

Tezukayama RIEB Discussion Paper Series No. 16

Tariffs, the exchange rate and international relocation of  
firms: A new open economy macroeconomics approach

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April 2015

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# Tariffs, the exchange rate and international relocation of firms: A new open economy macroeconomics approach

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## **Abstract**

This paper analyzes the macroeconomic effects of a tariff in a new open economy macroeconomics model with international relocation of firms. It is found that the imposition of a tariff by a country always appreciates its currency, causes firms located in the country to relocate to abroad and consequently increases the country's relative consumption and welfare. It is also found that an increase in the international firm mobility weakens the responses of both the relative home consumption and the exchange rate to the imposition of the tariff.

*JEL classification codes:* E62; F31; F41

*Key words:* Tariff; Relocation of firms; Exchange rate; New open economy macroeconomics

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## 1 Introduction

In the new open economy macroeconomics (NOEM) literature, the international transmission of macroeconomic policies has been studied extensively; see, e.g., Obstfeld and Rogoff (1995, 1996, 2002), Lane (1997), Betts and Devereux (2000a, 2000b), Hau (2000), Bergin and Feenstra (2001), Caselli (2001), Corsetti and Pesenti (2001, 2005), Cavallo and Ghironi (2002), Devereux and Engel (2002), Kollmann (2001, 2002), Smets and Wouters (2002), Chu (2005), Ganelli (2005), Sutherland (2005a, 2005b), and Senay and Sutherland (2007).<sup>1</sup> This literature has focused on mainly how the exchange rate and consumption of each country are influenced by unanticipated monetary and fiscal shocks in one country under monopolistic distortions and nominal price (or wage) rigidities. For example, as is well-known by now, the benchmark model of Obstfeld and Rogoff (1995) shows that a domestic monetary expansion raises foreign and domestic output and welfare through the first-order effect of increasing world consumption when there is a fixed international distribution of firms.

In the theoretical literature on the NOEM, however, there has been little study of the macroeconomic impacts of a tariff. The exceptions are Fender and Yip (2000) and Reitz and Slopek (2005), who investigated the macroeconomic effects of a tariff in a NOEM model with a fixed international distribution of firms.<sup>2</sup> They showed that the imposition

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<sup>1</sup> Other related references include Benigno (2002), Engel (2002), Warnock (2003), Devereux (2004), Andersen and Beier (2005), Tille (2008), Johdo (2013), and Sousa (2013). For a survey of the NOEM models, see Lane (2001).

<sup>2</sup> Reitz and Slopek (2005) extended the Fender and Yip framework to include the intertemporal linkages by taking short-run current account imbalances into consideration and showed different mechanisms for consumption and welfare effects of a tariff to those obtained from the benchmark Fender and Yip model. Other related references include Ryou (2002), Novy (2010), Hwang and Turnovsky (2013) and Wang and Zou (2013).

of a tariff by a country always appreciates its currency, and consequently increases the country's relative consumption and welfare, respectively. However, in their models, the following question remains unresolved: how is the relationship between the imposition of a tariff and relative home consumptions changed if international firm mobility is taken into account; and how does the imposition of a tariff by one country affect international relocation of firms through the change in the exchange rate? We do not believe that it is appropriate to ignore interactions between international firm relocation and the exchange rate when examining the impact of a tariff.<sup>3</sup> Because, there is a large body of empirical research on the relationship between the exchange rate and firms' production location (and their foreign direct investment (FDI)) (see, e.g., Cushman, 1985 and 1988, Froot and Stein, 1991, Campa, 1993, Klein and Rosengren, 1994, Goldberg and Kolstad, 1995, Blonigen, 1997, Goldberg and Klein, 1998, Bénassy-quéré et al, 2001, Chakrabarti and Scholnick, 2002, and Farrell et al., 2004).

In order to address these issues, this paper takes the model of Reitz and Slopek (2005) and combines it with the model of Johdo (2015), who proposes a NOEM model that incorporates the international movement of firms, to account for the impact of a tariff on the consumption of the two countries in a situation where international firm mobility is taken into account.<sup>4</sup> In particular, a novel feature of this model is that the international distribution of firms responds to exchange rate movements caused by the

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<sup>3</sup> Empirical evidence shows that higher tariff has an important effect on foreign direct investment of firms based in developed countries (see Brainard, 1997, and Blonigen, 2002).

<sup>4</sup> Johdo (2015) contrasts a two-country NOEM model without international relocation with a NOEM model with international relocation of firms, and succeeds in showing explicitly the effects of one country's monetary expansion on the consumption of the two countries and the exchange rate, leading to foreign firm relocation to the home country.

imposition of a tariff. Thus, our model has different mechanisms for consumption effects to those obtained from the model of Reitz and Slopek (2005).

We conclude that the imposition of a tariff by the home country results in a proportionate increase in both the short-run and long-run relative home consumptions and appreciation of the home currency. In addition, it is found that the appreciation decreases (increases) the real profits of firms located in the home country (abroad), and consequently firms relocate to the foreign country. Further, we show that a decrease in the relocation costs (or an increase in the firm mobility) weakens the responses of both the relative consumptions and the equilibrium exchange rate to the imposition of the tariff.

The remainder of this paper is structured as follows. In Section 2, we outline the features of a two country intertemporal model with international relocation of firms. In Section 3, we present the symmetric equilibrium with flexible nominal wages. In Section 4, we present a log-linearized version of this model. In Section 5, we examine how the imposition of an unanticipated permanent tariff by the home country affects the international distribution of firms between countries, the exchange rate, and cross-country differences in consumption. In section 6, we examine the relative welfare effects of the tariff. The final section summarizes the findings and concludes the paper.

## **2 The Model**

We assume a two-country world economy, with a home and a foreign country. The models for the foreign and home countries are the same, and an asterisk is used to denote foreign variables. There is monopolistic competition in the markets for goods

and labor, whereas the markets for money and international bonds are perfectly competitive. Monopolistically competitive firms exist continuously in the world in the  $[0, 1]$  range. Each firm uses only domestic labor as an input and produces a single differentiated product. Each product is freely traded and firms earn positive pure profits. Firms are mobile internationally, but their owners are not. Producers in the interval  $[0, n_t]$  locate in the home country, and the remaining  $(n_t, 1]$  producers locate in the foreign country, where  $n_t$  is endogenous. The size of the world population is normalized to unity. We also assume that in the home country, households inhabit the interval  $[0, s]$  and those in the foreign country inhabit the interval  $(s, 1]$ .<sup>5</sup> Finally, we assume that only the home country imposes a tariff,  $\tau_t$ , on imported foreign goods.

Home and foreign households have perfect foresight and share the same utility function.<sup>6</sup> The intertemporal objective of household  $i \in (0, s)$  in the home country at time 0 is to maximize the following lifetime utility:<sup>7</sup>

$$U^i_0 = \sum_{t=0}^{\infty} \beta^t (\log C^i_t + \chi \log(M^i_t/P_t) - (\kappa/2)(\ell^{si}_t)^2), \quad (1)$$

where  $0 < \beta < 1$  is a constant subjective discount factor,  $\ell^{si}_t$  is the amount of labor supplied by household  $i$  in period  $t$ , and the consumption index  $C^i_t$  is defined as follows:

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<sup>5</sup> In the NOEM literature, the share of firms located in each country is assumed to be equivalent to the share of households that inhabit each country; i.e.,  $n = s$ , because a continuum of the population in the world is assumed to be composed of consumer–producers (i.e., in a yeoman–farmer economy).

<sup>6</sup> However, in this model, agents are shocked by unanticipated monetary policies.

<sup>7</sup> In what follows, we mainly focus on the description of the home country because the foreign country is described analogously.

$$C_t^i = \left( \int_0^1 C_t^i(j)^{(\theta-1)/\theta} dj \right)^{\theta/(\theta-1)}, \theta > 1, \quad (2)$$

where  $\theta$  is the elasticity of substitution between any two differentiated goods,  $C_t^i(j)$  is the consumption of good  $j$  in period  $t$  for household  $i$ .<sup>8</sup> In addition, the second term in (1) is real money balances ( $M_t^i/P_t$ ), where  $M_t^i$  denotes nominal money balances held at the beginning of period  $t + 1$ , and  $P_t$  is the home country consumption price index (CPI), which is defined as  $P_t = \left( \int_0^1 P_t(j)^{1-\theta} dj \right)^{1/(1-\theta)}$ , where  $P_t(j)$  is the home-currency producer price of good  $j$  in period  $t$ . Analogously, the foreign country CPI is  $P_t^* = \left( \int_0^1 P_t^*(j)^{1-\theta} dj \right)^{1/(1-\theta)}$ , where  $P_t^*(j)$  is the foreign-currency producer price of good  $j$  in period  $t$ . Under the law of one price with respect to producer prices, i.e.,  $P_t(j) = \varepsilon_t P_t^*(j)$ , where  $\varepsilon_t$  is the nominal exchange rate, defined as the home currency price per unit of foreign currency, we can rewrite the price indices as

$$P_t = \left( \int_0^{n_t} P_t(j)^{1-\theta} dj + \int_{n_t}^1 \left( (1 + \tau_t) \varepsilon_t P_t^*(j) \right)^{1-\theta} dj \right)^{1/(1-\theta)}, \quad (3)$$

$$P_t^* = \left( \int_0^{n_t} (P_t(j)/\varepsilon_t)^{1-\theta} dj + \int_{n_t}^1 P_t^*(j)^{1-\theta} dj \right)^{1/(1-\theta)}. \quad (4)$$

If the tariff is zero (i.e.,  $\tau_t = 0$ ), a comparison of the above price indices implies that purchasing power parity is represented by  $P_t = \varepsilon_t P_t^*$ . Following the literature, we assume that there is an international risk-free real bond market and that real bonds are denominated in units of the composite consumption good. In this model, households receive returns on risk-free real bonds, earn wage income by supplying labor, and

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<sup>8</sup> Throughout the paper, we also use the index  $j \in [0, 1]$  to refer to the product of firm  $j$ .

receive profits from all firms equally. Therefore, the household budget constraint can be written as:

$$P_t B_{t+1}^i + M_t^i = P_t(1+r_t)B_t^i + M_{t-1}^i + W_t^i \ell_t^{s_i} + P_t \int_0^{n_t} (\Pi_t(j)/P_t) dj + P_t \int_{n_t}^1 (\Pi_t^*(j)/P_t^*) dj - P_t C_t^i + P_t T_t^i, \quad (5)$$

where  $B_{t+1}^i$  denotes real bonds held by home agent  $i$  in period  $t + 1$ ,  $r_t$  denotes the real interest rate on bonds that applies between periods  $t - 1$  and  $t$ ,  $W_t^i \ell_t^{s_i}$  is nominal labor income, where  $W_t^i$  denotes the nominal wage rate of household  $i$  in period  $t$ ,  $\int_0^{n_t} \Pi_t(j)/P_t dj$  ( $\int_{n_t}^1 \Pi_t^*(j)/P_t^* dj$ ) represents the total real profit flows of firms located at home (abroad), where  $\Pi_t(j)$  ( $\Pi_t^*(j)$ ) is the nominal profit flow of firm  $j$  located at home (abroad). In addition,  $P_t C_t^i$  represents nominal consumption expenditure and  $T_t^i$  denotes real lump-sum transfers from the government in period  $t$ . Note that all variables in (5) are measured in per capita terms. In the government sector, we assume that government spending is zero and that all seigniorage revenues derived from printing the national currency and all tariff revenue are rebated to the public in the form of lump-sum transfers. Hence, the government budget constraint in the home country is  $T_t = \tau_t \varepsilon_t P_t^*(f)(1-n_t)C(f) + [(M_t - M_{t-1})/P_t]$ , where  $M_t$  is aggregate money supply, and  $T_t = \int_0^s T_t^i di$ .

In the home country, firm  $j \in [0, n_t]$  hires a continuum of differentiated labor inputs domestically and produces a unique product according to the CES production function,  $y_t(j) = (s^{-1/\phi} \int_0^s \ell_t^{di} (\phi - 1)/\phi di)^{\phi/(\phi - 1)}$ , where  $y_t(j)$  denotes the production of home-located



firm  $j$  in period  $t$ ,  $\ell_t^{di}(j)$  is the firm  $j$ 's input of labor from household  $i$  in period  $t$ , and  $\phi > 1$  is the elasticity of input substitution. Given the home firm's cost minimization problem, firm  $j$ 's optimal labor demand for household  $i$ 's labor input is as follows:

$$\ell_t^{di}(j) = s^{-1}(W_t^i/W_t)^{-\phi}y_i(j), \quad (6)$$

where  $W_t \equiv (s^{-1} \int_0^s W_t^i (1-\phi) di)^{1/(1-\phi)}$  is a price index for labor input.

We now consider the optimization problem of households. In the first stage, households in the home (resp. foreign) country maximize the consumption index  $C_t^i$  (resp.  $C_t^{i*}$ ) subject to a given level of expenditure by optimally allocating differentiated goods  $C_t^i(j), j \in [0, 1]$ . This static problem yields:

$$C_t^i(h) = (P_t(h)/P_t)^{-\theta}C_t^i, \quad C_t^i(f) = (P_t(f)(1+\tau_i)/P_t)^{-\theta}C_t^i, \quad (7)$$

$$C_t^{i*}(h) = (P_t^*(h)/P_t^*)^{-\theta}C_t^{i*}, \quad C_t^{i*}(f) = (P_t^*(f)/P_t^*)^{-\theta}C_t^{i*}.^9 \quad (8)$$

Aggregating the demands in (7) and (8) across all households worldwide and equating the resulting equation to  $y_t(h)$  yields the following market clearing condition for any product  $h$  in period  $t$ :

$$y_t(h) = sC_t^i(h) + (1-s)C_t^{i*}(h). \quad (9)$$

Similarly, for any product  $f$  of the foreign located firms, we obtain  $y_t(f)^* = sC_t^i(f) + (1-s)C_t^{i*}(f)$ . In the second stage, households maximize (1) subject to (5). The first-order conditions for this problem with respect to  $B_{t+1}^i$  and  $M_t^i$  can be written as

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<sup>9</sup> We have used the index  $h$  to denote the symmetric values within the home country, and have used the index  $f$  for the foreign country.

$$C_{t+1}^i = \beta(1 + r_{t+1})C_t^i, \quad (10)$$

$$M_t^i/P_t = \chi C_t^i((1 + i_{t+1})/i_{t+1}), \quad (11)$$

where  $i_{t+1}$  is the nominal interest rate for home-currency loans between periods  $t$  and  $t+1$ , defined as usual by  $1 + i_{t+1} = (P_{t+1}/P_t)(1 + r_t)$ . Equation (10) is the Euler equation for consumption and (11) is the one for money demand.

In the monopolistic goods markets, each firm has some monopoly power over pricing. Because home-located firm  $j$  hires labor domestically, given  $W_t$ ,  $P_t$ ,  $C_t^i$ ,  $C_t^{i*}$  and  $n_t$ , and subject to (6) and (9), home-located firm  $j$  faces the following profit-maximization problem:  $\max_{P_t(h)} \Pi_t(h) = P_t(h)y_t(h) - \int_0^s W_t^i \ell_t^{di}(h)di = (P_t(h) - W_t)y_t(h)$ .

By substituting  $y_t(h)$  from equation (9) into the firm's nominal profit  $\Pi_t(h)$  and then differentiating the resulting equation with respect to  $P_t(h)$ , we obtain the following price mark-up:

$$P_t(h) = (\theta/(\theta - 1))W_t. \quad (12)$$

Because  $W_t$  is given, from (12), all home-located firms charge the same price. Substituting (9) and (12) and those of foreign counterparts into the real profit flows of the home- and foreign- located firms,  $\Pi_t(h)/P_t$  and  $\Pi_t(f)^*/P_t^*$ , respectively, yields,

$$\Pi_t(h)/P_t = (1/\theta)(P_t(h)/P_t)y_t(h), \quad \Pi_t(f)^*/P_t^* = (1/\theta)(P_t^*(f)/P_t^*)y_t(f)^*. \quad (13)$$

The model assumes that the driving force for relocation to other country is a difference in real profits between two bounded countries.<sup>10</sup> In addition, we assume that all firms are not allowed to relocate instantaneously even if there is the profit gap. Following the formulation in Johdo (2015), the above adjustment process for relocation is formulated as follows:

$$n_t - n_{t-1} = \gamma[\Pi_t(h)/P_t - \Pi_t(f)^*/P_t^*]. \quad (14)$$

where  $\gamma$  ( $0 \leq \gamma < \infty$ ) is a constant positive parameter that determines the degree of firm mobility between the two countries: a larger value of  $\gamma$  implies higher firm mobility between two countries. Intuitively, the parameter  $\gamma$  reflects the costs falling on mobile firms in their new locations. Examples include the cost of finding appropriate plants, the cost of establishing the distribution networks, the cost of training the local workforce, the cost of coping with the foreign language, and the cost of adapting to the local legal system. Because of these costs, firms cannot move instantaneously to a better location even if a profit gap between two countries provides the motivation.

Following Corsetti and Pesenti (2001), we introduce nominal rigidities into the model in the form of one-period wage contracts under which nominal wages in period  $t$  are predetermined at time  $t - 1$ .<sup>11</sup> In the monopolistic labor market, each household provides a single variety of labor input to a continuum of domestic firms. Hence, the

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<sup>10</sup> In the literature on multinational firms, Helpman et al. (2004) and Eckel and Egger (2009) derive the share of multinational firms endogenously by using this type of profit differential between exporting and multinational activity.

<sup>11</sup> There are several studies in the NOEM literature based on wage rigidities including those of Rankin (1998), Obstfeld and Rogoff (1996, 2000a), Céspedes et al. (2000), Hau (2000), Corsetti and Pesenti (2001), Kollman (2001), Benigno (2002), and Chu (2005).

equilibrium labor-market conditions for the home and foreign countries imply that  $\ell_t^{si} = \int_0^{n_t} \ell_t^{di}(j) dj$ ,  $i \in [0, s]$  and  $\ell_t^{si*} = \int_{n_t}^1 \ell_t^{di*}(j) dj$ ,  $i \in (s, 1]$ , respectively. By taking  $W_t$ ,  $P_t$ ,  $y_t(j)$ , and  $n_t$  as given, substituting  $\ell_t^{si} = \int_0^{n_t} \ell_t^{di}(j) dj$  and (6) into the budget constraint given by (5), and maximizing the lifetime utility given by (1) with respect to  $W_t^i$ , we obtain the following first-order condition:

$$\kappa \ell_t^{si2} \phi (W_t^i / P_t)^{-1} = (\phi - 1) (\ell_t^{si} / C_t^i). \quad (15)$$

The right-hand side of (15) represents the marginal consumption utility of additional labor income resulting from a decrease in the nominal wage rate. This term is positive because  $\phi > 1$ . The left-hand side represents the marginal disutility of an associated increase in labor effort.

The equilibrium condition for the integrated international bond market is given by  $sB_{t+1} + (1-s)B_{t+1}^* = 0$ . The money markets are assumed always to clear in both countries, so that the equilibrium conditions are given by  $M_t = \int_0^s M_t^i di$  and  $M_t^* = \int_s^1 M_t^{*i} di$ , respectively.

### 3 A symmetric steady state

In this section, we derive the solution for a symmetric steady state in which all exogenous variables are constant, initial net foreign assets are zero ( $B_0 = 0$ ), the tariff is zero initially ( $\tau_0 = 0$ ) and  $s = s^* = 1/2$ . The superscript  $i$  and the index  $j$  are omitted because households and firms make the same equilibrium choices within and between

countries. Henceforth, we denote the steady-state values by using the subscript  $ss$ . In the symmetric steady state, in which all variables are constant in both countries, given the Euler equation for consumption (equation (10)), the constant real interest rate is given by  $r_{ss} = (1 - \beta)/\beta \equiv \delta$ , where  $\delta$  is the rate of time preference. The steady-state allocation of firms is  $n_{ss} = 1/2$ . The steady state output levels are

$$\begin{aligned} \ell_{ss}^s = \ell_{ss}^{s*} = C_{ss} = C_{ss}^* = C_{ss}^w = y_{ss}(h) = y_{ss}^*(f) \\ = ((\phi-1)/\phi)^{1/2}((\theta-1)/\theta)^{1/2}(1/\kappa)^{1/2}. \end{aligned} \quad (16)$$

Substituting  $y_{ss}(h)$  and  $y_{ss}^*(f)$  from equation (16) into equation (13) yields the following steady-state levels of real profit for home- and foreign-located firms, which are equal:

$$\Pi_{ss}(h)/P_{ss} = \Pi_{ss}(f)^*/P_{ss}^* = (1/\theta)((\phi-1)/\phi)^{1/2}((\theta-1)/\theta)^{1/2}(1/\kappa)^{1/2}. \quad (17)$$

## 4 The log-linearized model

### 4.1 The relationship between relocation and the exchange rate

To examine the macroeconomic effects of an unanticipated permanent tariff, we solve a log-linear approximation of the system around the initial, zero-shock steady state with  $B_{ss,0} = 0$  and  $\tau_{ss,0} = 0$ , as derived in the previous section. For any variable  $X$ , we use  $\hat{X}$  to denote ‘short run’ percentage deviations from the initial steady-state value; i.e.,  $\hat{X} = dX_1/X_{ss,0}$ , where  $X_{ss,0}$  is the initial, zero-shock steady-state value and subscript 1 denotes the period in which the tariff shock takes place. These short-run percentage deviations are consistent with the length of nominal wage contracts. Thus, nominal

wages and goods prices can be determined as  $\hat{W} = \hat{W}^* = \hat{P}(h) = \hat{P}^*(f) = 0$  in the short-run log-linearized equations. In addition, we use  $\bar{X}$  to denote ‘long run’ percentage deviations from the initial steady-state value; i.e.,  $\bar{X} = dX_2/X_{ss,0} = dX_{ss}/X_{ss,0}$ , which is consistent with flexible nominal wages. Note that  $X_2 = X_{ss}$  because the new steady state is reached at period 2.

By log-linearizing equation (14) around the symmetric steady state and setting  $\hat{P}(h) = \hat{P}^*(f) = 0$ , we obtain the following log-linearized expression for the short-run international relocation of firms:

$$\hat{n} = 2\gamma((\phi - 1)/\phi)^{1/2}((\theta - 1)/\theta)^{3/2}(1/\kappa)^{1/2}(\hat{\varepsilon} + (1/2)d\tau). \quad (18)$$

Equation (18) shows that exchange rate appreciation ( $\hat{\varepsilon} < 0$ ) induces global relocation of firms towards the foreign country ( $\hat{n} < 0$ ) for a given level of a tariff.<sup>12</sup> Intuitively, with fixed nominal wages, which cause nominal product prices to be sticky because of mark-up pricing by monopolistic product suppliers, the appreciation decreases relative home production through the ‘expenditure-switching effect’; i.e.,  $\hat{y}(h) - \hat{y}^*(f) = \theta\hat{\varepsilon} < 0$ .<sup>13</sup> This decreases the relative profits of home-located firms, and consequently some

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<sup>12</sup> This result is consistent with the evidence found in the empirical literature on the relationship between exchange rates and FDI (e.g., Cushman, 1988, Caves, 1989, Froot and Stein, 1991, Campa, 1993, Klein and Rosengren, 1994, Blonigen, 1997, Goldberg and Klein, 1998, Bénassy-quéré et al, 2001, Chakrabarti and Scholnick, 2002, Kiyota and Urata, 2004, and Bolling et al, 2007).

<sup>13</sup> The expenditure-switching effect arises intuitively because exchange rate appreciation causes a rise in the relative real price of home goods for households in both countries so that world consumption demand switches toward foreign goods. Corsetti et al (2005) also define this as ‘competitive effect’. For a detailed discussion of the expenditure-switching effect, see Senay and Sutherland (2004, 2007).

home-located firms relocate to the foreign country, i.e.,  $\hat{n} < 0$ . Equation (18) also shows that nominal exchange rate changes have greater effects the greater is the flexibility of relocation (the larger is  $\gamma$ ). By contrast, when relocation costs are high ( $\gamma = 0$ ), nominal exchange rate changes have a negligible effect on the relocation of firms.<sup>14</sup> In addition, from equation (18), for a given level of the exchange rate, the imposition of a tariff by the home country ( $d\tau > 0$ ) leads firms to relocate into the home country, i.e.,  $\hat{n} > 0$ . The mechanism of this effect is explained intuitively as follows. First, the imposition of the tariff raises domestic prices of foreign goods by  $d\tau$ . From equation (7), this in turn decreases the home demand for foreign goods and thereby decreasing foreign production and, hence the relative profits of foreign-located firms. Thus, the imposition of a tariff by the home country causes foreign located firms to relocate to the home country ( $\hat{n} > 0$ ).

## 4.2 The impacts of a tariff

We now consider the macroeconomic effects of the imposition of an unanticipated permanent tariff by the home country.<sup>15</sup> The closed-form solutions for key variables are as follows:

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<sup>14</sup> In an international macroeconomic model with heterogeneous firms, Ghironi and Melitz (2005) show the positive relationship between the relative availability of domestic and imported varieties (the share of domestic varieties in the consumption basket) and the expenditure-switching effect.

<sup>15</sup> Because of the symmetry of the model, a foreign tariff shock is treated analogously. In particular, we focus on the effects of tariff shocks of the home country.

$$\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^* = \left( \frac{Z_3 - (1/2)Z_1}{Z_1 + Z_2} \right) d\tau > 0, \quad (19)$$

$$\hat{\varepsilon} = - \left( \frac{Z_3 + (1/2)Z_1}{Z_1 + Z_2} \right) d\tau < 0, \quad (20)$$

$$\hat{n} = -\gamma \tilde{\phi}^{1/2} \tilde{\theta}^{3/2} \tilde{\kappa}^{1/2} \left( \frac{1+\delta}{\delta} \right) \left( \frac{1}{Z_1 + Z_2} \right) d\tau < 0, \quad (21)$$

where

$$Z_1 = \tilde{\theta}^2 [\theta + 4\gamma \tilde{\phi}^{1/2} \tilde{\theta}^{1/2} \tilde{\kappa}^{1/2}] > 0,$$

$$Z_2 = \left( \frac{1+\delta}{\delta} \right) + \left( \frac{\tilde{\theta}}{\delta} \right) \left[ \frac{\theta - 1 + 4\gamma \tilde{\phi}^{1/2} \tilde{\theta}^{3/2} \tilde{\kappa}^{1/2}}{\theta + 1 + 4\gamma \tilde{\phi}^{1/2} \tilde{\theta}^{3/2} \tilde{\kappa}^{1/2}} \right] > 0,$$

$$Z_3 = (1/2) \left( \frac{1+\delta}{\delta} \right) + (1/2) \tilde{\theta}^2 [\theta + 4\gamma \tilde{\phi}^{1/2} \tilde{\theta}^{1/2} \tilde{\kappa}^{1/2}] > 0,$$

$$\tilde{\phi} = \frac{\phi - 1}{\phi}, \tilde{\theta} = \frac{\theta - 1}{\theta}, \tilde{\kappa} = \frac{1}{\kappa}.$$

Equation (19) indicates that both the short-run and long-run relative home consumption levels increase when there is the imposition of a tariff by the home country ( $d\tau > 0$ ).

Equation (20) shows that the imposition of the tariff leads to exchange rate appreciation ( $\hat{\varepsilon} < 0$ ). Finally, the result in (21) shows that the imposition of the tariff leads to the relocation of some firms from the home to the foreign country.

The above results can be explained intuitively as follows. First, the imposition of a tariff by the home country has several opposing effects on the relative home consumption. On one hand, from equation (18), the imposition of the tariff results in more differentiated products being produced in the home country because of relocation



of some firms to the home country. This then leads to a shift in labor demand from the foreign to the home country. As a result, the relocation raises the relative labor income in the home country, which then raises the relative consumption in the home country (hereafter we shall call this the ‘relocation effect’). Secondly, the imposition of the tariff transfers the tariff revenue to the home households, and thereby raising the relative consumption in the home country (hereafter we shall call this the ‘tariff revenue effect’). However, thirdly, the imposition of the tariff raises domestic prices of foreign goods by  $d\tau$ , and thereby raising the domestic consumption price index, which leads to a fall in the real money supply. Therefore, the home currency must appreciate and raise the supply of real money balances in the home country to restore money market equilibrium.<sup>16</sup> From equation (18), the home currency appreciation induces relocation of firms towards the foreign country ( $\hat{n} < 0$ ), and therefore, this relocation decreases domestic consumption through the shift in labor demand from the home to the foreign country (hereafter we shall call this the ‘contrarian relocation effect’). Thus, the above three effects of the tariff on the relative consumption is conflicting. However, from equation (19), the total effects composed of the relocation and the tariff revenue effects unambiguously dominate the contrarian relocation effect, and hence the imposition of the tariff results in a proportionate increase in relative home consumption levels. Further, the imposition of the tariff leads to exchange rate appreciation (see equation (20)). This happens because given that the demand for real money balances is increasing in consumption (as implied by the money demand function), the home currency must

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<sup>16</sup> Reitz and Slopek (2005) also define this effect as the ‘contrarian terms of trade effect’.

appreciate and raise the supply of real money balances in the home country to restore money market equilibrium.

Next, the relocation impact of the imposition of the tariff has three effects with opposing implications. On one hand, the imposition of the tariff by the home country raises the home prices of foreign goods by  $d\tau$ . From equation (7), this decreases the home demand for foreign goods and thereby decreasing foreign production. Therefore, this decreases the relative profits of foreign-located firms, and consequently some foreign located firms relocate to the home country ( $\hat{n} > 0$ ). On the other hand, the imposition of the tariff transfers the tariff revenue to the home households, and thereby raising the relative consumption in the home country (the tariff revenue effect). This leads to exchange rate appreciation and causes consumption switching as world consumption demand shifts toward foreign country's goods because of the rise in the relative price of home goods. Accordingly, this causes some firms to relocate to foreign country because of the increase in relative profits of firms located in the foreign country ( $\hat{n} < 0$ ). Furthermore, the imposition of the tariff raises domestic prices of foreign goods by  $d\tau$ , and thereby raising the domestic consumption price index, which leads to a fall in the real money supply. Therefore, the home currency must appreciate to restore money market equilibrium, and consequently some firms relocate to the foreign country from (18) ( $\hat{n} < 0$ ). Therefore, the net relocation effect of the imposition of the tariff depends on the relative strength of these three conflicting pressures. However, from equation (21), the former effect is always dominated by the latter two effects, so we obtain  $\hat{n} < 0$ .

Finally, in the present model, the firm mobility plays an important role in determining the scale of relative consumption changes in response to the imposition of a tariff. This

is because, from equation (19), an increase in  $\gamma$  weakens the effect of the imposition of a tariff on relative home consumption. In other words, the larger is the international mobility of firms, the smaller is the response of relative consumption levels to the imposition of a tariff. Intuitively, as the relocation of firms becomes more flexible (as  $\gamma$  increases), there is a greater increase in relative foreign labor income because more firms relocate to the foreign country away from the home country (see equation (21)). Accordingly, the net increase in relative home consumption is smaller as  $\gamma$  increases. In addition, from the money market equilibrium, an increase in  $\gamma$  also weakens the effect of the imposition of a tariff on the equilibrium exchange rate. This happens because given that the demand for real money balances is increasing in consumption, there is the positive relationship between the exchange rate appreciation and the increase in the relative home consumptions.

## 5 Welfare effects

In order to evaluate whether the relative home welfare effect of the imposition of a tariff by the home country is positive or negative, we focus on the real component of an agent's consumption utility. By defining this component as  $U_0^R$ , we can rewrite equation (1) as  $U_0^R = \sum_{t=0}^{\infty} \beta^t (\log C_t - (\kappa/2)\ell_t^{s_2})$ . The impact of the tariff on relative home welfare is then as follows:

$$dU^R - dU^R = \left( \frac{1+\delta}{2\delta} \right) \left( \frac{1}{Z_1 + Z_2} \right) \left\{ \left( \frac{1+\delta}{\delta} \right) + \tilde{\phi}\tilde{\theta}(\theta + 4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}) + \left( \frac{\tilde{\phi}\tilde{\theta}}{\delta} \right) \left( \frac{\theta + 4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}}{\theta + 1 + 4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}} \right) \right\} d\tau > 0. \quad (22)$$

From equation (22), although home agents get less leisure from increasing labor effort, the relative welfare effect of the imposition of the tariff is unambiguously positive.

## **6 Conclusion**

This paper has presented the impacts of a tariff on consumption and exchange rate using a two-country intertemporal model with international firm mobility. The main findings of our analysis are that i) the imposition of a tariff by the home country always increases both the short-run and long-run levels of relative home consumption, ii) the imposition of the tariff results in appreciation of the home currency, iii) the appreciation then decreases the relative real profits of firms located in the home country, and consequently firms relocate to the foreign country, iv) an increase in the flexibility of relocation (or a decrease in the relocation costs) weakens the responses of both the relative consumption levels and the equilibrium exchange rate to the imposition of a tariff.

The model developed here is rather simple in a number of respects. This suggests many directions for future research. Firstly, the firms' decision to relocate is rather simplistic in this framework as it postulated that firm relocation depends on cross-country profit differences. This formulation may be unrealistic because the international relocation of firms is also determined by many other factors besides the relative price and tariffs. Incorporating other factors affecting relocation (corporation tax, transport costs, and infrastructure) may be important. Secondly, this paper assumed implicitly that each household exogenously owns an equity portfolio that is perfectly diversified across all firms. However, this assumption may be unrealistic because

real-world portfolios exhibit home bias, as the home households invest most of their wealth in local firms.<sup>17</sup> Therefore, incorporating the home bias issue in the analysis might be interesting. Furthermore, as the main purpose of this paper is to analyze the effects of the imposition a tariff by a country, interactions between the two governments in setting optimal tariff are not considered in the model. Therefore, extending the present model to a noncooperative game theoretic analysis and taking the tariff as a strategic variable may be interesting. These issues remain for future research.

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<sup>17</sup> For a discussion on the puzzle of home bias in equity portfolios, see Obstfeld and Rogoff (2000b).

## References

- Andersen, T.M. and Beir, N.C. (2005). 'International transmission of transitory and persistent monetary shocks under imperfect information', *Journal of International Economics*, 66, pp. 485–507.
- Bénassy-quéré, A., Fontagné, L. and Lahréche-révil, A. (2001). 'Exchange-rate strategies in the competition for attracting foreign direct investment', *Journal of the Japanese and International Economies*, 15, pp. 178–198.
- Benigno, P. (2002). 'A simple approach to international monetary policy coordination', *Journal of International Economics*, 57, pp. 177–196.
- Bergin, P.R. and Feenstra, R.C. (2001). 'Pricing-to-market, staggered contracts, and real exchange rate persistence', *Journal of International Economics*, 54, pp. 333–359.
- Betts, C. and Devereux, M. (2000a). 'Exchange rate dynamics in a model of pricing-to-market', *Journal of International Economics*, 50, pp. 215–244.
- Betts, C. and Devereux, M. (2000b). 'International monetary policy coordination and competitive depreciation: A reevaluation', *Journal of Money, Credit, and Banking*, 32, pp. 722–745.
- Blonigen, B.A. (1997). 'Tariff-jumping antidumping duties', *Journal of International Economics*, 57, pp. 31–50.
- Blonigen, B.A. (2002). 'Tariff-jumping antidumping duties', *Journal of International Economics*, 57, pp. 31–50.
- Bolling, C., Shane, M. and Roe, T. (2007). 'Exchange rates and U.S. foreign direct investment in the global processed food industry', *Agricultural and Resource Economics Review*, 36, pp. 230–238.

- Brainard, L.S. (1997). 'An empirical assessment of the proximity-concentration trade-off between multinational sales and trade', *American Economic Review*, 87, pp. 520–544.
- Campa, J.M. (1993). 'Entry by foreign firms in the united states under exchange rate uncertainty', *Review of Economics and statics*, 75, pp.614–622.
- Campbell, J.R. and Lapham, B. (2004). 'Real exchange rate fluctuations and the dynamics of retail trade industries on the U.S.-Canada border', *American Economic Review*, 94, pp. 1194–1206.
- Caselli, P. (2001). 'Fiscal consolidation under fixed exchange rates', *European Economic Review*, 45, pp. 425–450.
- Cavallo, M. and Ghironi, F. (2002). 'Net foreign assets and the exchange rate: Redux revised', *Journal of Monetary Economics*, 49, pp. 1057–1097.
- Caves, R. (1989). 'Exchange-rate movements and foreign direct investment in the United States', in *The Internationalization of U.S. Markets*, pp.199–228, Audretsch, D.B. and Claudon, M.P., eds, New York University Press.
- Céspedes, L., Chang, R. and Velasco, A. (2000). 'Balance sheets and exchange rate policy', NBER Working Paper 7840.
- Chakrabarti, R. and Scholnick, B. (2002). 'Exchange rate expectations and foreign direct investment flows', *Weltwirtschaftliches Archiv*, 138, pp. 1–21.
- Chu, H. (2005). 'Welfare and public: The role of internationalized production', *Economic Inquiry*, 43, pp. 542–557.
- Corsetti, G. and Pesenti, P. (2001). 'Welfare and macroeconomic interdependence', *Quarterly Journal of Economics*, 116, pp. 421–444.

- Corsetti, G. and Pesenti, P. (2005). 'International dimensions of optimal monetary policy', *Journal of Monetary Economics*, 52, pp. 281–305.
- Corsetti, G., Martin, P. and Pesenti, P. (2005). 'Productivity, terms of trade, and the 'home market effect'', *Journal of International Economics*, 73, pp. 99–127.
- Cushman, D.O. (1985). 'Real exchange rate risk, expectations, and the level of foreign direct investment', *Review of Economics and Statistics*, 67, pp. 297–308.
- Cushman, D.O. (1988). 'Exchange rate uncertainty and foreign direct investment in the United States', *Weltwirtschaftliches Archiv*, 124, pp. 322–336.
- Devereux, M.B. (2004). 'Should the exchange rate be a shock absorber?', *Journal of International Economics*, 62, pp. 359–377.
- Devereux, M. and Engel, C. (2002). 'Exchange rate pass-through, exchange rate volatility, and exchange rate disconnect', *Journal of Monetary Economics*, 49, pp. 913–940.
- Eckel, C. and Egger, H. (2009). 'Wage bargaining and multinational firms', *Journal of International Economics*, 77, pp. 206–214.
- Engel C. (2002). 'The responsiveness of consumer prices to exchange rates: A synthesis of some new open economy macro models', *Manchester School*, 70, pp. 1–15.
- Farrell, R., Gaston, N. and Sturm, J.M. (2004). 'Determinants of Japan's foreign direct investment: An industry and country panel study, 1984–1998', *Journal of the Japanese and International Economies*, 18, pp. 161–182.
- Fender, J. and Yip, C.K. (2000). 'Tariffs and exchange rate dynamics redux', *Journal of International Money and Finance*, 19, pp. 633–655.



- Froot, K.A. and Stein, J.C. (1991). 'Exchange rates and foreign direct investment: an imperfect capital markets approach', *Quarterly Journal of Economics*, 106, pp. 1191–1217.
- Ganelli, G. (2005). 'The new open economy macroeconomics of government debt', *Journal of International Economics*, 65, pp. 167–184.
- Ghironi, F. and Melitz, M.J. (2005). 'International trade and macroeconomic dynamics with heterogeneous firms', *Quarterly Journal of Economics*, 120, pp. 865–915.
- Goldberg, L. and Klein, M. (1998). 'Foreign direct investment, trade, and real exchange rate linkages in developing countries', in Glick, R., eds., *Managing Capital Flows and Exchange rates: Perspectives from the Pacific Basin*, pp. 73–100. Cambridge, UK: Cambridge University Press.
- Goldberg, L. and Kolstad, C. (1995). 'Foreign Direct Investment, Exchange rate variability and Demand Uncertainty', *International Economic Review*, 36, pp. 855–873.
- Hau, H. (2000). 'Exchange rate determination: The role of factor price rigidities and nontradeables', *Journal of International Economics*, 50, pp. 421–447.
- Helpman, E., Melitz, M.J. and Yeaple, S.R. (2004). 'Exports versus FDI', *American Economic Review*, 94, pp. 300–316.
- Hwnag, Y. and Turnovsky, S.J. (2013). 'Exchange rate pass-through and the effects of tariffs on economic performance and welfare', *Journal of International Money and Finance*, 33, pp. 81–102.
- Johdo, W. (2013). 'Does monetary expansion improve welfare under habit formation?', *Economics Bulletin*, 33, pp. 1959–1968.

- Johdo, W. (2015). 'Monetary policy, foreign welfare and international firm mobility', forthcoming in *International Journal of Economic Theory*.
- Kiyota, K. and Urata, S. (2004). 'Exchange rate, exchange rate volatility and foreign direct investment', *The World Economy*, 1501–1536.
- Klein, M.W. and Rosengren, E.S. (1994). 'The real exchange rate and foreign direct investment in the United States: relative wealth vs. relative wage effects', *Journal of International Economics*, 36, pp. 373–389.
- Kollmann, R. (2001). 'Explaining international comovements of output and asset returns: The role of money and nominal rigidities', *Journal of Economic Dynamics and Control*, 25, pp. 1547–1583.
- Kollmann, R. (2002). 'Monetary policy rules in the open economy: effects on welfare and business cycles', *Journal of Monetary Economics*, 49, pp. 989–1015.
- Lane, P.R. (1997). 'Inflation in open economies', *Journal of International Economics*, 42, pp. 327–347.
- Lane, P.R. (2001). 'The new open economy macroeconomics: A survey', *Journal of International Economics*, 54, pp. 235–266.
- Novy, N. (2010). 'Trade costs and the Open Macroeconomy', *Scandinavian Journal of Economics*, 112, pp. 514–545.
- Obstfeld, M. and Rogoff, K. (1995). 'Exchange rate dynamics redux', *Journal of Political Economy*, 103, pp. 624–660.
- Obstfeld, M. and Rogoff, K. (1996). *Foundations of International Macroeconomics*, MIT press, Cambridge, MA.

- Obstfeld, M. and Rogoff, K. (2000a). 'New directions for stochastic open economy models', *Journal of International Economics*, 50, pp. 117–153.
- Obstfeld, M. and Rogoff, K. (2000b). 'The six major puzzles in international macroeconomics: Is there a common cause?', *NBER Macroeconomics Annual*, 15, pp. 339–90.
- Obstfeld, M. and Rogoff, K. (2002). 'Global implications of self-oriented national monetary rules', *Quarterly Journal of Economics*, 117, pp. 503–535.
- Rankin, N. (1998). 'Nominal rigidity and monetary uncertainty in a small open economy', *Journal of Economic Dynamics and Control*, 22, pp. 679–702.
- Reitz, S. and Slopek, U.D. (2005). 'Macroeconomic effects of tariffs: Insights from a new open economy macroeconomics model', *Schweizerische Zeitschrift für Volkswirtschaft und Statistik*, 141, pp. 285–311.
- Ryou, J. (2002). 'Transaction costs and welfare effects of currency unions', *Seoul Journal of Economics*, 15, pp. 529–553.
- Senay, O. and Sutherland, A. (2004). 'The expenditure switching effect and fixed versus floating exchange rates', in Sinclair, P., Driver, R. and Thoenissen, C., eds., *Exchange rates, Capital Flows and Policy*, Routledge, London, UK.
- Senay, O. and Sutherland, A. (2007). 'Foreign money shocks and the welfare performance of alternative monetary policy regimes', *Scandinavian Journal of Economics*, 109, pp. 245–266.
- Smets, F. and Wouters, R. (2002). 'Openness, Imperfect exchange rate pass-through and monetary policy', *Journal of Monetary Economics*, 49, pp. 947–981.

- Sousa, T.V. (2013). 'Asymmetries in an open economy model', *Journal of International Money and Finance*, 33, pp. 358–380.
- Sutherland, A. (2005a). 'Cost-push shocks and monetary policy in open economies', *Oxford Economic Papers*, 57, pp. 1–33.
- Sutherland, A. (2005b). 'Incomplete pass-through and the welfare effects of exchange rate variability', *Journal of International Economics*, 65, pp. 375–399.
- Tille, C. (2008). 'Financial integration and the wealth effect of exchange rate fluctuations', *Journal of International Economics*, 75, pp. 283–294.
- Wang, C. and Zou, H. (2013). 'Optimal monetary and tariff policy in open economies', mimeo.
- Warnock, F.E. (2003). 'Exchange rate dynamics and the welfare effects of monetary policy in a two-country model with home-product bias', *Journal of International Money and Finance*, 22, pp. 343–363.