) S_t D_t - (1 + i_t) B_t. \quad (2.4)$$

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

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. Note that i_t^* is the world interest rate and is exogenously given.

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

$$C_{Nt} = (1 - \alpha) \frac{P_t C_t}{P_{Nt}}, \quad C_{Ft} = \alpha \frac{P_t C_t}{P_{Ft}}. \quad (2.5)$$

The household optimality conditions can be characterized by the following conditions:

$$\frac{1}{1 + i_{t+1}^*} \left[1 - \frac{\psi_D P_t}{S_t} (D_{t+1} - \bar{D}) \right] = \beta E_t \left[\frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{S_{t+1}}{S_t} \right] \quad (2.6)$$

$$\frac{1}{1 + i_{t+1}} = \beta E_t \left(\frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \right) \quad (2.7)$$

$$W_t = \eta L_t^\psi P_t C_t^\rho. \quad (2.8)$$

Equations (2.6) and (2.7) represent the Euler equation for the foreign and domestic bond holdings. Equation (2.8) is the labor supply equation. Combining (2.6) and (2.7) gives interest rate parity condition for this economy.

We assume that the foreign good has a constant price of one in terms of dollars in the world market,⁷ 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 in this small open economy: 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,

⁷For convenience, we assume that the price of imported consumption goods in terms of the foreign currency is equal to the foreign price level, P^* , which is generally normalized as 1.

while export goods are produced by combining labor and import intermediates(or capital goods).

2.2.1 The 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

$$Y_{Nt} = \left(\int_0^1 Y_{Nt}(j)^{\frac{\lambda-1}{\lambda}} dj \right)^{\frac{\lambda}{\lambda-1}}, \quad (2.9)$$

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

$$Y_{Nt}(j) = \left(\frac{P_{Nt}(j)}{P_{Nt}} \right)^{-\lambda} Y_{Nt}, \quad (2.10)$$

where the price index for composite non-traded goods, P_{Nt} , is given by

$$P_{Nt} = \left(\int_0^1 P_{Nt}(j)^{1-\lambda} \right)^{\frac{1}{1-\lambda}}. \quad (2.11)$$

Each monopolistically competitive firm has a linear production technology:

$$Y_{Nt}(j) = L_{Nt}(j) \quad (2.12)$$

We follow Rotemberg (1982) in assuming that each firm bears a small direct cost of price adjustments. As a result, firms will only adjust prices gradually in response to a shock to demand or marginal cost. 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:

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[P_{Nt+l}(j) Y_{Nt+l}(j) - MC_{Nt+l} Y_{Nt+l}(j) - \frac{\psi P_N}{2} P_{t+l} \left(\frac{P_{Nt+l}(j) - P_{Nt+l-1}(j)}{P_{Nt+l-1}(j)} \right)^2 \right], \quad (2.13)$$

where $\Gamma_{t+l} = \frac{1}{P_{t+l} C_{t+l}^\sigma}$ is the marginal utility of wealth for a representative household, and $MC_{Nt} = W_t$ represents the 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, $P_{Nt+l}(j)|_{l=0,\dots,\infty}$ to maximize (2.13). 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:⁸

$$P_{Nt} = \frac{\lambda}{\lambda-1} MC_{Nt} - \frac{\psi_{P_N}}{\lambda-1} \frac{P_t}{Y_{Nt}} \frac{P_{Nt}}{P_{Nt-1}} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right) + \frac{\psi_{P_N}}{\lambda-1} E_t \left[\beta \frac{\Gamma_{t+1}}{\Gamma_t} \frac{P_{t+1}}{Y_{Nt}} \frac{P_{Nt+1}}{P_{Nt}} \left(\frac{P_{Nt+1}}{P_{Nt}} - 1 \right) \right]. \quad (2.14)$$

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

2.2.2 The 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 and the aggregate traded good is given by

$$Y_{Tt} = \left(\int_0^1 Y_{Tt}(i)^{\frac{\lambda-1}{\lambda}} di \right)^{\frac{\lambda}{\lambda-1}}. \quad (2.15)$$

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

$$Y_{Tt}(i) = [\alpha_T^{\frac{1}{\theta}} L_{Tt}(i)^{\frac{\theta-1}{\theta}} + (1 - \alpha_T)^{\frac{1}{\theta}} IM_t(i)^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \quad (2.16)$$

where 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 special case, the production function can be characterized by a fixed proportional technology or a Leontief technology:

⁸This 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 price under Calvo pricing.

$$Y_{Tt}(i) = \min\left[\frac{L_{Tt}(i)}{\phi}, IM_t(i)\right] \quad (2.17)$$

That is, producing one unit of traded good requires ϕ units of local labor and one unit of imported intermediate goods. In this paper, we focus on 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.

In the general case where $\theta > 0$, the marginal cost, MC_{Tt} , is given by

$$MC_{Tt} = [\alpha_T W_t^{1-\theta} + (1 - \alpha_T)(S_t P_m^*)^{1-\theta}]^{\frac{1}{1-\theta}}, \quad (2.18)$$

If $\theta = 0$, then we have

$$MC_{Tt} = \phi W_t + S_t P_m^*, \quad (2.19)$$

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

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[S_t P_{TFt+l}^*(i) Y_{TFt+l}(i) - MC_{TFt+l} Y_{TFt+l}(i) - \frac{\psi_{P_T}}{2} P_{t+l} \left(\frac{P_{TFt+l}^*(i) - P_{TFt+l-1}^*(i)}{P_{TFt+l-1}^*(i)} \right)^2 \right], \quad (2.20)$$

subject to

$$Y_{TFt}(i) = \left(\frac{P_{TFt}^*(i)}{P_{Tt}^*} \right)^{-\lambda} Y_{Tt} = \left(\frac{P_{TFt}^*(i)}{P_{Tt}^*} \right)^{-\lambda} \left(\frac{P_{Tt}^*}{P^*} \right)^{-\mu} X_t, \quad (2.21)$$

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 produced traded goods; P_{Tt}^* is the price index for all domestically produced export goods sold in the world market (will be defined later); 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.

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

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[P_{TDt+l}(i) Y_{TDt+l}(i) - MC_{Tt+l} Y_{TDt+l}(i) - \frac{\psi_{P_T}}{2} P_{t+l} \left(\frac{P_{TDt+l}(i) - P_{TDt+l-1}(i)}{P_{TDt+l-1}(i)} \right)^2 \right], \quad (2.22)$$

subject to

$$Y_{TDt}(i) = \left(\frac{P_{TDt}(i)}{S_t P_{Tt}^*} \right)^{-\lambda} Y_{Tt} = \left(\frac{P_{TDt}}{S_t P_{Tt}^*} \right)^{-\lambda} \left(\frac{P_{Tt}^*}{P^*} \right)^{-\mu} X_t, \quad (2.23)$$

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:

$$P_{TFt}^* = \frac{\lambda}{\lambda-1} \frac{MC_{Tt}}{S_t} - \frac{\psi_{P_T}}{\lambda-1} \frac{1}{S_t} \frac{P_t}{Y_{TFt}} \frac{P_{TFt}}{P_{TFt-1}} \left(\frac{P_{TFt}}{P_{TFt-1}} - 1 \right) + \frac{\psi_{P_T}}{\lambda-1} E_t \left[\beta \frac{1}{S_t} \frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{P_{t+1}}{Y_{TFt}} \frac{P_{TFt+1}}{P_{TFt}} \left(\frac{P_{TFt+1}}{P_{TFt}} - 1 \right) \right]. \quad (2.24)$$

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

$$P_{TDt} = \frac{\lambda}{\lambda-1} MC_{Tt} - \frac{\psi_{P_T}}{\lambda-1} \frac{P_t}{Y_{TDt}} \frac{P_{TDt}}{P_{TDt-1}} \left(\frac{P_{TDt}}{P_{TDt-1}} - 1 \right) + \frac{\psi_{P_T}}{\lambda-1} E_t \left[\beta \frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{P_{t+1}}{Y_{TDt}} \frac{P_{TDt+1}}{P_{TDt}} \left(\frac{P_{TDt+1}}{P_{TDt}} - 1 \right) \right], \quad (2.25)$$

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

$$Y_{TFt} = \left(\frac{P_{TFt}^*}{P^*} \right)^{-\lambda} \left(\frac{P_{Tt}^*}{P^*} \right)^{-\mu} X_t, \quad Y_{TDt} = \left(\frac{P_{TDt}}{S_t P_{Tt}^*} \right)^{-\lambda} \left(\frac{P_{Tt}^*}{P^*} \right)^{-\mu} X_t, \quad (2.26)$$

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

$$P_{Tt}^* = [\kappa P_{TFt}^*{}^{1-\lambda} + (1-\kappa) \left(\frac{P_{TDt}}{S_t} \right)^{1-\lambda}]^{\frac{1}{1-\lambda}}. \quad (2.27)$$

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

2.3 Monetary Policy Rules

The 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

$$1 + i_{t+1} = \left(\frac{P_{Nt}}{P_{Nt-1}} \frac{1}{\bar{\pi}_n} \right)^{\mu_{\pi_n}} \left(\frac{S_t}{\bar{S}} \right)^{\mu_S} (1 + \bar{i}). \quad (2.28)$$

The parameter μ_{π_n} allows the monetary authority to control the inflation rate in the non-traded goods sector around a target rate of $\bar{\pi}_n$. μ_S controls the degree to which the monetary authority attempts to control variations in the exchange rate, around a target level of \bar{S} . The general form of the interest rule (2.28) allows for two types of monetary policy stances. The first rule is one whereby the monetary authority targets the inflation rate of non-traded goods (NTP rule), so that $\mu_{\pi_N} \rightarrow \infty$. 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 second rule we analyze is a simple fixed exchange rate rule (FER rule) by setting $\mu_S \rightarrow \infty$, whereby the monetary authority adjusts interest rates to keep the nominal exchange rate fixed at the target level of \bar{S} .¹⁰ Note that the form of our monetary rules is slightly different from that used by Devereux, Lane, and Xu (2006). We do not consider the consumer price inflation targeting (CPI) as a policy option in our model. This is because, with high exchange rate pass-through and the price rigidity in the non-traded sector in this economy, a CPI inflation targeting rule is almost equivalent to a fixed exchange rate rule.

2.4 External Shocks

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

$$\log(1 + i_{t+1}^*) = (1 - \rho_R)\log(1 + \bar{r}) + \rho_R \log(1 + i_t^*) + \epsilon_{i^*t}, \quad (2.29)$$

¹⁰In a numerical exercise, we set $\mu_{\pi_N} = 900$ and $\mu_S = 900$ for the NTP rule and the FER rule, respectively. In each case, we set the policy so that the equilibrium is determinate.

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

$$\log(X_t) = (1 - \rho_X)\log(\bar{X}) + \rho_X\log(X_{t-1}) + \epsilon_{xt} \quad (2.30)$$

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

2.5 Equilibrium

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

$$L_{Nt} + L_{Tt} = L_t, \quad (2.31)$$

where $L_{Tt} = \alpha_T \left(\frac{W_t}{MC_{Tt}}\right)^{-\theta} Y_{Tt}$.

The non-traded goods market clearing condition is given by

$$Y_{Nt} = (1 - \alpha) \frac{P_t Z_t}{P_{Nt}}, \quad (2.32)$$

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

$$Z_t = C_t + \frac{1}{2} \psi_{p_N} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1\right)^2 + \frac{\kappa}{2} \psi_{p_T} \left(\frac{P_{TFt}^*}{P_{TFt-1}^*} - 1\right)^2 + \frac{1 - \kappa}{2} \psi_{p_T} \left(\frac{P_{TDt}}{P_{TDt-1}} - 1\right)^2 + \frac{1}{2} \psi_D (D_{t+1} - \bar{D})^2 \quad (2.33)$$

In the traded goods market, we have $Y_{Tt} = \left(\frac{P_{Tt}}{P^*}\right)^{-\mu} X_t$, 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 (2.33), we can rewrite the household's budget constraint as

$$S_t P_{Tt}^* Y_{Tt} - \alpha P_t Z_t - S_t P_m^* I M_t + S_t D_{t+1} - (1 + i_t^*) S_t D_t = 0. \quad (2.34)$$

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, $S_t P_m^* I M_t$.

¹¹The details of the equilibrium conditions are given in the technical appendix.

3 The Dynamics of the Model

This section discusses impulse responses of key aggregate variables to external shocks. This can help to highlight the transmission mechanisms of external shocks in a small open economy characterized by the two features we emphasized, weak input substitution and extensive use of foreign currency pricing. We consider two types of external shocks: a) shocks to the world interest rate, which are represented by shocks to i_t^* ; and b) foreign demand shocks, which are represented by shocks to X_t .

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, $\frac{1}{\psi}$, 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 (2000) 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

Ortega and Rebei (2006) show that that price rigidity differs in different sectors. Prices are more rigid in the non-traded goods sector than in the traded goods sector. Therefore, to determine the degree of nominal rigidity in the model, we set the parameters governing

¹²As pointed out by Cook and Devereux (2001), markups are usually higher in emerging markets, so they choose $\lambda = 6$. In the processing trade firms, however, the profit margin is lower than the others, therefore, we still choose $\lambda = 11$ in this model.

¹³We set $\eta = 1$ as it is only a scale parameter in our model.

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
σ_ϵ	1%	θ	[0,2]	η	1
ϕ_{P_N}	120	ϕ_{P_T}	105		

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^{14} and 0.70 , respectively. 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 $\theta = 0.01^{15}$ and $\kappa = 1$. 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, when we discuss 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 external shocks, we set $\rho_R = 0.54$, $\sigma_{i^*} = 0.007$, $\rho_x = 0.70$, and $\sigma_x = 0.0044$. The values of these parameters are close to empirical estimates from Devereux, Lane, and Xu (2006), Uribe and Yue (2006), and Ortega and Rebei (2006).

¹⁴That 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.

¹⁵The 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.

3.2 Impulse Response Function

Now we analyze the impact of shocks under a NTP rule and a FER rule 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).

3.2.1 Interest Rate Shocks

Figures 1 and 2 illustrate the effects of a world interest rate shock. The responses of variables are in terms of the percentage deviation from their steady state values to a one-period 100 basic points increase to the world interest rate.

The NTP rule allows for exchange rate movement. When the foreign interest rate increases, the nominal exchange rate depreciates. Due to the full exchange rate pass-through 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, due to the presence of foreign currency pricing, 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 very small, though total labor increases sharply.

An 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 a contraction of the real variables. Consumption falls more than under the NTP rule, and now the non-traded goods sector output decreases as well because there is no 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 NTP rule except for the change in the marginal cost of traded goods. Under the NTP rule, MC_T increases since the nominal exchange rate depreciates. Under the FER rule, MC_T decreases because wages decrease.

In Figure 1 and 2, 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 causes large fluctuation in the nominal variables, especially in inflation.

3.2.2 Foreign Demand Shocks

Figure 3 illustrates the effects of a persistent positive shock to the foreign demand. Under the NTP rule, the shock will lead to nominal exchange rate appreciation. Since the export goods are priced in foreign currencies, 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 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, as 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 a decrease in inflation and in the marginal cost of traded goods.

Figure 4 shows that, under the FER rule, the response of traded goods output and traded goods price are exactly the same as under the NTP rule. Because there is no exchange rate movement, the responses of aggregate consumption and employment are different from those under the NTP rule. They both increase sharply and then return to their initial levels quickly. In addition, we also find that the fluctuation of the CPI price and the marginal cost are smaller than those under the NTP rule again. Note that MC_T increases under the FER rule because wages (non-traded good price) increase.

In summary, the effects of a foreign demand shock are different from those of an interest rate shock. 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 weakened. Allowing for exchange rate fluctuation cannot stabilize real variables, such as consumption and employment. Instead, it causes larger fluctuation in nominal variables, especially inflation.

In the next section, we investigate the implication of weak input substitution and foreign currency pricing on welfare ranking between the NPT and FER rules and check if a FER rule can dominate a NTP rule in terms of welfare.

4 Welfare Analysis

In this section, we discuss the welfare properties of monetary rules in the economy. The welfare measurement we use here is the conditional expected lifetime utility of the representative household at time zero. Following Schmitt-Grohe and Uribe (2004), the expected lifetime utility is computed conditional on the initial state being the deterministic steady state, which is the same for all policy regimes.¹⁶ 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:

$$\frac{\frac{1}{1-\rho}[(1 + \zeta_k)\bar{C}]^{1-\rho} - \frac{\eta}{1+\psi}\bar{L}^{1+\psi}}{1 - \beta} = EU_k, \quad (4.1)$$

where \bar{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 values of ζ_k correspond 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.¹⁷ The values of the structural parameters are those used in Section 3.1.

¹⁶This choice of the initial state has the advantage of ensuring that the economy starts from the same initial point for all policy regimes considered.

¹⁷The model is solved using Dynare.

Table 2: Welfare Comparison (%)

	$\kappa = 1$	$\kappa = 0$
$\theta = 0.01$	$(\xi_{NTP} = 0.841, \xi_{FER} = 0.845)$	$(\xi_{NTP} = 1.020, \xi_{FER} = 0.845)$
$\theta = 0.99$	$(\xi_{NTP} = 0.316, \xi_{FER} = 0.304)$	$(\xi_{NTP} = 0.338, \xi_{FER} = 0.304)$

In Table 2, we present the welfare results for four different cases when the model is driven by both a foreign demand shock and a world interest rate shock as specified in Section 3.1. We find that only in the benchmark case, ($\theta \rightarrow 0, \kappa = 1$), the FER rule marginally dominates the NTP rule in terms of welfare, although the welfare differential is small, at about 0.04% steady state consumption.¹⁸ Nevertheless, we can still see from Table 2 that when the elasticity of input substitution, θ , decreases or the degree of foreign currency pricing, κ , increases, the welfare ranking between the NTP rule and the FER rule is reversed.

To highlight the importance of both factors in determining the welfare ranking between the NTP rule and the FER rule, we do two welfare experiments. The results are given in Figures 5 and 6.

Figure 5 describes welfare changes under both the NTP rule and the FER rule when the degree of foreign currency pricing, κ , increases, given $\theta = 0.01$.¹⁹ This figure shows that welfare under the NTP rule decreases with κ , while welfare under the FER rule does not vary 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 NPT rule. The welfare under the NPT 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 NTP rule and the FER rule is different. Given low input substitution ($\theta = 0.01$), if κ is not too big, the NTP rule delivers higher welfare than

¹⁸Note that different θ implies different steady states, so welfare under different θ is not comparable.

¹⁹Note that, in this welfare experiment, the change in κ does not affect the steady state. The welfare results are thus comparable even when κ changes.

does the FER rule. However, when κ is big enough, the welfare ranking between them is reversed and the FER rule dominates.

Figure 6 shows changes in the welfare differential between the NTP rule and the FER rule when θ increases, given $\kappa = 1$. As θ increases, the steady state also changes. Therefore, we can only compare the welfare differential between the two rules, but not the welfare for different values of θ . In Figure 6, there is no monotonic relation between the welfare differential and θ . A low θ leads to a negative welfare differential, which implies that the FER rule dominates the NTP rule in terms of welfare. Obviously, when inputs have low substitutability, the expenditure-switching role of exchange rate adjustment on input substitution is limited. Given extensive use of foreign currency pricing, the FER rule is better.

However, we can also see from Figure 6 that, when θ increases, the welfare differential between the NTP 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 excess fluctuation of real variables, which also hurts the desirability of exchange rate flexibility. Nevertheless, for empirically relevant parameterizations, ($\theta \in [0, 2]$), 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

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 affect 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 with price rigidity is limited as the expenditure-switching effect in input substitution

²⁰Note 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 NTP rule. This is because the steady states change when θ changes and the welfare under the two rules changes as well.

is small or even disappears. Meanwhile, when most export goods are priced in the foreign currency, in the short run, export prices are fixed in terms of the foreign currency and 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 in traded goods input substitution and a high degree of foreign currency pricing of export goods, controlling the fluctuation of the nominal exchange rates seems to be the optimal policy. In other words, 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 Table 2 and Figures 5 and 6, we can see that, in empirically relevant parameterizations, both low input substitution and extensive foreign currency pricing are essential in producing this welfare result. This may be 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.

In summary, our paper provides a rationale for the so-called “fear of floating” phenomenon. Different from other works in the “fear of floating” literature, we focus on how the trade structure features in East Asian economies, instead of financial conditions, affect the choices of exchange rate policies.

5 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 the exchange rate in the face of external shocks. A flexible exchange rate regime does not help to stabilize the real variables, but leads to more fluctuations in the nominal variables, especially inflation. Allowing the exchange rates to float is not 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. 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.

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Technical Appendix

Not for Publication

A Equilibrium Condition

Household

$$P_t = P_{Nt}^{1-\alpha} S_t^\alpha \quad (\text{A.1})$$

$$C_{Nt} = (1 - \alpha) \frac{P_t C_t}{P_{Nt}} \quad (\text{A.2})$$

$$C_{Ft} = \alpha \frac{P_t C_t}{S_t} \quad (\text{A.3})$$

$$\frac{1}{1 + i_{t+1}^*} \left[1 - \frac{\psi_D P_t}{S_t} (D_{t+1} - \bar{D}) \right] = \beta E_t \left[\frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{S_{t+1}}{S_t} \right] \quad (\text{A.4})$$

$$\frac{1}{1 + i_{t+1}} = \beta E_t \left(\frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \right) \quad (\text{A.5})$$

$$W_t = \eta L_t^\psi P_t C_t^\rho. \quad (\text{A.6})$$

Non-traded Sector

$$Y_{Nt} = L_{Nt} \quad (\text{A.7})$$

$$P_{Nt} = \frac{\lambda}{\lambda - 1} W_t - \frac{\psi_{P_N}}{\lambda - 1} \frac{P_t}{Y_{Nt}} \frac{P_{Nt}}{P_{Nt-1}} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right) + \frac{\psi_{P_N}}{\lambda - 1} E_t \left[\beta \frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{P_{t+1}}{Y_{Nt}} \frac{P_{Nt+1}}{P_{Nt}} \left(\frac{P_{Nt+1}}{P_{Nt}} - 1 \right) \right]. \quad (\text{A.8})$$

Traded Sector

$$MC_{Tt} = [\alpha_T W_t^{1-\theta} + (1 - \alpha_T) (S_t P_m^*)^{1-\theta}]^{\frac{1}{1-\theta}} \quad (\text{A.9})$$

$$P_{Tt}^* = [\kappa P_{TFt}^{*1-\lambda} + (1 - \kappa) \left(\frac{P_{TDt}}{S_t} \right)^{1-\lambda}]^{\frac{1}{1-\lambda}} \quad (\text{A.10})$$

$$L_{Tt} = \alpha_T \left(\frac{W_t}{MC_{Tt}} \right)^{-\theta} Y_{Tt} \quad (\text{A.11})$$

$$IM_t = (1 - \alpha_T) \left(\frac{S_t P_m^*}{MC_{Tt}} \right)^{-\theta} Y_{Tt} \quad (\text{A.12})$$

$$Y_{TFt} = \left(\frac{P_{TFt}}{P_{Tt}^*}\right)^{-\lambda} Y_{Tt} \quad (\text{A.13})$$

$$Y_{TDt} = \left(\frac{P_{TDt}}{S_t P_{Tt}^*}\right)^{-\lambda} Y_{Tt} \quad (\text{A.14})$$

$$P_{TFt}^* = \frac{\lambda}{\lambda-1} \frac{MC_{Tt}}{S_t} - \frac{\psi_{P_T}}{\lambda-1} \frac{1}{S_t} \frac{P_t}{Y_{TFt}} \frac{P_{TFt}}{P_{TFt-1}} \left(\frac{P_{TFt}}{P_{TFt-1}} - 1\right) + \frac{\psi_{P_T}}{\lambda-1} E_t \left[\beta \frac{1}{S_t} \frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{P_{t+1}}{Y_{TFt}} \frac{P_{TFt+1}}{P_{TFt}} \left(\frac{P_{TFt+1}}{P_{TFt}} - 1\right) \right]. \quad (\text{A.15})$$

$$P_{TDt} = \frac{\lambda}{\lambda-1} MC_{Tt} - \frac{\psi_{P_T}}{\lambda-1} \frac{P_t}{Y_{TDt}} \frac{P_{TDt}}{P_{TDt-1}} \left(\frac{P_{TDt}}{P_{TDt-1}} - 1\right) + \frac{\psi_{P_T}}{\lambda-1} E_t \left[\beta \frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \frac{P_{t+1}}{Y_{TDt}} \frac{P_{TDt+1}}{P_{TDt}} \left(\frac{P_{TDt+1}}{P_{TDt}} - 1\right) \right] \quad (\text{A.16})$$

Market Clearing Condition

$$L = L_{Nt} + L_{Tt} \quad (\text{A.17})$$

$$Z_t = C_t + \frac{1}{2} \psi_{p_N} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1\right)^2 + \frac{\kappa}{2} \psi_{p_T} \left(\frac{P_{TFt}^*}{P_{TFt-1}^*} - 1\right)^2 + \frac{1-\kappa}{2} \psi_{p_T} \left(\frac{P_{TDt}}{P_{TDt-1}} - 1\right)^2 + \frac{1}{2} \psi_D (D_{t+1} - \bar{D})^2 \quad (\text{A.18})$$

$$Y_{Nt} = (1 - \alpha) \frac{P_t Z_t}{P_{Nt}} \quad (\text{A.19})$$

$$Y_{Tt} = \left(\frac{P_{Tt}^*}{P^*}\right)^{-\mu} X_t \quad (\text{A.20})$$

,

$$S_t P_{Tt}^* Y_{Tt} - \alpha P_t Z_t - S_t P_m^* I M_t + S_t D_{t+1} - (1 + i_t^*) S_t D_t = 0. \quad (\text{A.21})$$

$$1 + i_{t+1} = \left(\frac{P_{Nt}}{P_{Nt-1}} \frac{1}{\bar{\pi}_n}\right)^{\mu \pi_n} \left(\frac{S_t}{\bar{S}}\right)^{\mu_S} (1 + \bar{i}). \quad (\text{A.22})$$

Stochastic Process

$$\log(X_t) = (1 - \rho_x) \log(\bar{X}) + \rho_x \log(X_{t-1}) + \epsilon_{xt} \quad (\text{A.23})$$

$$\log(1 + i_{t+1}^*) = (1 - \rho_R) \log(1 + \bar{r}) + \rho_R \log(1 + i_t^*) + \epsilon_{i^*t} \quad (\text{A.24})$$

Figure 1: **Impulse Response to $+i^*$ shock under NTP Rule**

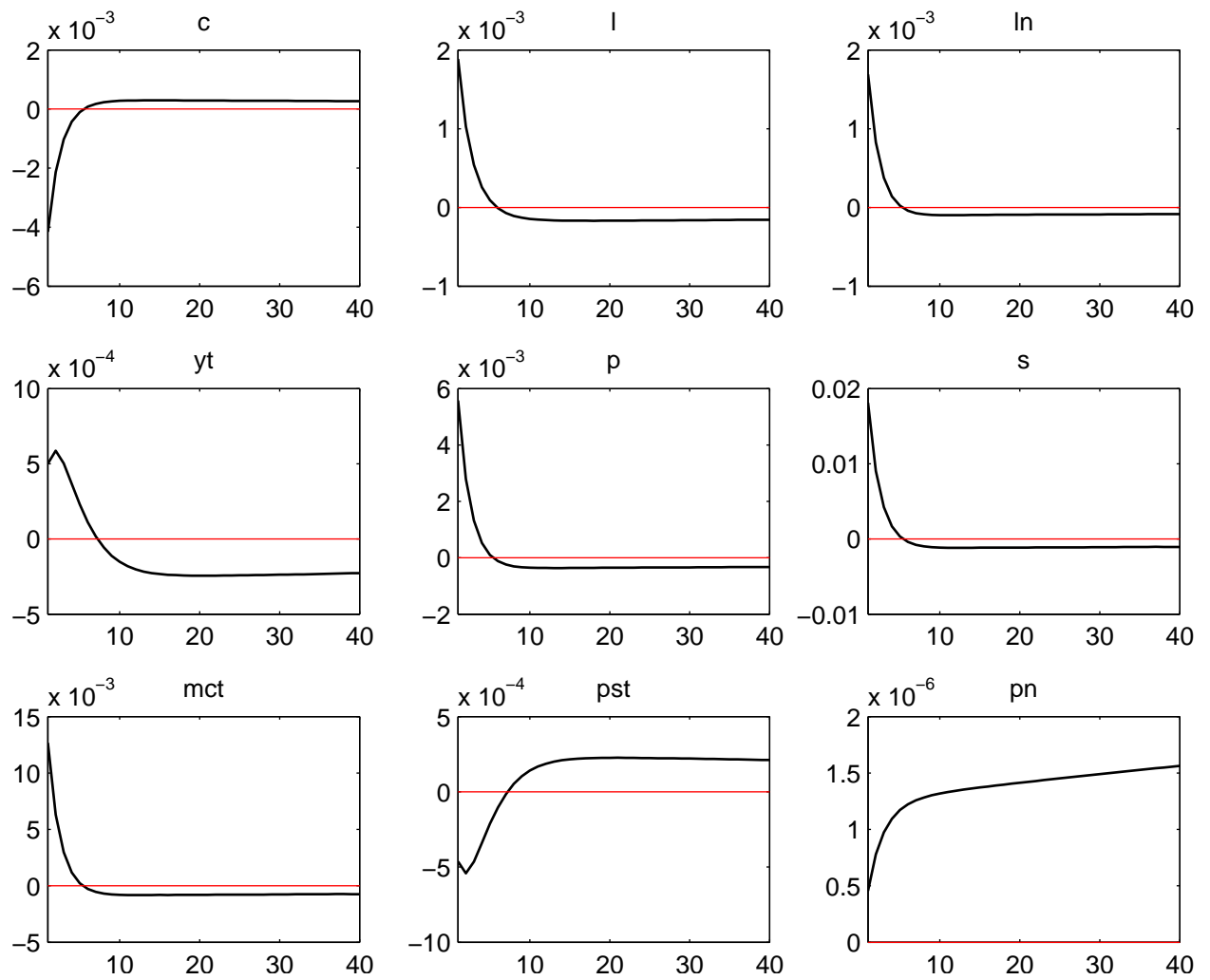


Figure 2: Impulse Response to $+i^*$ shock under FER rule

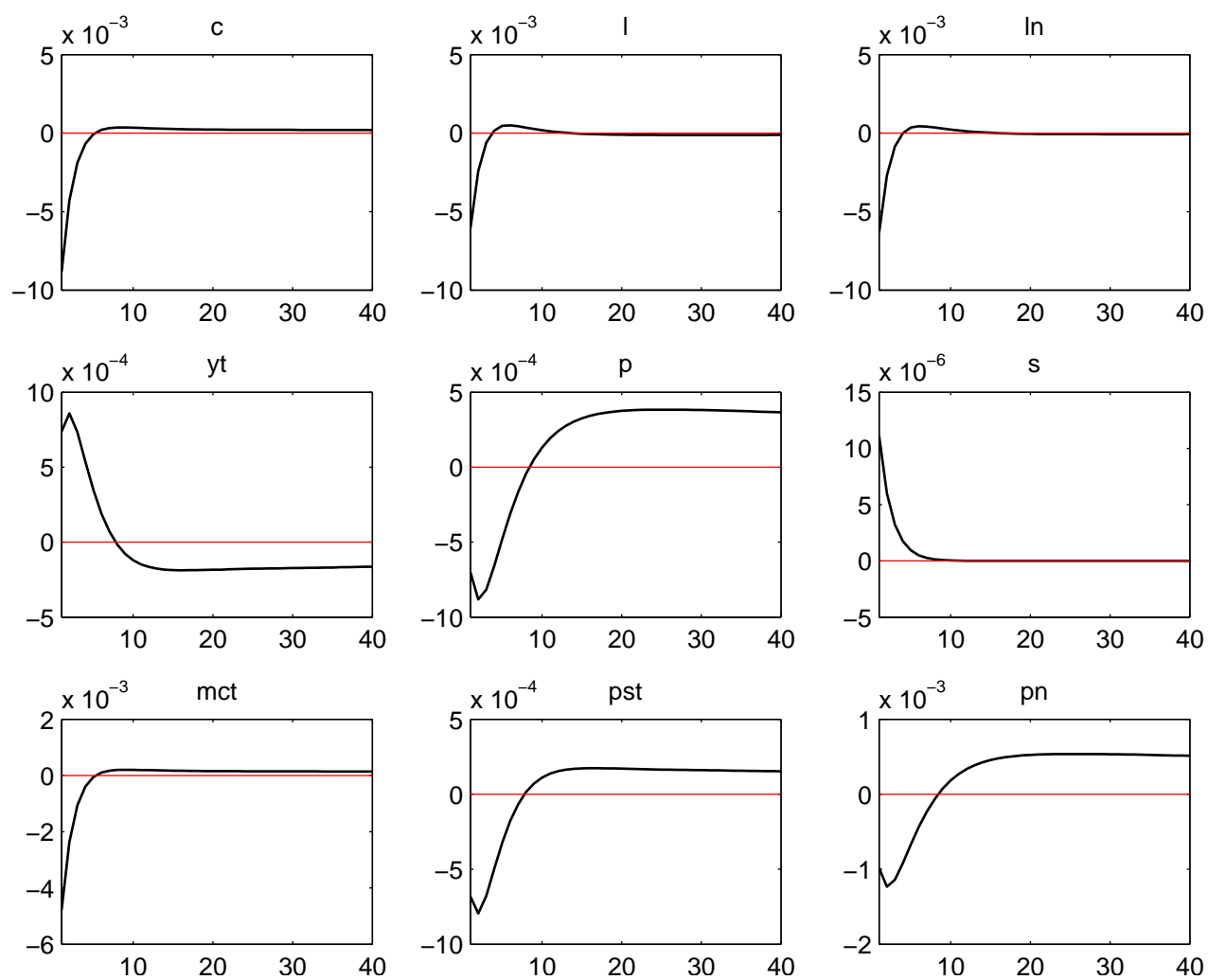


Figure 3: Impulse Response to $+X$ shock under NTP rule

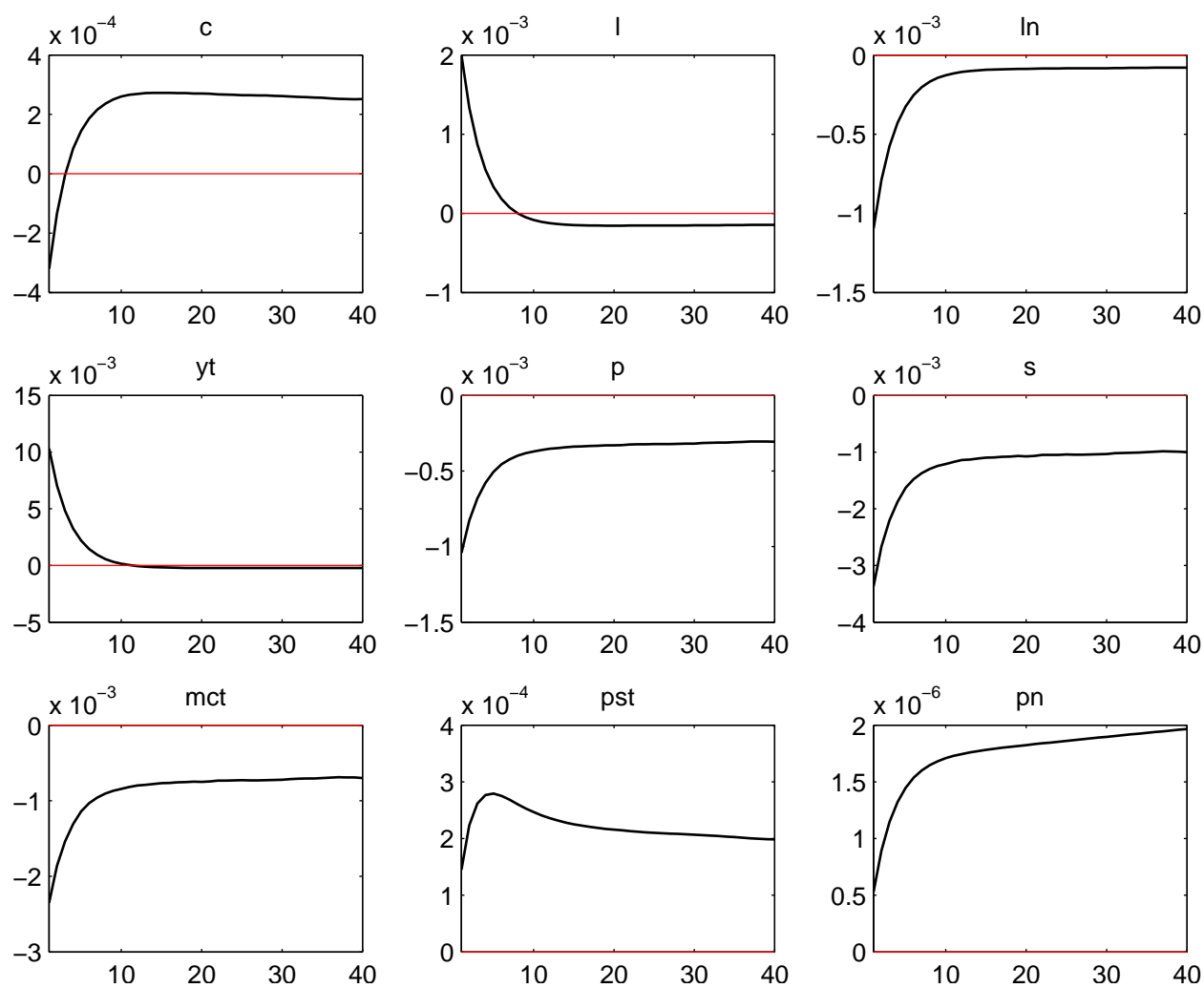


Figure 4: Impulse Response to $+X$ shock under FER rule

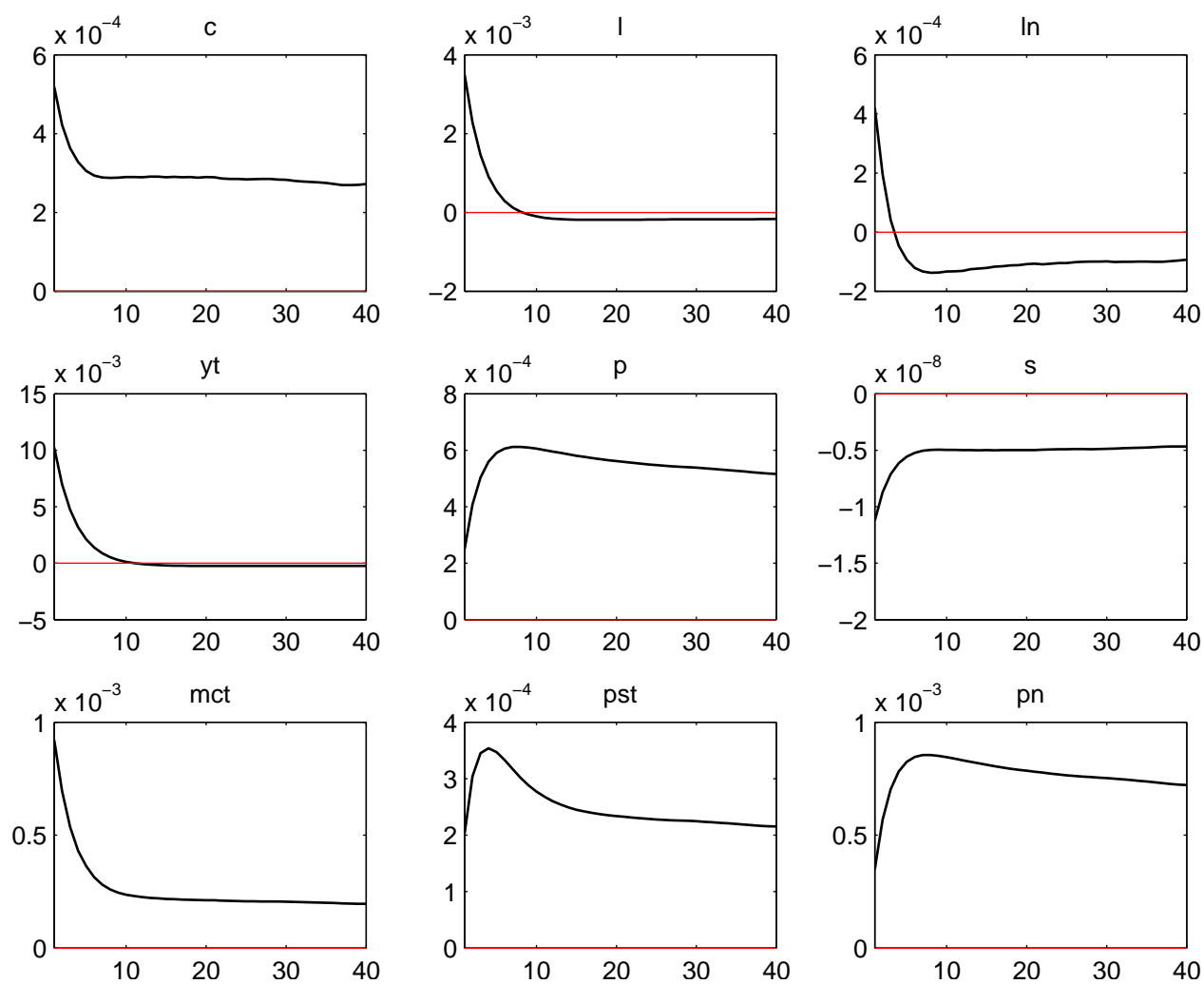


Figure 5: Welfare under NTP and FER rules when κ changes ($\theta = 0.01$)

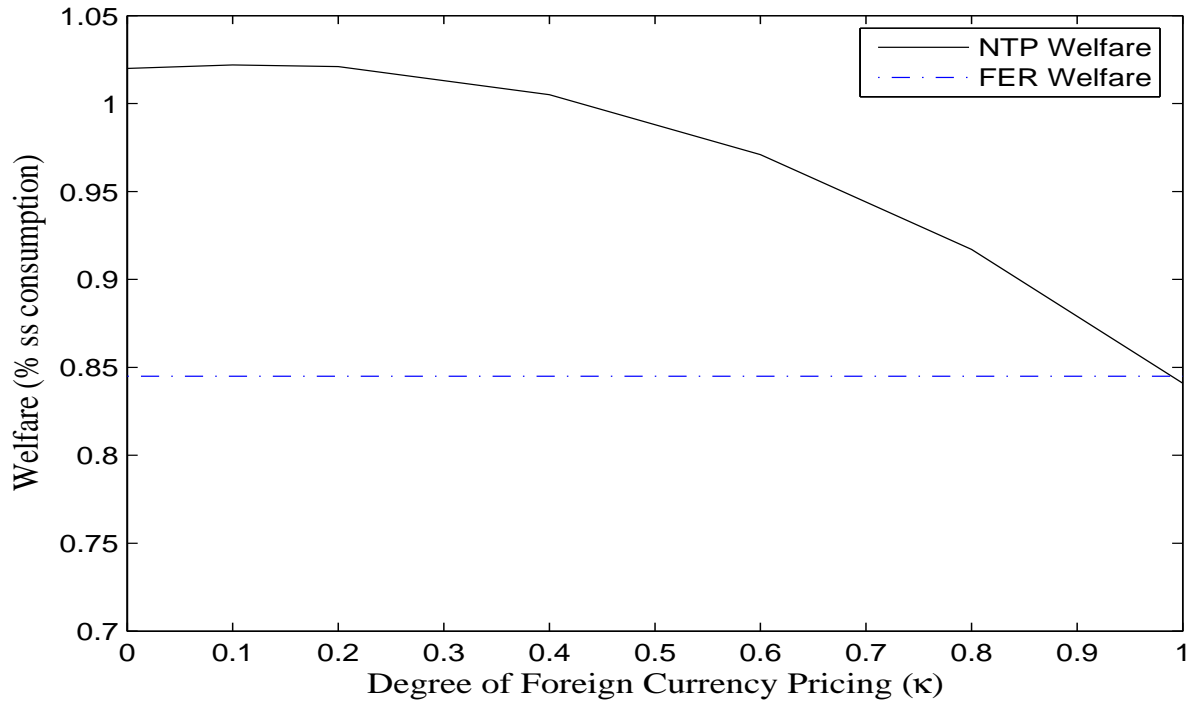


Figure 6: Welfare Differential between NTP and FER rules when θ changes ($\kappa = 1$)

