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Abstract

This paper uses a new open economy macroeconomics model with endogenous production location to analyze the impact of a decrease in the corporation tax rate of one country on both the international distribution of firms and the exchange rate. In this model, a reduction in home corporate tax rate leads to exchange rate depreciation and induces firms to relocate to the home country. This paper also shows that when relocation matters, a reduction in corporate tax benefits the home country, while it is detrimental to the foreign country.

JEL classification codes: E62; F31; F41

Key words: Corporate tax; Exchange rate; Relocation; Welfare

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1 Introduction

In recent years, the entry regulations governing multinational firms in developed (e.g., Japan, Singapore, South Korea, Canada, the US, and the European Union) and newly emerging (e.g., China, India, ASEAN, Mexico and Brazil) countries alike have been substantially liberalized. As a result, multinational firms from the US, Japan, the EU, and South Korea have very actively invested across national borders. In addition, in the past two decades, most OECD economies have lowered their corporate (or profit) taxes to attract foreign multinational firms (see, e.g., Haufler, 1999; Bretschger and Hettich, 2002; Fuest and Huber, 2002). The expectation is that the lowering of corporate taxes attracts foreign multinational firms, creates new employments, and thereby increases national income (or GDP). Given the recent rapid growth of international firm mobility, such expectations about the relationship between the national income of a country that lowers its corporate tax, and thereby promotes the relocation of firms away from foreign countries, are now widely common in the economics press.

However, although the above implication of corporate tax policies is standard, little attention has been paid to the point that the exchange rate can also be affected by international firm movement. We do not believe that it is appropriate to ignore the interaction between firm relocation and exchange rates when examining corporate tax effects on national incomes. Because, in an open economy with greater international firm mobility and expansion of free trade, international firm movement affects labor and goods markets across countries, thereby affecting national income and consumption, and consequently nominal exchange rate changes through money markets. Indeed, there is a large body of empirical research on the relationship between exchange rates 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 the tax competition literature, the relationship between corporate taxation and firm location has been studied extensively at a theoretical level (see, e.g., Janeba, 1995; Konan, 1997; Haufler and Wooton, 1999; Haufler and Schjelderup, 2000; Huizinga and Nielsen, 2002; Kind, Midelfart and Schjelderup, 2000, 2005). Of particular interest in the literature is the issue of whether each country should levy positive corporate taxes on multinational firms from the viewpoint of household welfare. However, we emphasize that none of the studies in the existing literature focus on relocation of firms and nominal exchange rates simultaneously, nor how interactions between these factors affect national income domestically and abroad in a dynamic general equilibrium model.

On the other hand, in the new open economy macroeconomics (NOEM) literature, the international transmission of the exchange rate dynamics 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 (2006), and Senay and Sutherland (2007).[1] This literature has focused on mainly how the exchange rate and production of each country are influenced by

[1] 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).

unanticipated monetary and fiscal shocks in one country under monopolistic distortions and price 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 spatial distribution of firms. However, it is less likely to do so in an economy with international mobility of firms. This is because the monetary expansion not only positively affects foreign output by increasing world consumption, but can also lower output through the international relocation of firms.[2]

Thus, in the theoretical literature on the NOEM, there has been little study of how allowing for international relocation of firms affects the macroeconomic impacts of policy shocks. One exception, however, is Johdo (2015), who presents a new NOEM model with international relocation of firms. Johdo (2015) contrasts a two-country NOEM model without international relocation with a NOEM model with international relocation, 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 firm relocation to the other country.

However, the above literature does not consider the impacts of a corporate tax decrease on international relocation and other macroeconomic variables, including consumption and the exchange rate. In order to address these issues, we extend the NOEM model of Johdo (2015) to include corporate tax rates, and examine how a reduction in the corporate tax in the home country affects the distribution of firms and

[2] This effect is attributed to the distortion of monopolistic competition in product markets. In closed-economy monopolistic competition models, Svensson (1986) and Blanchard and Kiyotaki (1987) also highlight this first-order effect of a marginal monetary expansion on output.

the nominal exchange rate, and how these factors affect the income and consumption of each country.

The remainder of this paper is structured as follows. In Section 2, we outline the features of the dynamic optimizing model. In Section 3, we present the symmetric equilibrium with flexible nominal wages. In Section 4, we present a log-linearized version of this model, and examine how an unanticipated decrease in the corporate tax rate affects the international distribution of firms between countries, the exchange rate, and cross-country differences in consumption. In Section 5, we examine the welfare effects. The final section summarizes the findings and concludes the paper.

2 Model structure

In this section, we construct a perfect-foresight two country model with international relocation of firms.[3] 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 in period t, and the remaining (n_t, 1] producers locate in the foreign country, where n_t is endogenous. The size of the world

[3] However, in this model, agents are shocked by unanticipated monetary policies.

population is normalized to unity. We assume that in the home country, households inhabit the interval [0, s] and those in the foreign country inhabit the interval (s, 1].[4]

Home and foreign households have perfect foresight and share the same utility function. The intertemporal objective of household $i \in (0, s)$ in the home country at time 0 is to maximize the following lifetime utility:[5]

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

where $0 < \beta < 1$ is a constant subjective discount factor, ℓ^{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:

$$C^i_t = \left(\int_0^1 C^i_t(j)^{(\theta-1)/\theta} dj \right)^{\theta/(\theta-1)}, \; \theta > 1,$$

where θ is the elasticity of substitution between any two differentiated goods, $C^i_t(j)$ is the consumption of good j in period t for household i.[6] In addition, the second term in (1) is real money balances (M^i_t/P_t), where M^i_t 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 price of good j in period t. Analogously, the foreign country CPI is $P^*_t = \left(\int_0^1 P^*_t(j)^{1-\theta} dj \right)^{1/(1-\theta)}$,

[4] 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).

[5] In what follows, we mainly focus on the description of the home country because the foreign country is described analogously.

[6] Throughout the paper, we also use the index $j \in [0, 1]$ to refer to the product of firm j.

where $P_t^*(j)$ is the foreign-currency price of good j. Under the law of one price, we can rewrite the price indices as

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

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

Because there are no trade costs between the two countries, the law of one price holds for any variety j; i.e., $P_t(j) = \varepsilon_t P_t^*(j)$, where ε_t is the nominal exchange rate, defined as the home currency price per unit of foreign currency. Given the law of one price, a comparison of the above price indices implies that purchasing power parity (PPP) is represented by $P_t = \varepsilon_t P_t^*$. In this context, 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. At each point in time, households receive returns on risk-free real bonds, earn wage income by supplying labor, and receive profits from all firms equally. Therefore, the household budget constraint can be written as:

$$P_t B^i_{t+1} + M^i_t = P_t(1+r_t)B^i_t + M^i_{t-1} + W^i_t \ell^{si}_t$$

$$+ \left((1-\tau_t)\int_0^{n_t} \Pi_t(j)\,dj + \int_{n_t}^1 \varepsilon_t \Pi_t^*(j)\,dj\right) - P_t C^i_t + P_t T^i_t, \qquad (2)$$

where B^i_{t+1} 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, $W^i_t \ell^{si}_t$ is nominal labor income, where W^i_t denotes the nominal wage rate of household i, $(1-\tau_t)\int_0^{n_t} \Pi_t(j)\,dj$ $\left(\int_{n_t}^1 \varepsilon_t \Pi_t^*(j)\,dj\right)$ represents the after-tax total nominal profit flows of firms located at

home (abroad), where τ_t denotes the corporate (or profit) tax rate of the home country. In addition, $P_tC^i_t$ represents nominal consumption expenditure and T^i_t denotes real lump-sum transfers from the government. Note that all variables in (2) 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 tax revenue are rebated to the public in the form of lump-sum transfers. Hence, the government budget constraint in the home country is $T_t = \tau_t \int_0^{n_t} \Pi_t(j)\, dj + [(M_t - M_{t-1})/P_t]$, 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, $\ell^{di}{}_t(j)$ 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:

$$\ell^{di}{}_t(j) = s^{-1}(W^i_t/W_t)^{-\phi} y_t(j), \tag{3}$$

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 dynamic optimization problem of households. In the first stage, households in the home (foreign) country maximize the consumption index C^i_t (C^{i*}_t) subject to a given level of expenditure $P_tC^i_t = \int_0^1 P_t(j) C^i_t(j) dj$ ($P^*_t C^{i*}_t = \int_0^1 P^*_t(j) C^{i*}_t(j) dj$)

by optimally allocating differentiated goods. This static problem yields the following demand functions for good j in the home and foreign countries, respectively:

$$C^i_t(j) = (P_t(j)/P_t)^{-\theta} C^i_t,\ C^{i\,*}_t(j) = (P^*_t(j)/P^*_t)^{-\theta} C^{i\,*}_t. \tag{4}$$

Aggregating the demands in (4) across all households worldwide and equating the resulting equation to $y_t(j)$ yields the following market clearing condition for any product j in period t:

$$y_t(j) = sC^i_t(j) + (1 - s)C^{i\,*}_t(j) = (P_t(j)/P_t)^{-\theta} C^w_t, \tag{5}$$

where $P_t(j)/P_t = P^*_t(j)/P^*_t$ from the law of one price, and $C^w_t \equiv (sC^i_t + (1 - s)C^{i\,*}_t)$ is aggregate per capita world consumption.[7] Similarly, for product j of the foreign located firms, we obtain $y^*_j = (P^*_t(j)/P^*_t)^{-\theta} C^w_t$. In the second stage, households maximize (1) subject to (2). The first-order conditions for this problem with respect to B^i_{t+1} and M^i_t can be written as

$$C^i_{t+1} = \beta(1 + r_{t+1})C^i_t, \tag{6}$$

$$M^i_t/P_t = \chi C^i_t((1 + i_{t+1})/i_{t+1}), \tag{7}$$

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 (6) is the Euler equation for consumption and (7) 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^w_t and n_t,

[7] Throughout the paper, we use the superscript w for aggregated per capita world variables.

and subject to (3) and (5), home-located firm j faces the following profit-maximization problem: $\max_{P_t(j)} \Pi_t(j) = P_t(j)y_t(j) - \int_0^s W_t^i \ell_t^{di}(j)di = (P_t(j) - W_t)y_t(j)$. By substituting $y_t(j)$ from equation (5) into the firm's profit $\Pi_t(j)$ and then differentiating the resulting equation with respect to $P_t(j)$, we obtain the following price mark-up:

$$P_t(j) = (\theta/(\theta - 1))W_t. \tag{8}$$

Because W_t is given, from (8), all home-located firms charge the same price. In what follows, we define these identical prices as $P_t(j) = P_t(h)$, $j \in [0, n_t]$.[8] These relationships imply that each home-located firm supplies the same quantity of goods, and hence each firm requires the same quantity of labor; i.e., $\ell^{id}{}_t(j) = \ell^{id}{}_t(h)$, $j \in [0, n_t]$, where the firm index j is omitted because of symmetry. The price mark-ups of foreign-located firms are identical because $P_t^*(j) = P_t^*(f)$, $j \in (n_t, 1]$. Substituting (5) and (8) 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

$$\Pi_t(h)/P_t = (1/\theta)(P_t(h)/P_t)^{1-\theta}C_t^w, \quad \Pi_t(f)^*/P_t^* = (1/\theta)(P_t^*(f)/P_t^*)^{1-\theta}C_t^w. \tag{9}$$

The model assumes that the driving force for relocation to other countries is a difference in real profits between two countries.[9] In addition, we assume that all firms are not allowed to relocate instantaneously even if there is the profit gap. Following the

[8] 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.

[9] 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.

formulation in Johdo (2015), the above adjustment processes for relocation are formulated as follows:

$$n_t - n_{t-1} = \gamma[(1-\tau_t)\Pi_t(h)/P_t - \Pi_t(f)^*/P_t^*] = \gamma[(1-\tau_t)\Pi_t(h)/P_t - \varepsilon_t\Pi_t(f)^*/P_t], \tag{10}$$

where the third term can be rewritten by using PPP, and γ ($0 \le \gamma < \infty$) is a constant positive parameter that determines the degree of firm mobility between the two countries: a larger value of γ implies higher firm mobility between two countries. Intuitively, the parameter γ 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 $t - 1$.[10] In the monopolistic labor market, each household provides a single variety of labor input to a continuum of domestic firms. Hence, the equilibrium labor-market conditions for the home and foreign countries imply that $\ell^{si}_t = \int_0^{n_t} \ell_t^{di}(j)dj$, $i \in [0, s]$ and $\ell^{si*}_t = \int_{n_t}^{1} \ell_t^{di*}(j)dj$, $i \in (s, 1]$, respectively. By taking W_t, P_t, $y_t(j)$,

[10] Kollmann (2001) introduces nominal wage rigidities such as those implied by staggered contracts, à la Calvo (1983), into the NOEM model, in which a fraction of labor suppliers are allowed to reset their wage rates to a newly optimal level after one period, which results in gradual nominal wage adjustment over time. Although this wage setting is realistic, we introduce one-period nominal wage setting for simplicity.

and n_t as given, substituting $\ell^{si}{}_t = \int_0^{n_t} \ell_t^{di}(j)dj$ and equation (3) into the budget constraint given by (2), and maximizing the lifetime utility given by (1) with respect to $W^i{}_t$, we obtain the following first-order condition:

$$\kappa \ell^{si}{}_t^{\,2} \phi (W^i{}_t/P_t)^{-1} = (\phi - 1)(\ell^{si}{}_t/C^i{}_t). \tag{11}$$

The right-hand side of (11) 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 ($B_0 = 0$), $\tau_0 = 0$ 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 (6)), the constant real interest rate is given by

$$r_{ss} = (1 - \beta)/\beta \equiv \delta, \tag{12}$$

where δ is the rate of time preference. The steady-state allocation of firms is

$$n_{ss} = 1/2. \tag{13}$$

The steady state output levels are

$$\ell^{s}_{ss} = \ell^{s*}_{ss} = C_{ss} = C^{*}_{ss} = C^{w}_{ss} = y_{ss}(h) = y_{ss}^{*}(f)$$

$$= ((\phi-1)/\phi)^{1/2}((\theta - 1)/\theta)^{1/2}(1/\kappa)^{1/2}. \tag{14}$$

Substituting C^{w}_{ss} from equation (14) into equation (9) yields the following steady-state levels of real profit for home- and foreign-located firms, which are equal:

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

4 Log-linear approximation

4.1 The relationship between relocation and the exchange rate

To examine the macroeconomic effects of an unanticipated corporate tax reduction, 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 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 $\overline{X}$ to denote 'long run' percentage deviations from the initial steady-state value; i.e., $\overline{X} = dX_2 / X_{ss,0} = dX_{ss} / X_{ss,0}$, 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 (10) 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 distribution of firms:

$$\hat{n} = 2\gamma\left((\phi-1)/\phi\right)^{1/2}\left((\theta-1)/\theta\right)^{3/2}(1/\kappa)^{1/2}\hat{\varepsilon} - (2\gamma/\theta)\left((\phi-1)/\phi\right)^{1/2}\left((\theta-1)/\theta\right)^{1/2}(1/\kappa)^{1/2}d\tau . \tag{15}$$

Equation (15) shows that an exchange rate depreciation induces global relocation of firms towards the home country for a given level of the corporate tax.[11] Intuitively, with fixed nominal wages, which cause nominal product prices to be sticky because of mark-up pricing by monopolistic product suppliers, the depreciation increases relative home production through the 'expenditure-switching effect'; i.e., $\hat{y}(h) - \hat{y}^*(f) = \theta\hat{\varepsilon}$.[12]

[11] This result is consistent with the evidence found in the empirical literature on the relationship betseen 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, Bolling et al, 2007, and Udomkerdmongkol et al, 2008).

[12] Cavelaars (2006) develops a NOEM model with nontraded goods and defines the parameter θ as the degree of competition in non-tradable goods sector in order to examine the output and price effects of an exogenous permanent increase in θ.

This increases the relative profits of home-located firms, and consequently other firms relocate to the home country.[13] Equation (15) also shows that nominal exchange rate changes have greater effects the greater is the flexibility of relocation (the larger is γ). By contrast, when relocation costs are high ($\gamma = 0$), nominal exchange rate changes have a negligible effect on the relocation of firms.[14] In addition, from equation (15), for a given level of the exchange rate, the reduction of a corporate tax by the home country ($d\tau < 0$) leads firms to relocate into the home country, i.e., $\hat{n} > 0$. This is because a decrease in τ leads to an increase in the relative real profit of firms located in the home country, and this leads to the relocation of some firms away from the foreign to the home country ($\hat{n} > 0$).

4.2 The effects of corporate tax reduction

We now consider the macroeconomic effects of an unanticipated infinitesimal reduction in the corporate tax rate of the home country in period 1. The closed-form solution for the short-run international distribution of firms is as follows:

$$\hat{n} = -\frac{2\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}}{A}\left\{1+\left(\frac{\tilde{\delta}}{\theta-1}\right)+\frac{2}{\delta\left[\theta+1+4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\right]}\right\}d\tau\,, \tag{16}$$

[13] The expenditure-switching effect arises intuitively because exchange rate depreciation causes a decrease in the relative real price of home goods for households in both countries so that world consumption demand switches toward home 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) and Sutherland (2006).

[14] In an international macroeconomic model incorporates heterogeneous firms, Ghironi and Melitz (2005) show the positive relationshipb between the relative availability of domestic and imported varieties (the share of domestic varieties in the consumption basket) and the expenditure switching effect.

where

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

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

The result in (16) shows that a reduction in the home country's corporate tax ($d\tau < 0$) leads to the relocation of some firms from the foreign to the home country ($\hat{n} > 0$). Next, we analyze the influence of the tax policy on short-run relative consumption and the nominal exchange rate. The closed-form solutions for these variables are as follows.

$$\hat{C} - \hat{C}^* = -\frac{1}{A\theta}\left\{4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\left[1 + \frac{2}{\delta\left[\theta + 1 + 4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\right]}\right] - \tilde{\delta}\right\}d\tau, \tag{17}$$

$$\hat{\varepsilon} = \frac{1}{A\theta}\left\{4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\left[1 + \frac{2}{\delta\left[\theta + 1 + 4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\right]}\right] - \tilde{\delta}\right\}d\tau.^{15} \tag{18}$$

As shown in (17), the impact of corporate tax reduction ($d\tau < 0$) has two effects with opposing implications. On one hand, a decrease in the corporate tax rate results in less differentiated products being produced in the foreign 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 short-run relative consumption level in the home country. Therefore, the first element is positive for home consumption and negative for foreign consumption (hereafter we shall call this the 'relocation effect'). On

[15] Given that $\hat{\varepsilon} = \bar{\varepsilon}$ holds from the money-market equilibrium conditions, and given that $\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^*$ also holds from the Euler consumption equations, the short-run equilibrium also holds in the long run.

the other hand, the tax decrease shifts tax revenue away from the home country towards the foreign country because the burden of the home country's corporate tax is partly borne by rent income repatriation to the foreign country's households. Therefore, the second element is negative for the home country and positive for the foreign country (hereafter we shall call this the 'tax redistribution effect'). Thus, the net outcome in (17) depends on the relative strengths of these competing pressures. However, if γ (the degree of firm mobility) is large (small), the relocation effect dominates (is dominated by) the tax redistribution effect, and therefore the corporate tax reduction results in a proportionate increase (decrease) in relative consumption levels. Intuitively, as the relocation of firms becomes more flexible (as γ increases), there is a greater increase in relative home labor income because more firms relocate, and therefore the increase in relative home consumption is greater.

The corporate tax reduction also leads to exchange rate appreciation when γ is large (see equation (18)). 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 appreciate and raise the supply of real money balances in the home country to restore money market equilibrium. The opposite mechanism is valid when γ is small: the corporate tax reduction leads to exchange rate depreciation.

In the next section, we use these results to evaluate whether the home and foreign welfare effects of a reduction in the corporate tax rate of the home country are positive or negative.

5 Welfare implications

In order to evaluate whether the home and foreign welfare effects of a reduction in the corporate tax rate of the home country are positive or negative, we focus on the component of an agent's consumption utility. By defining this component as U_0^R, we can rewrite equation (1) as $U_0^R = \sum_{t=0}^{\infty} \beta^t \, log \, C_t$. The impact of unanticipated profit tax policy shocks on domestic welfare is then as follows:

$$dU^R = -\frac{\tilde{\delta}}{2A\theta}\left\{4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\left[1+\frac{2}{\delta\left[\theta+1+4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\right]}\right]-\tilde{\delta}\right\}d\tau \cdot \tag{19}$$

Analogously, the impact on foreign welfare is

$$dU^{*R} = \frac{\tilde{\delta}}{2A\theta}\left\{4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\left[1+\frac{2}{\delta\left[\theta+1+4\gamma\tilde{\phi}^{1/2}\tilde{\theta}^{3/2}\tilde{\kappa}^{1/2}\right]}\right]-\tilde{\delta}\right\}d\tau \cdot \tag{20}$$

Equations (19) and (20) show that, in terms of the utility of the average national household, a reduction in the corporate tax ($d\tau < 0$) can have a 'beggar-thy-neighbor' effect when γ is large, while the tax policy can have a 'beggar-thyself' effect when γ is small. In particular, the result in (19) is explained intuitively as follows. First, in the home country, a marginal decrease in the home corporate tax rate has two opposing effects on welfare. On one hand, the tax decrease leads to a shift in labor demand away from the foreign country towards the home country because of the relocation of some firms towards the home country, thereby raising the labor income of the home country. This effect is positive for the home country (the relocation effect). On the other hand, the tax decrease allows the home government to shift tax revenue away from the home towards the foreign country because the burden of the home country's corporate tax is

borne, at least partly, by rent income repatriation to foreign households (the tax redistribution effect). Therefore, the overall welfare effect of a corporate tax decrease is ambiguous and the former effect (the relocation effect) must exceed the latter effect (the tax redistribution effect) if the relocation-promoting corporate tax deduction is to be effective in improving the welfare of the home country. To examine the relative strength of these effects, we examine the degree of firm mobility, γ. Given the result of equation (19), a reduction in the corporate tax rate in economies with a large γ causes the 'relocation effect' to dominate the 'tax redistribution effect', and hence the net income effect is positive. This raises short-run and long-run consumptions via the intertemporal consumption-smoothing channel, which increases its welfare. Accordingly, the welfare effect is unambiguously positive (negative) for the home country when the degree of firm mobility is large (small). In contrast, the opposite is true for the foreign country through relocation of firms and redistribution of tax revenue. Thus, when the degree of firm mobility is large (small), a reduction in the corporate tax by one country has a 'beggar-thy-neighbor' ('beggar-thyself') effect.

6 Conclusion

We have analyzed both a reduction in the corporate tax rate of the home country on its neighbor, and the incentive for the home country to decrease its corporate tax in turn. In our model, we found that the degree of firm mobility provides the key to understanding the potential impacts of corporate tax reduction. The main finding of our analysis is that if the degree of firm mobility is large, the home country always benefits at the expense of the foreign country. This result indicates the following policy

implication: if the aim of corporate tax policy in the home country is to attract foreign-located firms and increase welfare, then the tax must be decreased if the degree of firm mobility is large.

The model developed here is rather simple in a number of respects. This suggests many directions for future research. First, this paper may yield results that are more interesting if the current model is modified to include sunk costs, as in Russ (2007).[16] Second, given that the main purpose of this paper is to analyze the effects of a decrease in an exogenously fixed corporate tax, we do not consider the interactions between the two governments in setting optimal corporate taxes. Therefore, adapting the present model to a noncooperative game theoretic analysis and taking the corporate tax as a strategic variable may be an interesting extension.[17] These issues remain for future research.

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[16] Campa (1993) finds the negative effect of sunk costs (e.g., investment in advertising and media promotion) on industry entry into the US during the 1980s. Brainard (1997) also finds that overseas production by multinationals decreases with the fixed costs of production (scale economies at the plant level). Other related models incorporating fixed costs include Aizenman (1994) and Corsetti et al. (2005).

[17] In the game theoretic tax competition literature, researchers have made numerous attempts to show that corporate tax competition leads to a 'race to the bottom' (see, e.g., Janeba, 1995; Konan, 1997; Haufler and Wooton, 1999; Haufler and Schjelderup, 2000; Fuest and Huber, 2002; Huizinga and Nielsen, 2002; Kind et al., 2000, 2005; Becker and Fuest, 2010).

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