Globalization, Increasing Returns and Tax Competition

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Abstract

Mobile capital is an important production factor in forming international trade. Leading by the so-called footloose capital model, almost all models in the existing new trade theory assume mobile capital as the fixed input of production and immobile labor as marginal input, this paper considers the other case that immobile labor is the fixed input and mobile capital is the marginal input. There is only one manufacturing sector and we do not assume any homogeneous good so that wages are endogenously determined. This general-equilibrium model turns out to be totally solvable. We obtain a closed-form solution for the wages, showing that the larger country has a higher wage. We then prove that globalization is always beneficial to both large and small countries, although the nominal wage rate is not monotonic. This framework is then applied to examine a tax competition game that two governments levy tax (or subsidy) on mobile capital. Being able to incorporate the income effect, it is shown that the larger country subsidizes capital less and the tax differential decreases in the globalization level.

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1 Introduction

The new trade theory (NTT) literature aims to clarify the economic mechanisms of intra-industry trade when manufacturing production involves increasing return to scale (IRS) technology and monopolistic competition. Earlier models like Krugman (1980) and Helpman and Kugman (1985) assume only one production factor—labor and derive the result that the manufacturing sector agglomerates in a larger country, which is called the home market effect (HME).

Capital is another important input in manufacturing production in the real world, which needs to be included in the examination of trade issues. Capital and labor have different degree of mobility. Lucas (1990) documents that world capital markets were anywhere close to being free and competitive while labor is almost immobile across countries even inside EU. Accordingly, it is reasonable to consider capital mobile and labor immobile. Incorporating these features, Martin and Rogers (1995) establish a footloose capital model, which is now extensively applied to the analysis of many trade issues in NTT. Two-factor NTT frameworks have at least two merits. On the one hand, two-factor models can gain some new insights which cannot be observed in one-factor models (see Takatsuka and Zeng 2012a and 2012b). On the other hand, we are able to remove the assumption of a free-traded homogeneous good (sometimes called the agricultural good),[1] making it possible to examine the spatial income inequality (Takahashi et al., 2013).

As in Martin and Rogers (1995), Forslid and Ottaviano (2003) and Takahashi *et al.* (2013), it is better to assume heterogenous production factors for the fixed and variable inputs to achieve strong analysis tractability. Interestingly, they all assume the mobile factor like capital or skilled workers as the fixed input, while the immobile (unskilled) workers are assumed to be marginal input. This setting has the merit of capturing the relocation of firms and discussing the distribution of industry.

However, like stock investment, mobile capital is also used as marginal input in manufacturing production in the real world. We may ask a question whether the existing results depend on the features of the fixed and marginal input assumption. The primary purpose of this paper is to reformulate the footloose capital model and reexamine this issue, considering that capital is mobile and used as marginal input, while labor is immobile and employed as fixed input. This framework describes the situation that labor is used to "design the production line" (Peng *et al.*, 2006) that captures the diversity of differential products, while capital is used to buy machines and raw materials, whose amount is dependent on the quantity of firms' output. ue to the assumption of immobile

[1]This assumption is criticized by a lot of papers including Davis (1998).

labor, this model does not allow firm relocation. Nevertheless, we are able to observe the home market effects in terms of wages and in terms of trade pattern. Namely, the larger country has a higher wage rate and the larger country is a net exporter of the manufactured goods. Furthermore, the model is fully analytical solvable, and thus we are able to examine the welfare change in the process of globalization. Note that many policy makers are sensitive about de-industrialization of their countries. It is, therefore, important to examine the impact of trade liberalization without possible de-industrialization (see Baldwin and Robert-Nicoud, 2000). Our model provides a new and tractable tool for such a policy analysis.

The strong tractability of this model leads to the second purpose of this paper: it is applied to explore a tax competition game, in which production is under IRS technology. Taxation on mobile capital has three effects. The first is the *wage income effect*. Levying tax on capital in a country increases the capital rental rate there, which increases the marginal cost in firms' production, and then induces the return of the fixed input of labor (i.e.,wage) due to the assumption of free entry. The second is *the cost-of-living effect*. A higher tax on the capital increases the price of goods because the mark-up is a constant proportion of marginal production cost in a CES framework. Therefore, the overall price index (i.e., the cost of-living index) rises in that country. The third is *the tax revenue effect*. Higher taxation on the capital in a country implies a high tax revenue and a higher income for the residents there since we assume that the tax revenue is redistributed equally among the workers. This tax revenue increases the residents' income which impacts on the consumption. The first and second effects decrease the welfare, while the third effect raises the welfare. The local government determines the optimal tax rate to maximize the welfare.

Existing literature reveals the technical difficulties to deal with all three effects simultaneously. For example, as the first paper considering tax competition with IRS production technology, Baldwin and Krugman (2004) explain that a large country can levy a higher tax than a small country because firms make higher profits in the larger country. Their study is based on a core-periphery structure with a catastrophic evolution path. A later paper of Borck and Pflüger (2006) considers the possibility of partial agglomeration. To gain solvability, they assume that the governments maximize their own objective function rather than the residential utility, it thus deletes the tax revenue effect on the residents. Even so, their models are still analytically unsolvable. Meanwhile, Ottaviano and van Ypersele (2005) include capital as another production factor. To improve the analytical intractability, they adopt a quasi-linear utility function of Ottaviano *et al.* (2002). However, such a framework is unable to capture the income effect, suffocating the tax revenue effect. Therefore, in their setup, all firms are likely to cluster in the larger country, and the equilibrium tax rates are not uniquely determined when two countries are asymmetric. In addition, both countries do not impose tax on two symmetric countries. Finally, Mai *et al.* (2008) examine the tariff on the importing goods. Their results are based on extreme cases that the trade costs are either sufficient high or low, revealing the difficulty of comprehensive findings with general trade costs in tax competition.

In contrast to their papers, we examine the taxation (or subsidization) game regarding capital employment, in which each country noncooperatively chooses its optimal tax rate in order to maximize the welfare level of its residents, anticipating the consequences of the capital flow and price competition among the firms. We find the sum of the first and second effects dominate the third effect, therefore, two countries always subsidize capital employment to attract capital inflow. The subsidy rate crucially depends on the country size and trade freeness. Unlike Ottaviano and van Ypersele (2005), by capturing the income effect, we find that the equilibrium tax ratio is not indeterminate and the governments have to subsidy capital even if two countries are symmetric.

The organization of the paper is as follows. Section 2 presents the basic model and specifies the equilibrium wages in the two countries. Section 3 characterizes the impact of globalization and the country size on the wage, welfare, capital movement, and interprets the home market effect. Section 4 investigates the Nash equilibrium of tax competition between two countries, whereas section 5 concludes.

2 The model and equilibrium

The global economy consists of two countries (or regions): Home and Foreign. The countries have the same physical geographical constraints, except for their populations. The mass of total population is L, and $\theta > 1/2$ of which reside in Home. The typical individual is assumed to supply one unit of labor and own 1 unit of capital, with utility function

$$U = \left(\int_0^L d_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}.$$

Consumers maximize their utility with respect to their budget constraint. Let (p, d) be the price of each variety and the national demand of a specific manufacturing variety produced in Home. Firms producing different varieties have symmetric technology so we omit the variety name in these notations. We denote variables pertaining to Foreign by an asterisk (*), and those related to imports by an upper bar ($^-$). Then we have

$$d = \frac{p^{-\sigma}}{P^{1-\sigma}}Y, \quad \bar{d} = \frac{\bar{p}^{-\sigma}}{(P^*)^{1-\sigma}}Y^*, \quad d^* = \frac{(p^*)^{-\sigma}}{(P^*)^{1-\sigma}}Y^*, \quad \bar{d}^* = \frac{(\bar{p}^*)^{-\sigma}}{P^{1-\sigma}}Y, \tag{1}$$

where P and P^* are price indices in Home and Foreign, respectively.

The production technology for any variety of each firm needs one unit of labor as the fixed input, which is assumed to be immobile across the countries, and also requires $(\sigma-1)/\sigma$ units of capital as marginal input. And it is clear that capital can be employed in two countries. Due to the free mobility of capital, the capital returns in two countries are equalized at equilibrium. We take this capital return as numéraire. Assume Samuelson's iceberg international transportation costs: τ (≥ 1) units of a manufactured good must be shipped for one unit of requirement in the other country. The production of each variety is split into domestic and foreign markets. A firm located in Home sets prices of goods to maximize its profit as

$$\pi = pd + \bar{p}\bar{d} - \frac{\sigma-1}{\sigma}(d + \tau\bar{d}) - w,$$

where w is the nominal wage of each worker in Home.

By use of (1), the optimal prices of good for firms in Home and Foreign, are, respectively, given by

$$p = p^* = 1, \quad \bar{p} = \bar{p}^* = \tau. \tag{2}$$

The national incomes include wage income and capital return, they are therefore given by

$$y = \theta L(w+1), \quad y^* = (1-\theta)L(w^*+1),$$

We have thus the price indices as

$$P = [(\theta L + (1-\theta)L\tau^{1-\sigma}]^{\frac{1}{1-\sigma}}, \quad P^* = [(1-\theta)L + \theta L\tau^{1-\sigma}]^{\frac{1}{1-\sigma}}.$$

Let $\phi = \tau^{1-\sigma}$, which is called trade freeness in the literature. The output of a firm in Home is

$$x = d + \tau\bar{d} = \frac{\theta L(w+1)}{\theta L + (1-\theta)L\phi} + \phi\frac{(1-\theta)L(w^*+1)}{(1-\theta)L + \theta L\phi}, \tag{3}$$

Similarly, the production of a firm in Foreign is given by

$$x^* = \frac{(1-\theta)L(w^*+1)}{(1-\theta)L+\theta L\phi} + \phi\frac{\theta L(w+1)}{\theta L+(1-\theta)L\phi}. \tag{4}$$

Due to the free-entry condition of firms, the net profits of firms are zero, which yield

$$w + \frac{\sigma-1}{\sigma}x = x, \quad w^* + \frac{\sigma-1}{\sigma}x^* = x^*. \tag{5}$$

Substituting (3) and (4) into (5), we obtain two equations to determine the wages in Home and Foreign, respectively, as

$$w = \frac{(\sigma-1)[\phi^2(1-\theta)^2+\theta(1+\phi)-\theta^2]+\phi[\theta(1-\phi)+\phi]}{(\sigma-1)\{\sigma\phi+\theta(1-\theta)(1-\phi)[\sigma-1-(\sigma+1)\phi]\}}, \tag{6}$$

$$w^* = \frac{\sigma\phi+\theta(\sigma-1-\phi)(1-\phi)-\theta^2(\sigma-1)(1-\phi^2)}{(\sigma-1)\{\sigma\phi+\theta(1-\theta)(1-\phi)[\sigma-1-(\sigma+1)\phi]\}}. \tag{7}$$

Note that the wages in the two countries are dependent on the trade freeness (ϕ) as well as the population size (θ) and the elasticity of goods substitution (σ).

3 Wages and welfare

In this section, we focus on the impact of globalization and population size on the wage and welfare of residents. The wages are explicitly derived in the preceding section, improving the tractability of the welfare issue. We start to examine how wage and welfare change when trade integration is deepened.

At first, denote $w(\phi)$, then since $w(0) = w(1) = w^*(0) = w^*(1)$, and the wage curves are not monotone, a critical point of ϕ is given by

$$\phi_0 = \frac{1}{1+\sqrt{\dfrac{\sigma}{\theta(1-\theta)(\sigma-1)}}}.$$

Thus, we have

Proposition 1 *(i) For $\theta > 1/2$, nominal wage w (resp. w^*) increases (resp. decreases) in ϕ for $\phi \in [0, \phi_0)$ and decreases (resp. increases) in ϕ for $\phi \in (\phi_0, 1]$. (ii) Welfare levels in both countries increase in ϕ.*

Proof: (i) Since

$$\frac{dw}{d\phi} = \frac{(2\theta-1)(1-\theta)\sigma[\theta(1-\theta)(\sigma-1)(1-\phi)^2 - \sigma\phi^2]}{(\sigma-1)\{\phi[1-2\theta(1-\theta)(1-\phi)] + (\sigma-1)[\theta(1-\theta)(1-\phi)^2+\phi]\}^2}, \tag{8}$$

and ϕ_0 is the only solution of $\sigma\phi^2 - \theta(1-\theta)(\sigma-1)(1-\phi)^2 = 0$ in $(0,1)$, we have the result on w. The result on w^* is shown similarly. To prove (ii), note that the welfare level in Home is calculated as

$$\begin{aligned}\omega =& \frac{w+1}{[\theta+(1-\theta)\phi]^{\frac{1}{1-\sigma}}}\\ =& \frac{\sigma[\theta(1-\phi)+\phi][(\sigma-1)(1-\theta+\theta\phi)+\phi]}{(\sigma-1)\{\sigma\phi+\theta(1-\theta)(1-\phi)[\sigma-1-(\sigma+1)\phi]\}}[\theta+(1-\theta)\phi]^{\frac{1}{\sigma-1}}.\end{aligned}$$

Therefore, it holds that

$$\begin{aligned}\frac{\partial\omega}{\partial\phi} =& \frac{(1-\theta)\sigma(\theta+\phi-\theta\phi)^{\frac{1}{\sigma-1}}}{(\sigma-1)^2\{\sigma\phi+\theta(1-\theta)(1-\phi)[\sigma-1-(\sigma+1)\phi]\}^2}\\ & \Big([1-2\theta(1-\theta)(1-\phi)]\phi^2 + (1-\theta)(1+\phi)[\theta^2(1-\phi)^2+\phi](\sigma-1)^2\\ & + \phi(\sigma-1)\{\theta(1-\theta)(1+2\theta)\phi^2 + [2(1-\theta)+\theta(2\theta-1)^2]\phi\\ & + [(1-\theta)^2+\theta(1+\theta)](1-\theta)\}\Big)\\ >& 0.\end{aligned}$$

□

When trade costs are high ($\phi \in (0, \phi_0)$), like other NTT models, the agglomeration force increases in ϕ, resulting a higher wage w for a larger ϕ. However, when trade costs are small ($\phi \in (\phi_0, 1)$, the prices in domestic and foreign markets become close. The marginal costs of production in two countries converge, reducing the differential of fixed costs. Therefore, a larger ϕ is accompanied by a lower w.

As declared by Helpman and Krugman (1985, p.179), it is difficult to prove in general that countries gain from trade in differentiated products models. By removing the agricultural sector, Takahashi et al. (2013) made a progress and find that both countries benefit from trade integration when ϕ is either small or large. In contrast, Proposition 1 declares that both countries gain from trade for any trade costs. This sharp result can be attributed to the property that firm numbers are fixed in our setup. In the larger country, the benefit of lowered prices of imported goods is larger than the loss of reduced nominal wage when trade is more integrated.

Now we turn to the role of country size. Equations (6) and (7) conclude that wages also rely on the population size. For any given finite trade costs, the larger country has a higher nominal wage due to the agglomeration effect. But this force is not monotone in country size. Figure 1 plots the relation between w and θ, in which parameters are chosen as $\phi = 0.6$ and $\sigma = 6$. When Home is too big, the production in Foreign becomes relatively important which reduces the nominal wage w. Nevertheless, the number of firms in Home is proportional to its size. Therefore, the price index in Home is lowered when θ increases, which increases the welfare.

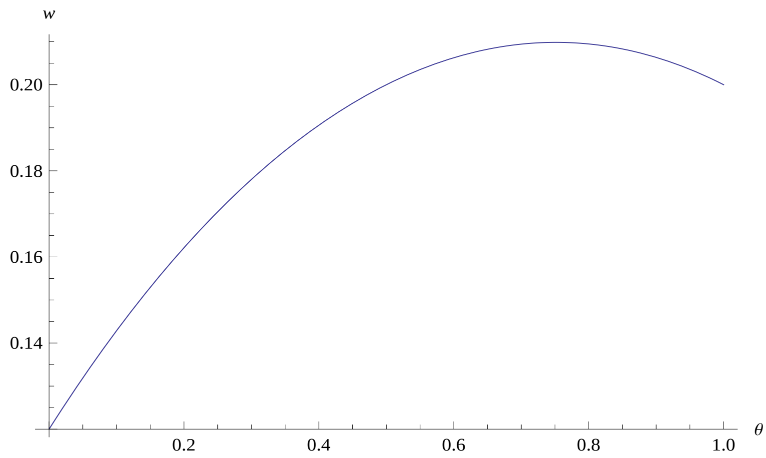

Figure 1: The relation between wage w and country size θ

Proposition 2 *The welfare level of a country increases in its size.*

Proof: The result regarding the welfare can be obtained as follows.

$$\begin{aligned}\frac{\partial \omega}{\partial \theta} =& \frac{\sigma(1-\phi)(\theta+\phi-\theta\phi)^{\frac{1}{\sigma-1}}}{(\sigma-1)^2\{\sigma\phi+\theta(1-\theta)(1-\phi)[\sigma-1-(\sigma+1)\phi]\}^2} \\ & \Big[(1-\theta)^2\theta(\sigma-1)^2+(1-\theta)(1+\sigma)[\theta^2\sigma+(1-\theta)(\sigma-1+\theta)]\phi^3 \\ & +\{(1-\theta)^2+\theta(1+\theta)+[(1-\theta)(2-\theta)+2\theta^2](\sigma-1)\}(1-\theta)(\sigma-1)\phi \\ & +\Big((1-\theta)^2+\theta^2+(\sigma-1)\{1-\theta+\theta^3+(1-\theta)[1+3(1-\theta)\theta]\sigma\}\Big)\phi^2\Big] \\ >& 0.\end{aligned}$$

$\square$

Now we examine how wage depends on σ. We have

$$\frac{d}{d\sigma}\frac{w}{w^*} = -\frac{\theta(1-\theta)(2\theta-1)(1-\phi)^2\phi(1+\phi)}{\{\sigma\phi-\theta^2(\sigma-1)(1-\phi^2)+\theta(1-\phi)[\sigma-(1+\phi)]\}^2} < 0,$$

so the relative nominal wage in the larger country is decreasing in the elasticity of substitution among goods. This finding is consistent with the well-known fact that a small σ produces a larger second-nature force. Since firms numbers are fixed in this framework, the agglomeration is represented by a higher wage rate, namely, the HME in terms of wage.

Although firm numbers are fixed by the labor distribution in this framework, we are able to explore how the production is related to globalization by investigating the capital movement. We denote the share of capital employed in Home country as k, and it is given by

$$k = \theta\frac{\sigma-1}{\sigma}x = \theta(\sigma-1)w. \tag{9}$$

By use of (6), we have

$$\begin{aligned} k-\theta =& \theta[(\sigma-1)w-1] \\ =& \frac{\theta(1-\theta)\sigma(1-\phi)\phi}{\theta(1-\theta)[\sigma-1+(\sigma+1)\phi^2]+[(1-\theta)^2+\theta^2]\sigma\phi}(2\theta-1), \end{aligned}$$

which is positive iff $\theta > 1/2$. Therefore, similar to the result of Takahashi *et al.* (2013), capital moves from the smaller country to the larger country. Although the firm number is fixed in our model, it is shown that the mobile factor of capital agglomerates in the larger country, which is another face of the home market effect.

Since

$$\frac{\partial(k-\theta)}{\partial\phi} = \frac{\theta(1-\theta)(2\theta-1)\sigma[\theta(1-\theta)(\sigma-1)(1-\phi)^2-\sigma\phi^2]}{\{\theta(1-\theta)[\sigma-1+(\sigma+1)\phi^2]+[(1-\theta)^2+\theta^2]\sigma\phi\}^2}, \tag{10}$$

we know that both w and $k-\theta$ reach their maximum at ϕ_0 by the comparison of (8) and (10). Thus, we have

Proposition 3 *(i) The capital inflows from the smaller country to the larger country. (ii) $k-\theta$ increases when $\phi < \phi_0$ and decreases when $\phi > \phi_0$.*

Equation (10) reveals that the secondly magnificent effect is not necessary true. In fact, $k-\theta$ increases when $\phi < \phi_0$ and decreases when $\phi > \phi_0$, we observe an agglomeration process first and a dispersion process later.

Since $k-\theta > 0$ always holds, the larger country is a net exporter of the manufacturing goods for any ϕ, as a result of trade balance.

4 Tax competition

We now turn to examine a tax competition game regarding the capital employment between two countries. We solve the equilibrium tax rate and analyze how it depends on trade integration.

Assume that Home imposes tax t on each unit of capital, and Foreign country imposes tax t^*. Then (2) is replaced by

$$p = 1+t, \quad p^* = 1+t^*, \quad \bar{p} = (1+t)\tau, \quad \bar{p^*} = (1+t^*)\tau,$$

this enables us to rewrite the income and price index in Home and Foreign, respectively, as follows:

$$\begin{aligned}
y &= w + 1 + \frac{kt}{\theta}, \\
y^* &= w^* + 1 + \frac{(1-k)t^*}{1-\theta}, \\
P &= [\theta L(1+t)^{1-\sigma} + (1-\theta)L(1+t^*)^{1-\sigma}\phi]^{\frac{1}{1-\sigma}}, \\
P^* &= [(1-\theta)L(1+t^*)^{1-\sigma} + \theta L(1+t)^{1-\sigma}\phi]^{\frac{1}{1-\phi}}.
\end{aligned}$$

In turn, the production levels of firms in Home and Foreign are given by

$$\begin{aligned}
x &= \frac{(1+t)^{-\sigma}\theta(w+1+\frac{kt}{\theta})}{\theta(1+t)^{1-\sigma} + (1-\theta)(1+t^*)^{1-\sigma}\phi} + \phi\frac{(1+t)^{-\sigma}(1-\theta)(w^*+1+\frac{(1-k)t^*}{1-\theta})}{(1-\theta)(1+t^*)^{1-\sigma} + \theta(1+t)^{1-\sigma}\phi}, \\
x^* &= \phi\frac{(1+t^*)^{-\sigma}\theta(w+1+\frac{kt}{\theta})}{\theta(1+t)^{1-\sigma} + (1-\theta)(1+t^*)^{1-\sigma}\phi} + \frac{(1+t^*)^{-\sigma}(1-\theta)(w^*+1+\frac{(1-k)t^*}{1-\theta})}{(1-\theta)(1+t^*)^{1-\sigma} + \theta(1+t)^{1-\sigma}\phi},
\end{aligned}$$

respectively. Extending (5) and (9), we have the following equations for three variables w, w^* and k.

$$\begin{aligned}
\frac{\sigma w}{1+t} &= \frac{(1+t)^{-\sigma}\theta(w+1+\frac{kt}{\theta})}{\theta(1+t) + (1-\theta)(1+t^*)\phi} + \phi\frac{(1+t)^{-\sigma}(1-\theta)(w^*+r+\frac{(1-k)t^*}{1-\theta})}{(1-\theta)(1+t^*) + \theta(r+t)\phi}, \\
\frac{\sigma w^*}{1+t^*} &= \phi\frac{(1+t^*)^{-\sigma}\theta(w+1+\frac{kt}{\theta})}{\theta(1+t) + (1-\theta)(1+t^*)\phi} + \frac{(1+t^*)^{-\sigma}(1-\theta)(w^*+1+\frac{(1-k)t^*}{1-\theta})}{(1-\theta)(1+t^*) + \theta(1+t)\phi}, \\
k &= \theta\frac{\sigma-1}{\sigma}\frac{\sigma w}{1+t}. \qquad (11)
\end{aligned}$$

Solving these three equations yields the nominal wage and capital employment in Home and Foreign as follows:

$$
\begin{aligned}
w =& \frac{(1+t)(1+t^*)^{\sigma-1}}{(\sigma-1)\mathcal{D}}\{(1+t^*)^{\sigma}\theta\sigma\phi + (1+t)^{\sigma-1}(1-\theta)[(1+t^*)\sigma\phi^2 \\
&+ \theta(\sigma-1)(1-\phi^2)]\}, \\
w^* =& \frac{(1+t^*)(1+t)^{\sigma-1}}{(\sigma-1)\mathcal{D}}\{(1+t)^{\sigma}(1-\theta)\sigma\phi + (1+t^*)^{\sigma-1}\theta[(1+t)\sigma\phi^2 \\
&+ (1-\theta)(\sigma-1)(1-\phi^2)]\}, \\
k =& \frac{\theta(1+t^*)^{\sigma-1}}{\mathcal{D}}\{(1+t^*)^{\sigma}\theta\sigma\phi + (1+t)^{\sigma-1}(1-\theta)[(1+t^*)\sigma\phi^2 \\
&+ \theta(\sigma-1)(1-\phi^2)]\},
\end{aligned}
$$

where

$$
\begin{aligned}
\mathcal{D} =&[(1+t)^{2\sigma-1}(1-\theta)^2 + (1+t^*)^{2\sigma-1}\theta^2]\sigma\phi \\
&+ (1+t)^{\sigma-1}(1+t^*)^{\sigma-1}\theta(1-\theta)[\sigma-1+\phi^2+(1+t+t^*)\sigma\phi^2].
\end{aligned}
$$

Therefore, the individual welfare in Home is given by

$$
\begin{aligned}
\omega =& \frac{1+w+\frac{kt}{\theta}}{L^{\frac{1}{1-\sigma}}[\theta(1+t)^{1-\sigma}+(1-\theta)(1+t^*)^{1-\sigma}\phi]^{\frac{1}{1-\sigma}}} \\
=& \frac{1+t+w(1+t\sigma)}{L^{\frac{1}{1-\sigma}}(1+t)[\theta(1+t)^{1-\sigma}+(1-\theta)(1+t^*)^{1-\sigma}\phi]^{\frac{1}{1-\sigma}}},
\end{aligned}
$$

where the second equality is from (11). Similarly, the welfare in Foreign is

$$
\omega^* = \frac{1+t^*+w^*(1+t^*\sigma)}{L^{\frac{1}{1-\sigma}}(1+t^*)[\theta(1+t)^{1-\sigma}\phi+(1-\theta)(1+t^*)^{1-\sigma}]^{\frac{1}{1-\sigma}}}.
$$

Hence, the first-order condition for welfare with respect to its tax rate becomes:

$$
\begin{aligned}
\frac{\partial\omega}{\partial t} &= \frac{\omega\mathcal{A}(t,t^*)}{(\sigma-1)(1+t^*)[1+t+w(1+t\sigma)]\mathcal{D}} = 0, \\
\frac{\partial\omega^*}{\partial t^*} &= \frac{\omega^*\mathcal{B}(t,t^*)}{(\sigma-1)(1+t)[1+t^*+w^*(1+t^*\sigma)]\mathcal{D}} = 0,
\end{aligned}
$$

where

$$
\mathcal{A}(t,t^*) =(1+t)^{\sigma}\sigma\phi\{(1+t)^{\sigma}(1-\theta)[\theta+\sigma(1+t^*-\theta)]\phi
$$

$$
\begin{aligned}
&- (1+t^*)^\sigma \theta(\sigma-1)(\theta+t\sigma)\} \\
&+ w\sigma(\sigma-1)\phi(1+t\sigma)\frac{1+t^*}{1+t}\{\theta^2(\sigma-1)(1+t^*)^{2\sigma-1} \\
&- (1+t)^\sigma(1-\theta)[(1+t)^{\sigma-1}(1-\theta)\sigma + (1+t^*)^{\sigma-1}\theta\phi]\}, \\
\mathcal{B}(t,t^*) =&(1+t)^\sigma \sigma\phi\{(1+t^*)^\sigma\theta[1-\theta+\sigma(t+\theta)]\phi \\
&- (1+t)^\sigma(1-\theta)(\sigma-1)(1-\theta+t^*\sigma)\} \\
&+ w^*\sigma(\sigma-1)\phi(1+t^*\sigma)\frac{1+t}{1+t^*}\{(1-\theta)^2(\sigma-1)(1+t)^{2\sigma-1} \\
&- (1+t^*)^\sigma\theta[(1+t^*)^{\sigma-1}\theta\sigma + (1+t)^{\sigma-1}(1-\theta)\phi]\}.
\end{aligned}
$$

Thus, equilibrium tax rates t and t^* must satisfy the condition that

$$\mathcal{A}(t,t^*) = \mathcal{B}(t,t^*) = 0. \tag{12}$$

The above equations are not solvable in general. To capture the essence, we first consider the case of symmetric countries: $\theta = 1/2$. Then, we have the equilibrium tax rates $t = t^*$, so that (12) is simplified as

$$-\frac{(1+t)^{2\sigma}\sigma^2\phi}{4}[1-\phi+t(2\sigma-1-\phi)] = 0,$$

which has a solution

$$t = -\frac{1-\phi}{2\sigma-1-\phi}. \tag{13}$$

Since $\phi \in (0,1)$ and $\sigma > 1$, the equilibrium tax rate takes a negative value, indicating that countries pay subsides to attract mobile capital to increase good production. Meanwhile, (13) increases and is convex in ϕ. Therefore, the subside value decreases when globalization deepens. This subside finally becomes zero in the case of free trade. Intuitively, when trade is free enough, the advantage of local production disappears. Finally, since (13) increases in σ, the government subsidizes the firm more when varieties are less substitutable. Summarizing the above, we have:

Proposition 4 *Under the tax competition on the capital employment between Home and Foreign with the identical population size,*
(i) two countries subsidy the capital in the Nash equilibrium.
(ii) the equilibrium subsidy rate decreases with ϕ and σ.

The negative tax ratio of (13) is contrastive to the positive equilibrium tax on imported goods in Mai et al. (2008). However, it is the same as in the case of asymmetric and no-cluster countries of Ottaviano and van Ypersele (2005). Therefore, the policy of tax on product is different that on production factor. Meanwhile, since their quasi-linear utility function fails to capture the income effect in Ottaviano and van Ypersele (2005), governments can do nothing in equilibrium when countries are symmetric.

Since (12) is still not analytically solvable for asymmetric countries, we now perform a simulation for the general case. By taking $\theta = 0.6, \sigma = 3$, Figure 2 shows the equilibrium tax rates in two countries and their difference. We can observe the following facts. (i) The larger country provides a smaller subsidy. This can be attributed to the agglomeration rent in the large country. (ii) The subsidy ratios in both countries decrease when globalization deepens. (iii) The subsidy differential also decreases with globalization. Our equilibrium tax rate is always negative, which is contrastive to the positive tax rate of Ottaviano and van Ypersele (2005) in the asymmetric case of a cluster. Because firms are allowed to agglomerate in the larger country, the agglomeration rent makes it possible for the larger country to impose a tax on firms.

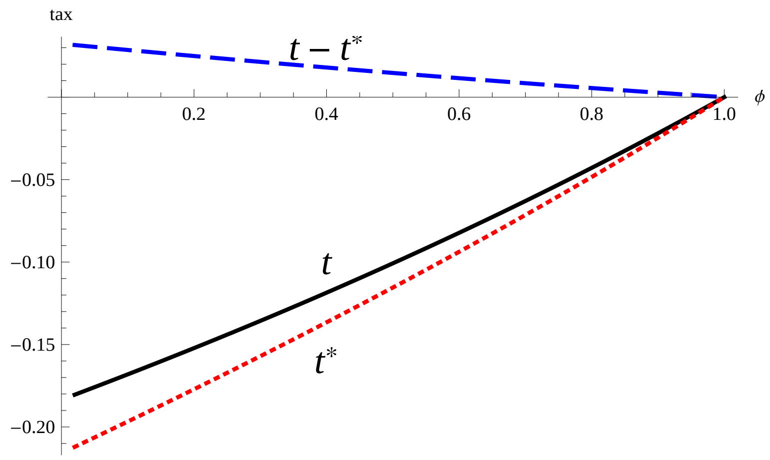

Figure 2: The relation between the optimal tax rate with trade freeness

5 Conclusion

Trade liberazation without delocation is a great concern of Baldwin and Robert-Nicoud (2000) since many policymakers around the world view de-industrialization per se as unfavorable. To reach this aim, they assume that two countries coordinate their tariff cutting in a manner that allows both partners' barrier to fall from infinite to zero without any delocation.

By considering mobile capital as marginal input and immobile labor as fixed input in manufacturing production, this paper reformulates the footloose capital model and reexamines some interesting issues in NTT, providing an easy way to model trade without delocation. This new model has strong tractability, based on which we show that the welfare in either country increases in trade freeness and country size. We further explore the tax competition game in which countries impose tax on or provide subsides to mobile capital to maximize the welfare of their own residents. It is shown that both countries provide subsides in the Nash equilibrium, which decline when trade integration deepens.

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